Preserving and dating Glastonbury Lake Village Project 6989

Final Report

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1 Summary

The project was primarily conducted to determine the extent and condition of the archaeology left *in situ* after the Bulleid and Gray excavations. The ditch on the west side of the site had water control and supply structures created and water table monitoring equipment was installed in two locations. It was also intended that sampling for scientific dating could provide a robust chronology for the settlement and that other research questions could be answered.

The fieldwork succeeded in all these aims. The extent of the *in situ* archaeology was seen to vary significantly across the site. Mound 59 appeared to have been completely removed, including even the substructure. In contrast, the floor and wall line of the earliest roundhouse on Mound 74 were still extant while the later walls and floors had been totally excavated. In Mound 9 the lowest foundations and floors were also largely intact and posts from many of the sequence of roundhouse walls were still present. The palisade stakes at both the north and south sides of the site had been largely left in situ although the early excavations had been carried down around the timbers.

The fieldwork provided accurate information for the OD height of the surviving remains, which can be used in hydrological modelling and for guiding a future preservation strategy. Some of the wood showed obvious signs of desiccation, shrinkage and splitting, most notably the smaller wall stakes. The longer palisade stakes did not show these signs, possibly because their bottom ends always remained in contact with the water table. Analysis of the present condition of the material has shown that it is in an advanced state of decay, leaving it very vulnerable to damage associated with desiccation.

The presence of the palisade stakes suggests any material trapped underneath them when they collapsed is likely to be in a good state of preservation. Judging from Bulleid's observations it is likely that midden material will be present alongside the palisades. The wood that was excavated and reburied on site by Bulleid and Gray was found to have survived the experience – possibly the longest archaeological reburial experiment in the UK.

The water control structures were successfully created by the Somerset Internal Drainage Boards on the west side of the monument. This has created a new supply and penning regime for that section of the ditch which borders the settlement. It has now been possible to try and retain a high summer pen level (4.0m OD) in that ditch for the first time. Water table monitoring took place over three years. Water tables are high except during the summer and autumn months. In the first two years the water table remained above the *in situ* waterlogged deposits but in the dry summer of 2018 the water table went below. This suggests that the upper deposits may be at risk of destruction from very dry summers, that are predicted to become more frequent and extreme because of global warming.

The excavations produced the first precise evidence for the size and species of the wooden components of the structures on the settlement. Palaeoenvironmental analysis under Mound 9 demonstrated how the settlement had developed and established the character of the foundations and floors of a roundhouse and the occupation area between two buildings.

The main advance in our understanding of the settlement was produced by the scientific dating programme. Although dendrochronology was not successful, an extensive radiocarbon dating programme, utilising Bayesian analysis, was able for the first time to produce a precise and robust chronology for the site and, by extension, for the artefacts

excavated from it. This demonstrated the short-lived character of the occupation and the frequency of roundhouse rebuilding.

The fieldwork has clearly demonstrated that the site still retains great potential for enhancing our understanding of Iron Age society. Although many research questions have been answered, the potential remains for future very small-scale excavation to answer specific research questions about topics such as diet and economy or to retrieve further samples for scientific dating. It is a testament to the skill of Arthur Bulleid that his records can be reliably used to accurately locate such ‘keyhole’ fieldwork.

The projects results have been presented in two articles (Hill *et al*. 2018 and Marshall *et al*. 2020) focusing on the paleoenvironmental and chronological aspects. A third article about the structural evidence of the settlement is in preparation. In addition, two Historic England Research Reports have been produced (Hazell and Challinor 2018 and Nayling *et al*. 2017).

2 Background

2.1 Site discovery, description and original excavations

The English publication of Ferdinand Keller’s book on the lake villages of Switzerland and Europe (Keller 1878) inspired many antiquarians across the continent. In Somerset, Arthur Bulleid (figure 2), a medical student from Glastonbury, spent four years searching the local moors at weekends and during holidays, seeking a local equivalent to the Swiss sites. In 1892 his dedication paid off when he discovered a bumpy field beside the road between Godney and Glastonbury where pieces of pottery and bone were visible in mole hills - Glastonbury Lake Village had been discovered (figure1).

Figure 1 Site location map

Every year until 1898 Bulleid spent six months excavating the site on behalf of the Glastonbury Antiquarian Society, who had been given the field by the owner Mr Bath, and the other half of the year sorting the finds. Bulleid worked with a small team of labourers but was advised by a committee of the great and good of British archaeology including General Pitt-Rivers, Prof Boyd Dawkins, Sir John Evans and Dr Robert Munro.

Figure 2 Arthur Bulleid in the doorway of the site hut

The huge numbers of artefacts swamped the family home and Bulleid took a break to finish his medical studies at the insistence of his fiancée’s father, who wisely wouldn’t allow her to marry an impoverished archaeologist. Between 1904 and 1907 Bulleid finished the excavation of the village in combination with Harold St George Gray, the curator of the Somerset Archaeology and Natural History Society museum in Taunton and a former assistant to Pitt-Rivers. The two men published the results in two volumes (Bulleid and Gray 1911 and 1917) which together represent one of the more thorough excavation reports of their age.

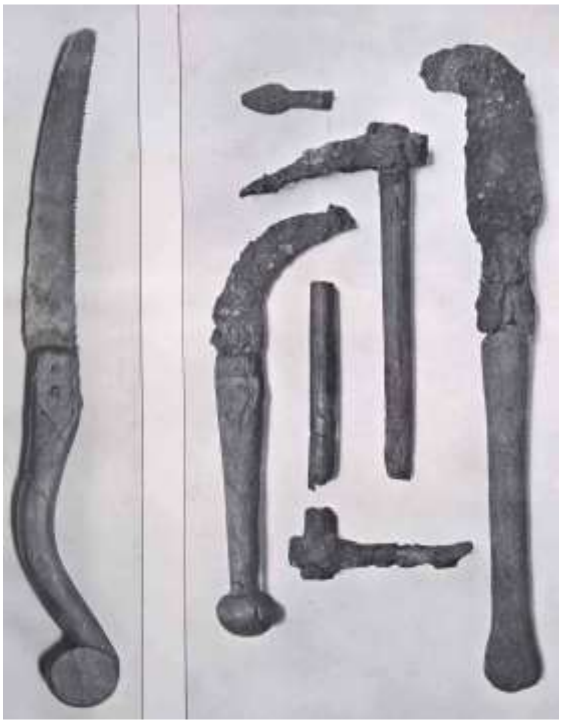

Figure 3 Tools with wooden handles from the site

The site Bulleid and Gray excavated was the best-preserved Iron Age settlement ever discovered in the UK. The waterlogged peat and clay had prevented the normal types of decay from occurring, ensuring that wooden objects such as turned wooden bowls, bentwood boxes and the wooden handles of tools survived for thousands of years (figure 3). The wetland environment also meant that occupation layers built up to considerable depths and weren't truncated by any significant erosion (figure 4). There were foundations, wall posts, and superimposed floors incorporating a huge variety of domestic artefacts.

The significance of the site was immediately recognised, and many heritage groups flocked to see the excavations. There was much coverage in the local and national press and in 1911 the artist Amédée Forestier completed a series of reconstruction paintings of the lake village for the Illustrated London News that are some of the finest images of their type (image on front cover of this report). The photographs of the roundhouse floors, the well-crafted illustrations of the decorated finds and the Forestier artwork did a great deal to create enduring preconceptions of Iron Age society.

Bulleid realised that the village he had discovered had been built in a swamp in a slightly drier area marked out by trees such as willow and alder, whose leaves survived in the wet peaty mud. To live in such a wetland the inhabitants felled trees and laid down foundations of timber, brushwood, bracken and stone. On top of this approximately 1,000 tonnes of clay were brought to the site to create 90 floors or spreads of circular or oval shape, mainly 4-12m in diameter.

Figure 4 The hearth and wooden foundation from Mound 71

On roughly 40 of the clay spreads, wooden roundhouses had been built, usually with a central hearth and sometimes with a small oven. In most of these dwellings the floors, central hearth and walls had to be replaced numerous times, forming mounds up to 1.1m high that were visible to Bulleid on the ground surface. The weight of the clay floors caused the habitation areas to sink into the underlying soft peat, which was undoubtedly one reason for their frequent replacement.

The foundations of the dwellings and the timber walkway surfaces around the edge of the settlement were held in place by an almost complete ring of palisade posts. These had usually collapsed outwards as the pressure from the material they retained pushed them over into the swamp. The palisades were rebuilt several times and a causeway or landing stage was created on the eastern side of the settlement.

The original excavations were quite well recorded for their time but there are many unanswered questions about their methodology. Of critical importance is the depth to which they carried their excavations. It seems clear that all the habitation mounds and ‘floors’ were fully excavated and removed except for the central hearth in mound 9 (see below). The photographs of the excavation suggest that the palisades and foundations were left intact (figure 5) although the published sections show the base of the foundations and the bottom of the vertical posts. It is uncertain if these were sections extrapolated using deeper excavation in very restricted areas. A draft of one section drawing shows the length of the wall posts being extended to produce the published version. This raises questions over the degree to which the published sections incorporated informed guesswork about the depth of the foundation deposits and wall posts. No photographs show a full section through the foundations or a complete wall or palisade post.

Figure 5 Palisades (top) and foundations on the SW side of the settlement in 1897

2.2 Investigations since 1907

Since the original excavation, eight further trenches have been opened on the site (see figure 6 for locations). All of them have been very small in size and largely confined to the perimeter of the site. The main core of the settlement has not been investigated since Bulleid and Gray’s excavations ended in 1907.

Michael Avery excavated three trenches at the northern end of the settlement in 1969 but the recording seems to have been very poor and it is unlikely that the fieldwork will be published or that an intelligible archive will ever be produced. The next intervention occurred in 1984 when the Somerset Levels Project excavated three trenches, one to the north of the settlement, one on its western edge and one across the causeway (Coles, Coles and

Morgan 1988). In 2003 the MARISP project excavated two trenches as part of a wider study of waterlogged archaeological sites in the Brue valley (Brunning 2013). One trench was located outside the settlement on the south side and the other across part of the palisade and foundations at the south-western edge of the settlement.

The Somerset Levels Project recorded visual information on the condition of the site and a suite of analysis was used on wood samples as part of the MARISP project, like that described in the methodology section below. Hydrological monitoring began in January 2004 with redox and ground water recordings in two transects over a 12 month period as part of the MARISP project (Brunning 2013).

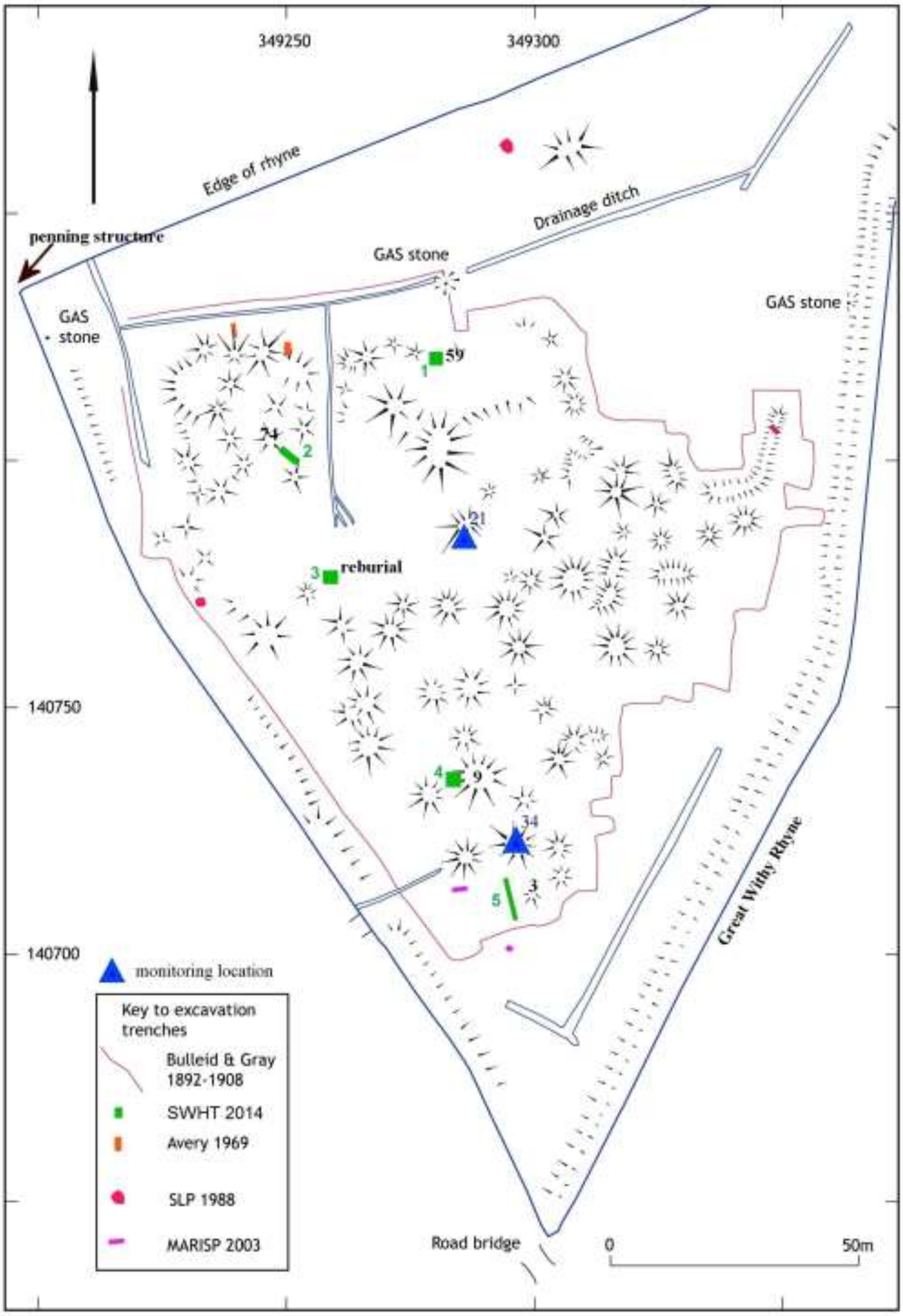

Figure 6 Location of excavations since Bulleid and Gray

Much more detailed and widespread analysis occurred as part of an AHRC/EPSRC project PhD at Reading University by Louise Jones, supported by English Heritage and Somerset County Council between 2008 and 2013 (Jones 2013). This involved the examination of 30 sediment cores across the site and detailed geochemical analysis of them providing a good basis of the variability in hydraulic conductivity, pH, and sediment chemistry. Monthly monitoring using piezometers (20 locations), redox probes (six locations) and Time Domain Reflectometry (11 locations used one at a time) took place between August 2009 and January 2011. A three-dimensional hydrological model was constructed for the site, demonstrating considerable variability and complexity across the site, including at times a perched water table. After the formal end of that project Vanessa Straker continued the monitoring of the water table for several months but it became increasingly difficult to locate the monitoring points and it was eventually abandoned.

A thorough reassessment of the original excavation archive has also been undertaken by John Coles and Steve Minnitt (1996). This included reassessments of several artefact classes and the establishment of a phased development for the site, based on the stratigraphic relationships recorded by Bulleid. This comprised early, middle, later and final phases. An attempt was also made to obtain scientific dating from stratified artefacts from the site. The results broadly contradicted the typological dating from the same mounds, leaving a large question mark over the actual date of the settlement (see dating section below).

3 Methodology

3.1 Excavation

Five small trenches were excavated for sampling (figure 6). The areas were chosen to provide a representative baseline sample of the present condition of the monument. To achieve this, they were widely spread across the settlement area. They were also chosen to investigate different periods of Bulleid and Gray's excavations to assess the potential implications of changes in their excavation methodology over time (table 1 below). The locations were also intended to encounter structural material of different phases of the settlement occupation so that representative samples could be sampled for scientific dating. In 4 of the 5 cases, it was hoped that stratigraphical relationships would allow Bayesian modelling of the results (eg. from sequential wall or palisade lines).

The location of trench 3 was chosen to investigate an area where wooden material was deliberately reburied by Bulleid and Gray at the end of their excavations. The approximate location is shown in their publication, but nothing is known about the depth of the reburial or the way in which the objects were reburied. The project sought to examine whether this 107-year experiment in reburial had been effective.

Ideally several other areas would have been investigated to provide a more representative sample of preservation conditions and each would be much larger in size to provide greater choice in the selection of samples for dating. These advantages were outweighed by the need to limit the impact on the monument. The deep sequence of superimposed hearths and charcoal layers in mound 9 was initially selected for radiocarbon and archaeomagnetic dating and Bayesian analysis but this was rejected after consultation with Historic England, because it would involve the removal of the only deeply stratified occupation layers left on the site. The Mound 9 excavation was therefore confined to the entrance area.

Table 1 trench location strategy

Excavation area	Part of site	Excav date	Coles and Minnitt Phase				Notes
			Early	Middle	Later	Final	
1. Edge of mound 59 and palisades	N edge	1895	Y	Y	Y	-	Mound – wall posts may survive
			-	Y	Y	Y	Palisade – probably 2 or 3 phases
2. Mound 74	NW	1902	Y	Y	Y	-	3 sequential wall lines and oak posts
3. Reburial site	Centre	1907	Reburied objects can probably be assigned to location and context				
4. Mound 9	S. centre	1896	-	Y	Y	Y	Entrance may contain timbers suitable for dendro and 2 sequential wall lines
5. Palisade by Mound 3	S. edge	1897	-	-	Y	Y	Possible sequence of 3 palisade lines

All the trenches were opened by hand. In each trench, Bulleid and Gray's backfill was removed without differentiating between tip lines. This was because it was felt that the complex recording of the backfill would provide little archaeological data and would be very time consuming. The backfill was therefore rapidly removed by spading. All the artefacts seen during this removal were retained, but some must inevitably have been missed and ended up on the spoil heap. A metal detector was used to locate any coins or other metalwork such as brooches, which might have been in the backfill. None were found.

The trenches functioned as evaluations rather than full excavations. Once *in situ* deposits were encountered, planning, recording and sampling took place. The only *in situ* structural remains excavated and removed from the trench were those that were being sampled. It was expected that some additional excavation might be required to establish stratigraphic relationships between structural groups to enhance the dating programme. In the event, this was not really required as the deep excavation by Bulleid and Gray had either removed the stratigraphy or allowed visible comprehension of the stratigraphy still *in situ*.

Once waterlogged wooden remains were encountered, they were kept wet during excavation using hand sprays. Coloured plastic sheeting covered the areas not being worked on. Relevant Historic England guidelines were followed (Historic England 2015). Water levels were generally at roughly the height of the wooden remains and a small pump had to be used occasionally to allow their excavation, usually at the beginning of the working day. Small sumps were created in each trench to facilitate the pumping and hand bailing. Each trench was only open for a relatively short time period and the in situ waterlogged remains were exposed for less than five days during the excavation of each trench.

Sampling of wooden remains was undertaken for species identification, condition assessment and dating purposes. The sampling strategy for species identification was discussed on site after the first trenches were opened. It was resolved to try and identify each significant piece of structural wood, establish its age and record its size. It was not envisaged that any material would be conserved.

3.1.1 Palaeoenvironmental analysis

The methodologies for pollen, plant macrofossils, beetles, micromorphology, diatoms, forams and wood, and supplementary data are included in Appendix A.

The original project design did not envisage any sampling for palaeoenvironmental analysis because of the significant work that had already taken place (Godwin 1955, Housley 1988, 1995; Aalbersberg, 1999; Housley *et al* 2000, 2007; Brown 2006; Aalbersberg and Brown, 2011; Tinsley and Jones 2013). During the excavations it was decided that the opportunity to examine samples from directly underneath a roundhouse floor was too significant to be ignored. The project design was therefore updated to include palaeoenvironmental assessment in one location.

Trench 4 offered a convenient opportunity for this where Bulleid's original excavation had removed part of a roundhouse floor, producing a location where sampling could take place with minimal damage to the settlement. The sampling of the main area was undertaken by Julie Jones and Vanessa Straker and is described more fully in section 4.5.

4 Excavation results

4.1 Trench 1: Mound 59 and palisade

This trench was 4m (N-S) by 3m (E-W). It was located towards the northern edge of the settlement in an area where a palisade line running roughly northwest to southeast intersected with the walls of mound 59 (figure 7). The palisade curved around the northern side of Mound 60 and further south into the heart of the settlement and may join up with a line of stakes running north-south over roughly 20m. Mound 59 had four super imposed floors. The earliest (floor 4) was a 5.2m diameter clay layer with no hearth bounded on its northern edge by a line of hurdles. Floor 3 was a more definite roundhouse with a 4.6m diameter clay floor and central hearth contained within a woven wall post line with a small gap on the southern side. Floor 2 was a direct replacement with a slightly larger diameter (4.9m) and a central hearth. The final clay spread (floor 1) was 26 x 7m in extent and covered mounds 59, 60 and 61 with a thin 9m long extension projecting out into the wetland from the eastern end. A dense line of palisade stakes ran east-west along the northern edge of this clay spread suggesting that both they and floor 1 were contemporary. The foundations of mound 59 were substantial, with layers of logs, brushwood and rush all underlying floor 4. They had been deposited upon a midden deposit containing pottery, bone (animal and human) and wood.

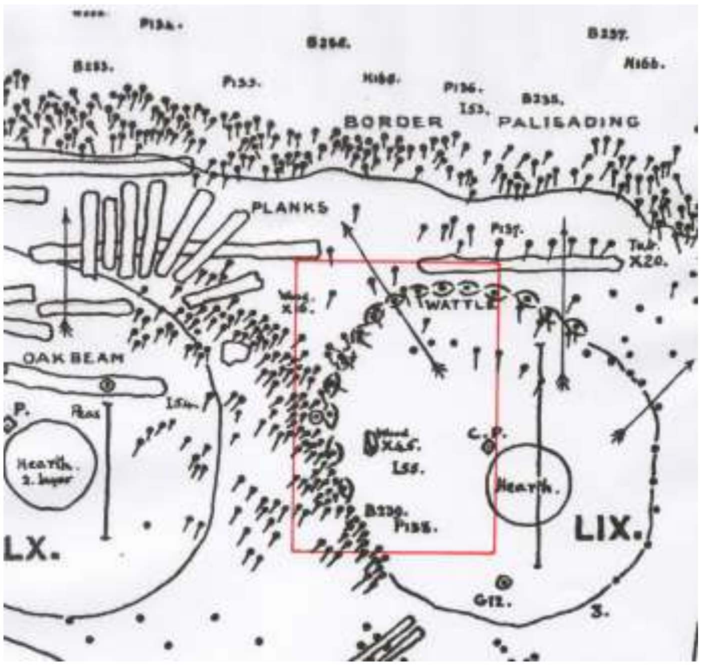

Figure 7 Location of trench 1 shown on the original plan of Mound 59 by Bulleid

Coles and Minnitt attribute floor 4 to their early phase, the northwest-southeast palisade and floors 2-3 to the middle phase and floor 1 to the late phase (1996, 73-4). Bulleid describes the foundations as 'lying apparently outside a line of old palisading-posts' (Bulleid and Gray 1911, 140). This suggests that the northwest-southeast palisade was in place before the foundations for mound 59. Mound 59 is the only significant structure outside this early palisade line on the Coles and Minnitt phasing plan so its formation at a slightly later date would be entirely credible. The only section through Mound 59 (Bulleid and Gray 1911, plate

30 opp. p.144) shows the timber foundations and the wall and palisade stakes to a depth of four feet below the earliest floor level. The only plan (Bulleid and Gray 1911, plate 29 opp. p.140) shows the wall posts and wattling of floor 3, intersecting with the early palisade line on its western side and with the earlier and later wall stakes to the inside and outside of that line respectively. Where the palisade and wall line meet, a single vertical oak post is shown. It is roughly in line with a series of three similar oak posts that had been driven through an oak beam in the foundation of mound 60 to the west. This suggests that it may have been part of an early structure.

4.1.1 Bulleid's 1895 excavation and backfill

The Bulleid excavation in this area had been taken down through the occupation layers and well into the underlying peat. In the southwest side of the trench excavation had ceased at the level where they encountered the slumped and bent over tops of a line of palisade stakes (figures 8 and 9). A baulk of undisturbed peat at that level (3) ran from the palisade along the southern edge of the trench. Another baulk of peat at roughly that level was intermittently present on the eastern side of the trench.

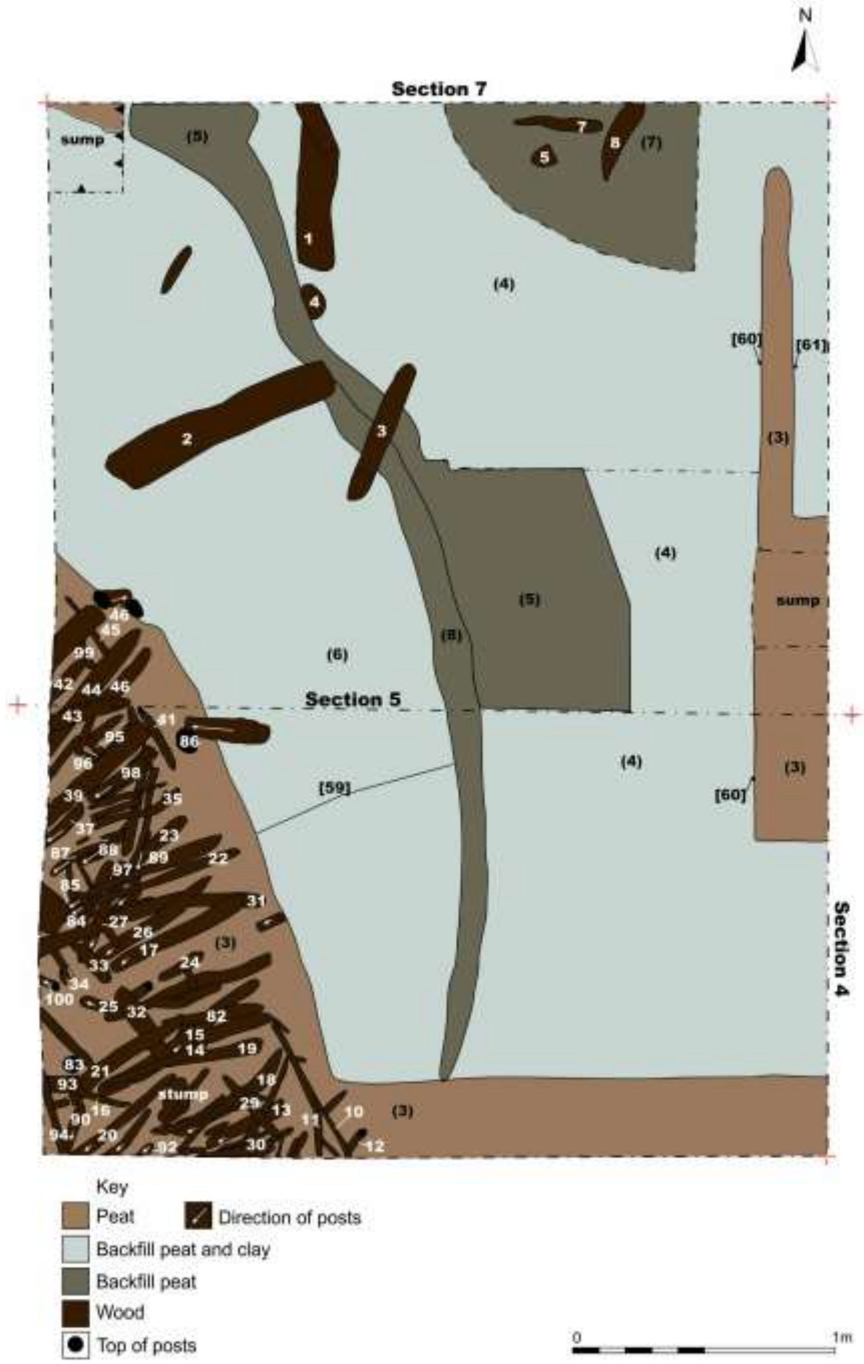

Figure 8 Trench 1 plan

The deepest elements of Bulleid's excavation consisted of three trenches that had been excavated to considerable depth into the peat. The western trench [59] closely followed the edge of the palisade timbers and mirrored their curving line. It widened from c.0.5m at the southern end to a maximum of c.1.4m at the north western end. A section across this trench showed that it was over 40cm deep, having a vertical faces on both its eastern and western sides. This trench was separated from another trench to the east by a thin baulk of peat (context 3 on fig.10) that ran from the northwest corner of the trench to the baulk of peat at the southern end.

To the east of the peat baulk was another Bulleid trench [60]. Its western side was stepped down into the underlying peat but its western side was vertical. Where it was sectioned, it had been cut into the peat to a depth of 58cm. The trench continued eastwards out of the 2014 trench at the southern and northern ends, with a baulk of peat in between. That peat baulk had been cut by another north-south trench [61] over a distance of c.1.3m (N-S).

Figure 9 (right) View of the SW corner of trench 1 showing the collapsed palisade (top) and deeper excavations of Bulleid and Gray with clay fill. Scales 1m. Looking to W.

In Bulleid's eastern trench [60] blocks of redeposited peat (5) have tumbled down the stepped in situ peat (figures 8 and 10). A thin layer of blue grey clay (8) separated these blocks from the *in situ* peat. It seems likely that the peat blocks were derived from the digging of the trench [59] to the west, from where they were tossed into the adjoining trench. Above the peat blocks was a blue-grey clay (18) that was very similar to the lowest backfill (17) in the western trench. Above the blue grey clay was a yellow clay (4 and 6) with occasional peaty inclusions. The remainder of the backfill consisted of a mixture of yellow and blue-grey clay, sometimes mottled orange, and with numerous peaty inclusions (1, 2, 4). Distinct layers of backfilling were discernible but were not recorded in detail, except at the northern end of the excavation where a layer of redeposited peat containing some yellow clay lumps (7) extended c1.6m into the trench. The backfill immediately on top of the palisade and the southern baulk had a greater peat content, possibly as a deliberate attempt to protect it before the main backfilling. Several large and small pieces of wood were present in the backfill, especially towards the northern end of the trench (wood 1-9).

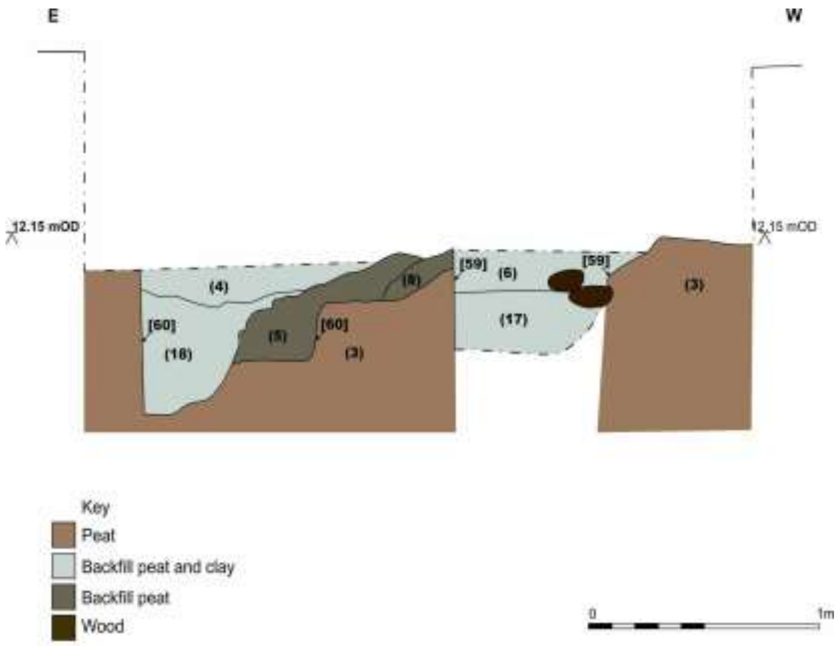

Figure 10 Section 5 facing north

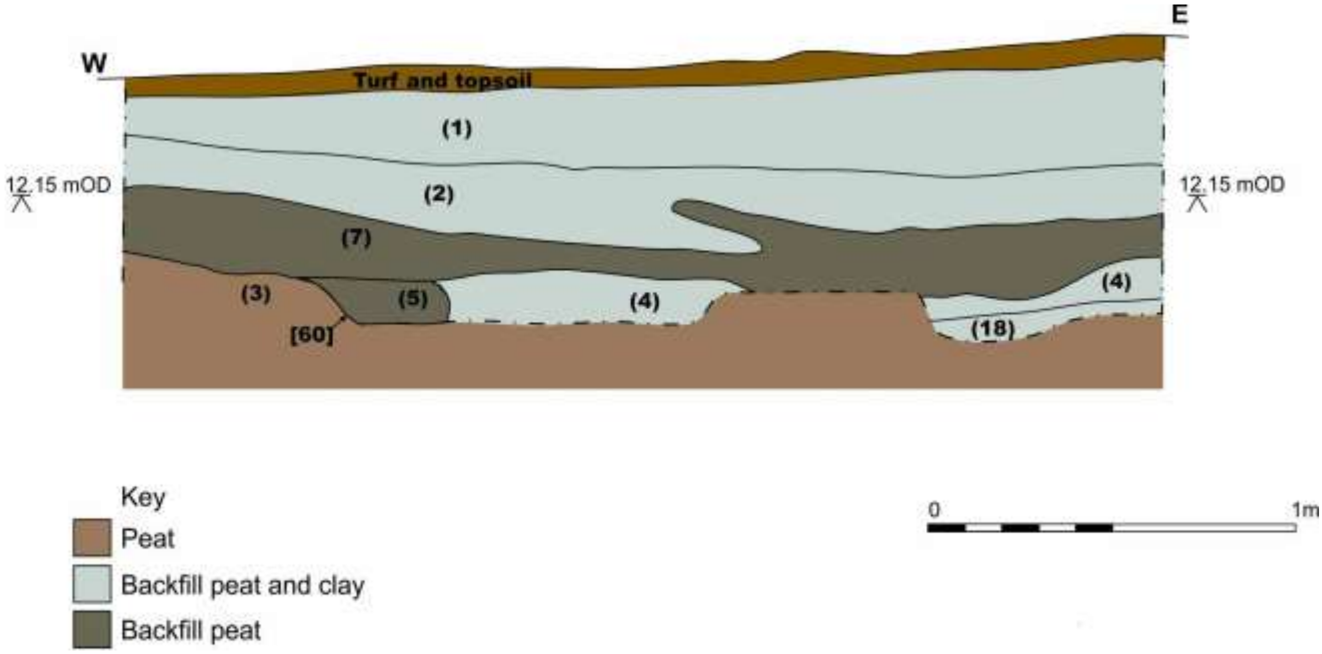

Figure 11 Section 7 facing south

4.1.2 *In situ* Iron Age remains

The *in situ* peat baulks on the eastern and southern edges of the excavation showed no visible evidence of Iron Age structures or occupation despite being in the location of Mound 59. It therefore appears that Bulleid had removed all the occupation layers and substructure of that roundhouse. The significant depth of Bulleid's excavation under Mound 59 can be attributed to the interesting midden deposits that he encountered there. It appears that he continued the excavation downwards until no more cultural material was found.

In the south-western corner of the trench, the remains of the northwest-southeast palisade (structural groups 2 and 3) had been left *in situ*, together with some possible wall posts (structural group 1) intermingled with them. The ground surface around the trench was between 4.40 and 4.47mOD. The tops of the palisade posts were between 3.71 and 3.78m OD.

Mound 59 wall stakes (Gp.1)

Bulleid had removed most of the wall line of the roundhouses of Mound 59. The only elements that survived were two stakes (41 and 12) and two horizontal pieces of roundwood (10 and 11) that may represent wattling between the stakes. Wattling was recorded on the plan of the wall line by Bullied where it intersected with the palisade (Bulleid and Grey 1911, plate 29). Bulleid recorded that this wall was associated with floor 3 of Mound 59. These elements probably survived because of their proximity to the palisade stakes.

All four elements were young pieces of willow or poplar roundwood that still retained their bark. The horizontal wattling pieces were compressed, and probably had original diameters of c.12 and 17mm. Wall stakes 12 and 41 were c.50mm and 57mm in diameter respectively. Stake 41 had slumped to the south-east and was lying at an angle of c.60 degrees. It survived to a length of 300mm.

Palisade lines (Gp. 2 and 3)

Two palisade lines could be distinguished, on parallel alignments. In the south-west corner of the trench six stakes (20, 21, 90-92 and 100) represent the western line (Gp3). The main palisade (Gp.2) is represented by 26 stakes (figures 8 and 12). The posts in both lines were roundwood and had slumped towards the north-east, lying at angles of 25-48 degrees. After the posts had slumped, their tops had been pushed over virtually flat, entailing cracks in the roundwood that go almost completely across their diameters. The species used included young alder, willow/poplar, oak, buckthorn and birch, and the diameters varied between 29 and 87mm, with distortion by compression affecting most of the pieces. Although the tops of the posts were very poorly preserved, one of them (87) still retained evidence of being cut to a pencil shaped point, hinting that they may all have been similarly shaped.

Figure 12 The palisade line, with the tops pushed over almost flat to the NW

<u>Horizontal material amongst the palisade posts (Gp. 4 and 5)</u>
Various pieces of small roundwood were lying horizontally amongst the palisade posts. Some of these may represent material that was retained by the palisades, such as 93 and 94 for the western line and 27, 29, 32 and 33 for the main line. Some of the roundwood is definitely lying under the collapsed posts (eg. 45, 95 and 96) while others appear under some and over others (eg. 31 and 36). Some of the smaller material may originally have been woven between the posts to give them strength, and then been pushed out of place when the palisade collapsed. All the horizontal roundwood was young poplar/willow but varied considerably in size from 12-122mm in diameter, with significant distortion of those dimensions because of compression.

<u>Large vertical posts (Gp.6)</u>
Three large vertical posts were present amongst the palisade stakes. Two of these (46 and 86) were at the very edge of the palisade line and their tops had been disturbed by Bulleid's excavation. One of these two is probably the vertical pile shown on Bulleid's plan of the area lying between the palisade and the mound 59 roundhouse wall. Both had been disturbed by that excavation, post 46 having its top broken off but left *in situ*, and post 86 having its top broken off and its middle bent broken and bent over (figure 13). This damage probably happened during the backfilling. Before the breakage, both posts must have stood higher than the surrounding peat and palisade posts, which probably left them vulnerable to

Figure 13 Post 86 revealed by the removal of the backfill of the deeper excavation by Bulleid and Gray. Scale 40cm

damage during the backfilling. The third post (83) was near the western edge of the trench amongst the western palisade line.

Posts 83 and 86 were both straight-grained roundwood, of 96 and 103mm diameters, and were over 100mm long. Neither were lifted whole, but the bottom end of 86 exhibited cuts all around it where it had begun to be cut to a point, suggesting that the full length could not be much greater. Post 46 was a radially split piece of oak 756mm long, 100mm wide and 85mm broad. It retained its sapwood on one side and had been carefully cut into a vaguely oval shape. The tip had broken across a circular or oval perforation, 30mm across, which was going through the timber tangentially on the heartwood side. This suggests that it was originally a larger, radially split timber, with a circular hole running through it.

The purpose of the vertical posts is uncertain. They are not slumped like the palisade posts, but it is possible that 83 may represent the original line of the main palisade posts when they were upright. Post 86 may have been part of the mound 59 roundhouse wall line but could equally have formed the eastward extension of a line of oak posts that extended under the foundations of mound 60, where they were driven through holes in a large east-west orientated oak beam.

4.2 Trench 2: Mounds 74 and 75

This trench was 6m by 2m in size and was orientated roughly north south. It was positioned to encompass the edge of mounds 74 and 75, together with a large oak beam that lay between them (figure 14). Mound 74 was first examined solely by Gray in a small trench in 1902 and subsequently by more extensive excavation in 1906 by Bulleid and Gray. Mound 75 was excavated in the 1906 and 1907 seasons of fieldwork, with the area examined in Trench 2 located within the 1906 excavation area.

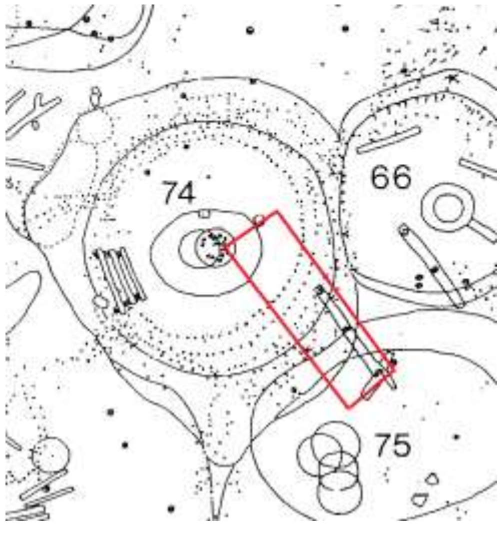

Figure 14 Trench 2 location superimposed on Bulleid's plan of mounds 74 and 75 as redrawn by Coles and Minnitt

The oak beam was recorded as having three holes through which oak piles had been driven. It may represent one side of a rectangular structure to the southeast of Mound 74, the parallel side being further east under Mound 66. Alder stumps were noted in several places around Mounds 74 and 75, sometimes stratified under the Mound floors.

Mound 74 was formed of 5 sequential clay floors covering an area of 10m by 9.8m, with a thickness of 1.2m (figure 15). The earliest roundhouse was 5.8m in diameter with a substructure of rows of alder logs on top of brushwood and larger timbers. Floor 5 was a patch of clay, 3.7m in diameter, around a hearth that had been renewed four times. Floor 4 was 7m across, covered with brushwood and timber around a central hearth that had been renewed three times. Floor 3 was a clay spread 8.5m across with a central hearth and timbers on the northern part. Floor 2 was a wider clay spread, 9.7m across, and floor 1 was another clay spread of similar size. Both floors 1 and 2 had a central hearth.

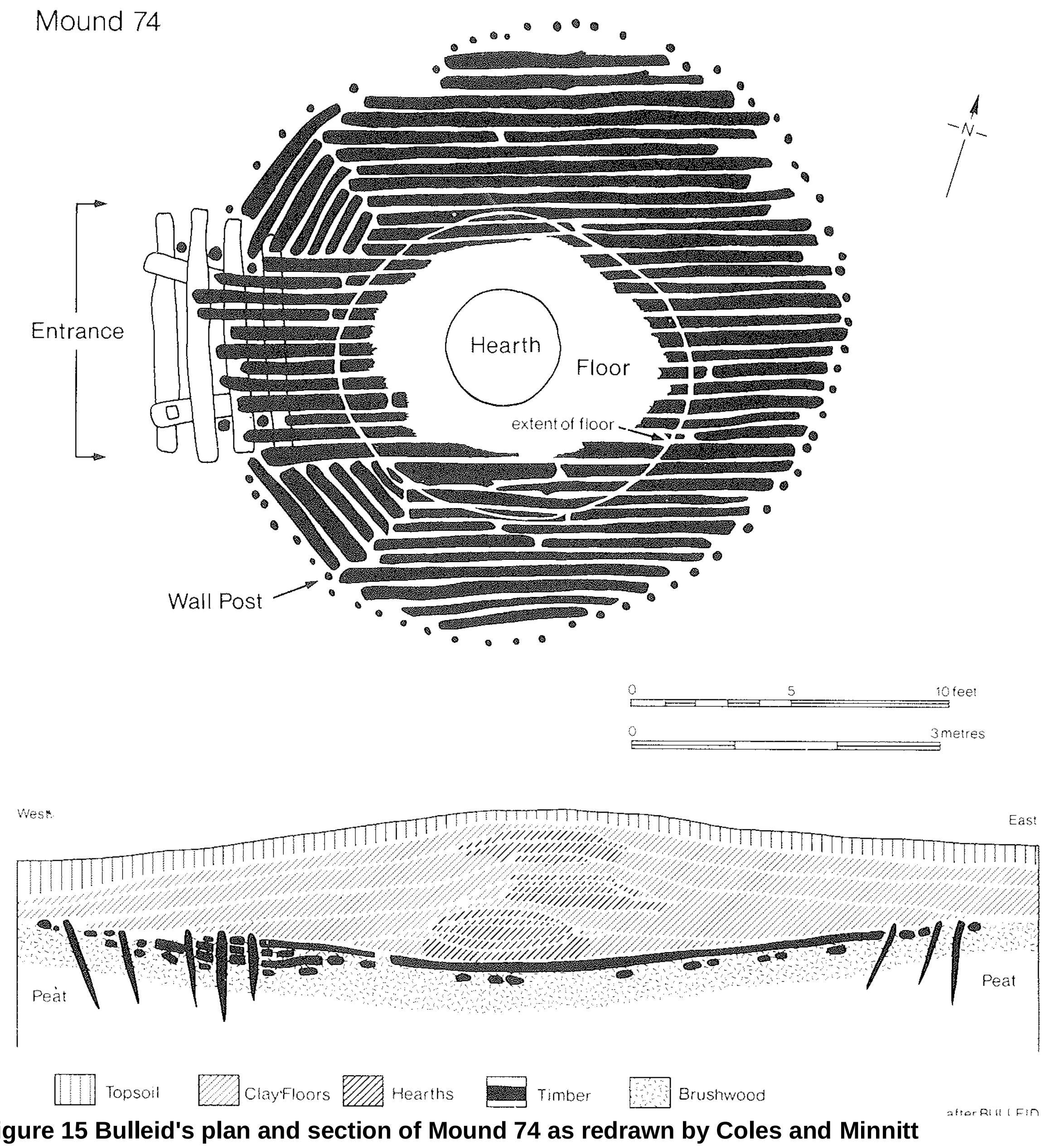

Figure 15 Bulleid's plan and section of Mound 74 as redrawn by Coles and Minnitt

Mound 75 was composed of floor clay floors covering an area of 10m by 9.75m with a maximum thickness of 600mm. Coles and Minnitt (1996, 85) suggest the existence of an earlier floor 5, composed of brushwood with a central hearth that was rebuilt five times in roughly the same position. This was overlain by two floors (4 and 3) of clay and black earth. Floor 2 (9.7 x 8.8m) overlay these and had an off-centre hearth to the N-W. Floor 1 (8.2 x 6.1m) partly overlapped floor 2 and extended northwards. No clear roundhouse wall posts were recorded with any of these floors, although some are present in a rough line along the western side of the mound and in a cluster associated with some oak posts on the southeast side.

The last 2 floors (1-2) of Mound 74 overlie floors 1-2 of Mound 75 and join floor 2 of Mound 66 (to the east). The oak beam and its posts are overlain by floors 1-5 of Mound 74 and floors 1-2 of Mound 75. Coles and Minnitt attribute Mound 74 floor 5, and Mound 75 floors 4-3 to their early phase; Mound 74 floors 4-3 and Mound 75 floors 2-1 to their middle phase; and Mound 74 floors 2-1 to their late phase (1996, 83-5). Floors 1-2 of Mound 75 are attributed to the middle phase.

4.2.1 The 1902 and 1906 excavations and backfill

Photographs of the excavation of Mound 74 in 1906 (Bullied and Gray, 1911, Plate 36 opp. p162) show the whole mound stripped, with a spoil heap visible on the east side of the area and the suggestion of an irregular mound of spoil in the foreground of the picture to the north of the site. The edge of the trench appears to the south of mound 74 suggesting that the excavation of the northern part of Mound 75 must have happened later in that digging season.

Beneath the topsoil, the backfill of the Bulleid and Gray excavations consisted of grey clay with orange mottling (10) that was overlaid at the northern end of the trench by a similar grey clay with orange and yellow mottling (9). An irregular patch of very dark grey, ash like material (12), 2mm thick, was present at the bottom of the backfill where it overlay some of the *in situ* timbers. In places, a thin grey clay with orange and yellow mottling (14) was present between it and the timber. These layers obscured the planks and posts of the early floor which were drawn by Bulleid, so they must be backfill rather than *in situ* deposits.

4.2.2 *In situ* Iron Age remains

Underneath the 1906 backfill were the remains of the earliest roundhouse of mound 74, at the north-western end of the trench, comprising a horizontal log substructure or flooring, with brushwood beneath and a surrounding arc of wall stakes (structural groups 7-9). An undisturbed peat layer was present over the rest of the trench with a row of three oak posts (structural group 10) aligned NE-SW in the middle of the trench. A small tree stump (50) was present beside one of the oak posts at the south-western end of the trench. The wooden structural remains correspond very closely to those recorded by Bulleid in this area.

The ground surface at Trench 2 varied between 4.30m and 4.49m OD. The highest *in situ* archaeology was the top of the hearth in the west corner at 4.04m OD. The top of the wooden flooring and associated wall posts of Mound 74 were between 3.83m and 3.68m OD. The tops of the oak posts were between 3.84-3.90m OD.

<u>Large posts (Gp 10)</u>
A rough line of three vertical oak posts (47, 48 and 49) ran NE-SW. Posts 48 and 49 were 1.4m apart, and post 47 was 1m away from post 48. A non-oak post (50) was positioned immediately beside post 49. Post 49 was over 300mm long and had been formed into a roughly circular shape, 103 by 93mm, by reducing a radially split timber. The pile was all heartwood. Post 48 had been fashioned from oak heartwood in a similar way. It was over 1100mm long and 85 by 90mm in cross-section. Post 47 was a piece of oak roundwood, 80mm in diameter and over 580mm long. Post 50 was a quarter split, 80 by 110mm in section and over 200mm long. None of the worked ends of the posts were visible.

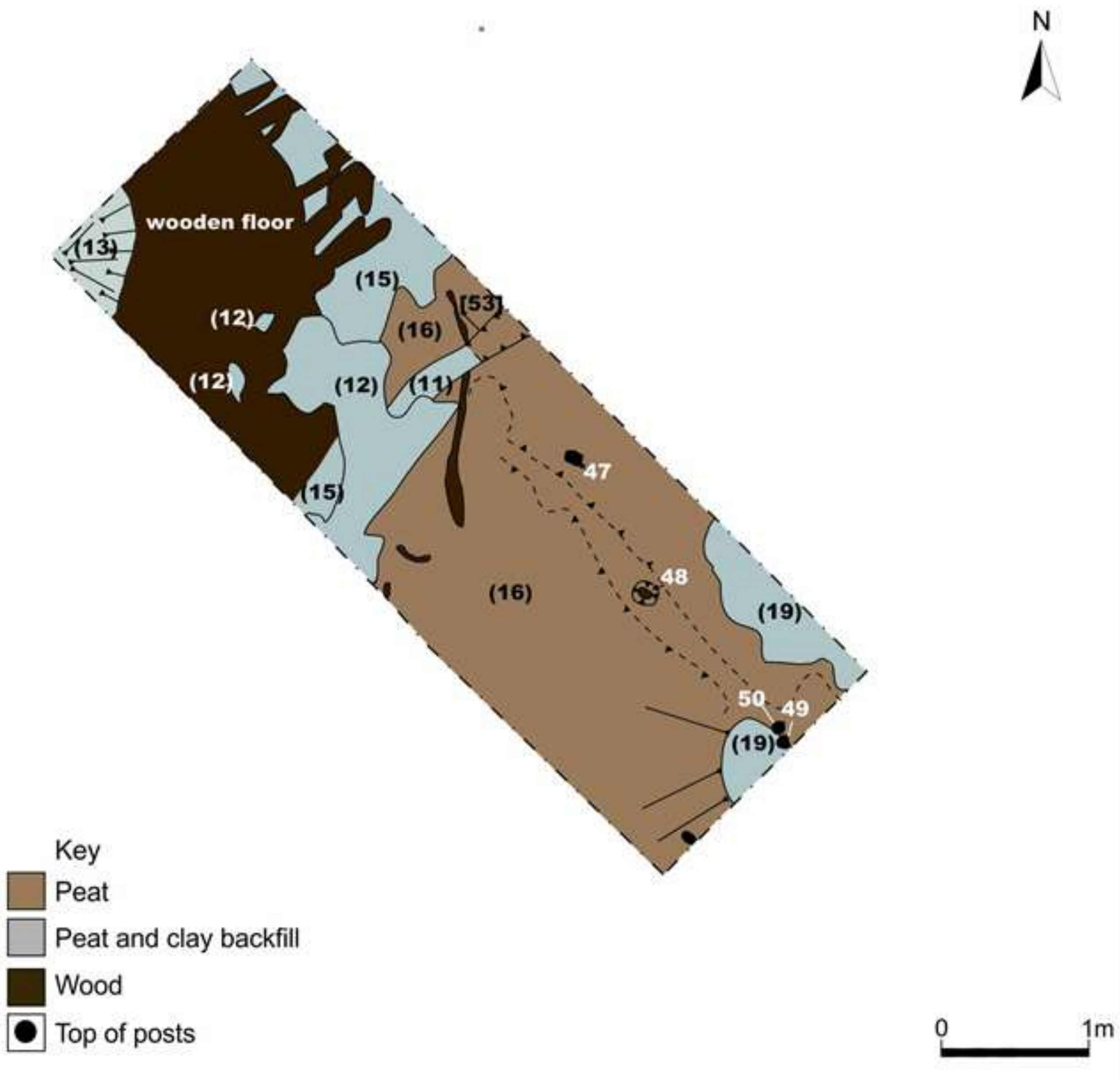

Figure 16 Trench 2 plan

A shallow ridge of peat, 1-2cm high and 10-40cm wide, ran between posts 48 and 49 and c.10cm away from post 47. This ridge may have supported the oak beam shown on Bulleid's plan. A shallow trough in the peat, 10-20cm wide and c.2cm deep ran at right angles to the ridge at its north-western end [53]. The trough was filled with light grey clay with orange mottling (11), similar to the backfill above it. This feature may represent the place where a timber had been removed and the void filled with clay, either in the Iron Age or at the end of the Bulleid and Gray excavation. The ridge roughly corresponds to the location of the oak beam planned by Bulleid.

Roundhouse flooring, wall posts, hearth and substructure (Gps. 7,8,9)
In the northeast corner of the trench was the edge of a low mound of yellow clay, up to 10cm thick, which lay directly above the wooden roundhouse flooring or foundation. A 2mm thick layer of dark grey ash (13) capped the clay. Neither the ash nor clay were excavated.

The north-western end of the trench was filled with a series of horizontal logs (Gp.7 wood 51-66), laid in an E-W orientation (Figure 17). The eastern end of the logs was supported by a series of similar timbers orientated N-S (wood 77, 78) with some others following the curvature of the floor. The original excavation had removed some of the material around the logs. The logs were set in pale yellow-brown clay (15), which was 2-10cm thick. Underneath the logs was a layer or brushwood (Gp.8 wood 80) that was only exposed in one small area. The extent and depth of the brushwood is uncertain.

Figure 17 The wooden flooring foundation of Mound 74. Scales 1m and 50cm

All the horizontal elements had been compressed vertically and had obviously suffered from some decay. The horizontal logs were 27-85mm in the horizontal plane and 11-44mm in the vertical. The original logs were probably 20-60mm in diameter before compression. Identification was hampered by poor preservation, but the successful identifications suggested that the logs were alder. The underlying brushwood was 1-2cm in diameter.

Figure 18 Wall stake 73. Scale intervals 5cm

Around the outside of the wooden flooring/foundation ran a series of small posts (Gp. 9 wood 67-70; 72-3; 75-6) and associated wattling (wood 71 and 74). The tops of the posts had all been pushed over, some of them suffering from vertical compression that had caused a crumpled zig-zag form to the top of the post. This must have happened while still they were still green, possibly during the first rebuilding phase when they would have become redundant and covered by the next clay floor. Posts 67-70 were pushed over to the southwest and posts 72-3, and 75-6 were pushed over towards the southeast.

The nine wall posts were mainly spaced 25cm apart, with one example of a 20cm spacing and another of 30cm. The posts themselves were all small, young poplar or willow roundwood of 15-54mm diameter with an average of 38mm (figures 18 and 19). They survived to lengths of 182-650mm. As the tops of the wall posts were bent over, they had obviously not been driven to their surviving lengths below the top of the log flooring.

Figure 19 Wall stake 72 showing crumpled top and desiccation crack. Scale intervals 5cm

Small pieces of poorly preserved roundwood were lying horizontally between the wall posts. The surviving elements wove in and out around the posts and therefore almost certainly represent the lowest pieces of a wattle wall. The wattling was 12-17mm in diameter but neither of the samples taken was well enough preserved for species identification.

The structures in this trench correspond very well to those recorded by Bulleid. The clay dome topped with ash (13) probably represents the edge of hearth 11, sitting directly on top of the wooden foundations or flooring. This can be seen in figure 36 and plate 36 (Bullied and Gray, 1911, p162 and opposing) in the original report. That plan and photograph probably represent the final stage of the excavation of the mound, with white laths marking out the rings of wall posts. As the 2014 excavation only encountered the earliest of these post rings, it is possible that the laths marked the positions of the later rings after they had been removed. As the surviving posts were so slight, it is possible that the later posts were not so deeply buried and therefore were either removed during the original excavation or much less well preserved and did not survive to the present day.

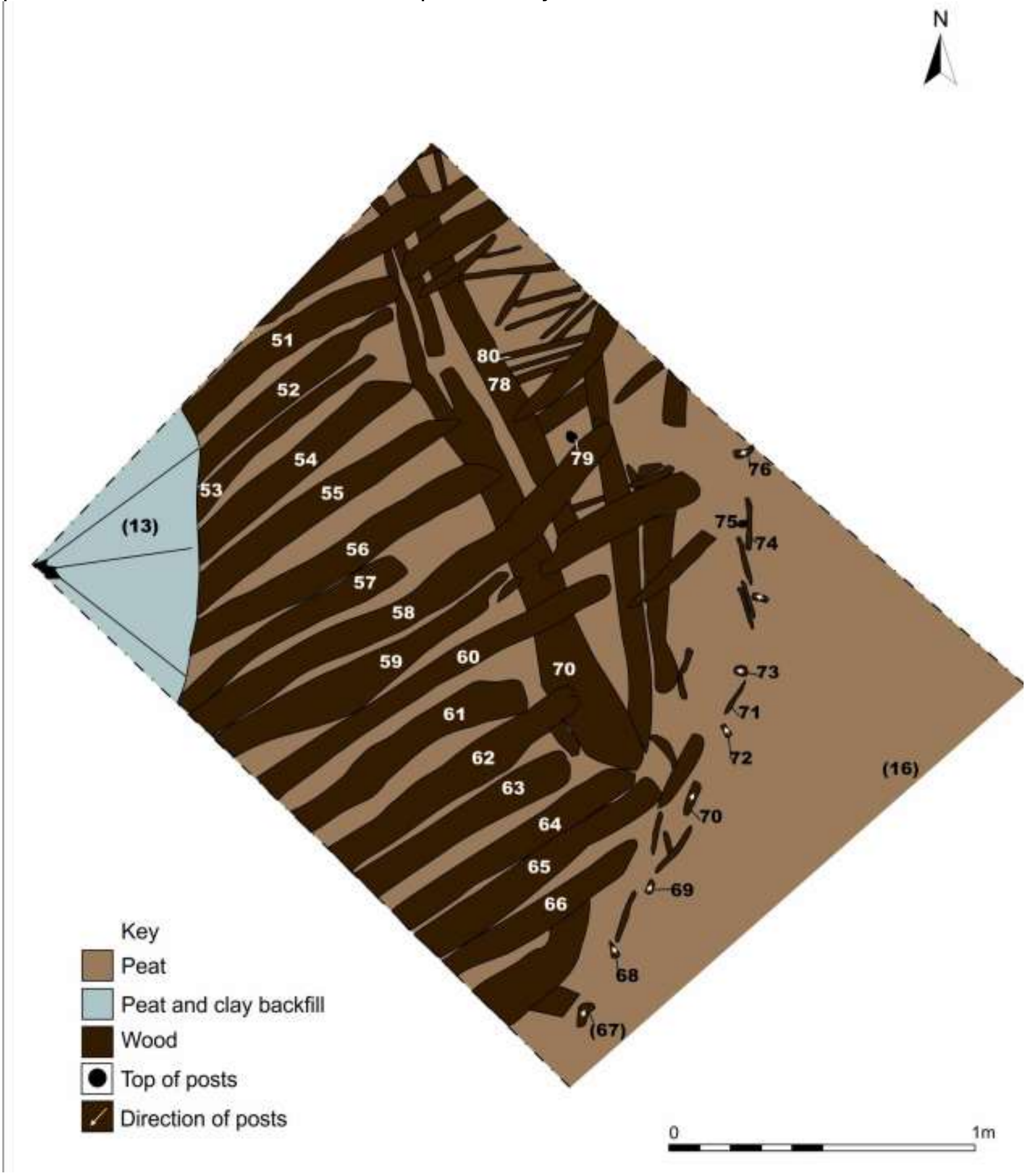

Figure 20 Close up plan of the flooring in Mound74

4.3 Trench 3: Wood reburial site

Trench 3 was 4x4m in size with a 2x2m extension to the south. It was positioned in the centre of the settlement in a location where Bulleid and Gray had reburied some of the worked timbers that they could not conserve. The location of this reburial was simply marked as 'Pieces of cut wood buried' on one of the plans (Bulleid and Gray 1911, Plate 39 opp. p. 174). An area in the north-eastern part of the trench, and a 2m by 0.4m line on the western side, were not excavated to the undisturbed peat because it was felt that the objectives of the project were adequately met by investigation of the features in the rest of the trench.

4.3.1 The Bulleid and Gray excavations and backfill

Beneath the turf and topsoil was a mixed layer of yellow and grey clay with occasional lenses of redeposited peat and topsoil (35). This represents the backfill from the original excavation and terminated cleanly on *in situ* peat at a depth of 40-45cm below ground. The peat had several desiccation cracks in its surface that were filled with grey clay.

Within the peat several shallow rectangular trenches had been cut, presumably by Bulleid and Gray. Only the smallest of these [27] was entirely contained within the limits of the trench. Cut 27 was 0.7m by 0.5m and c.18cm deep. It was filled with a yellow clay with orange mottles with patches of redeposited peat (28).

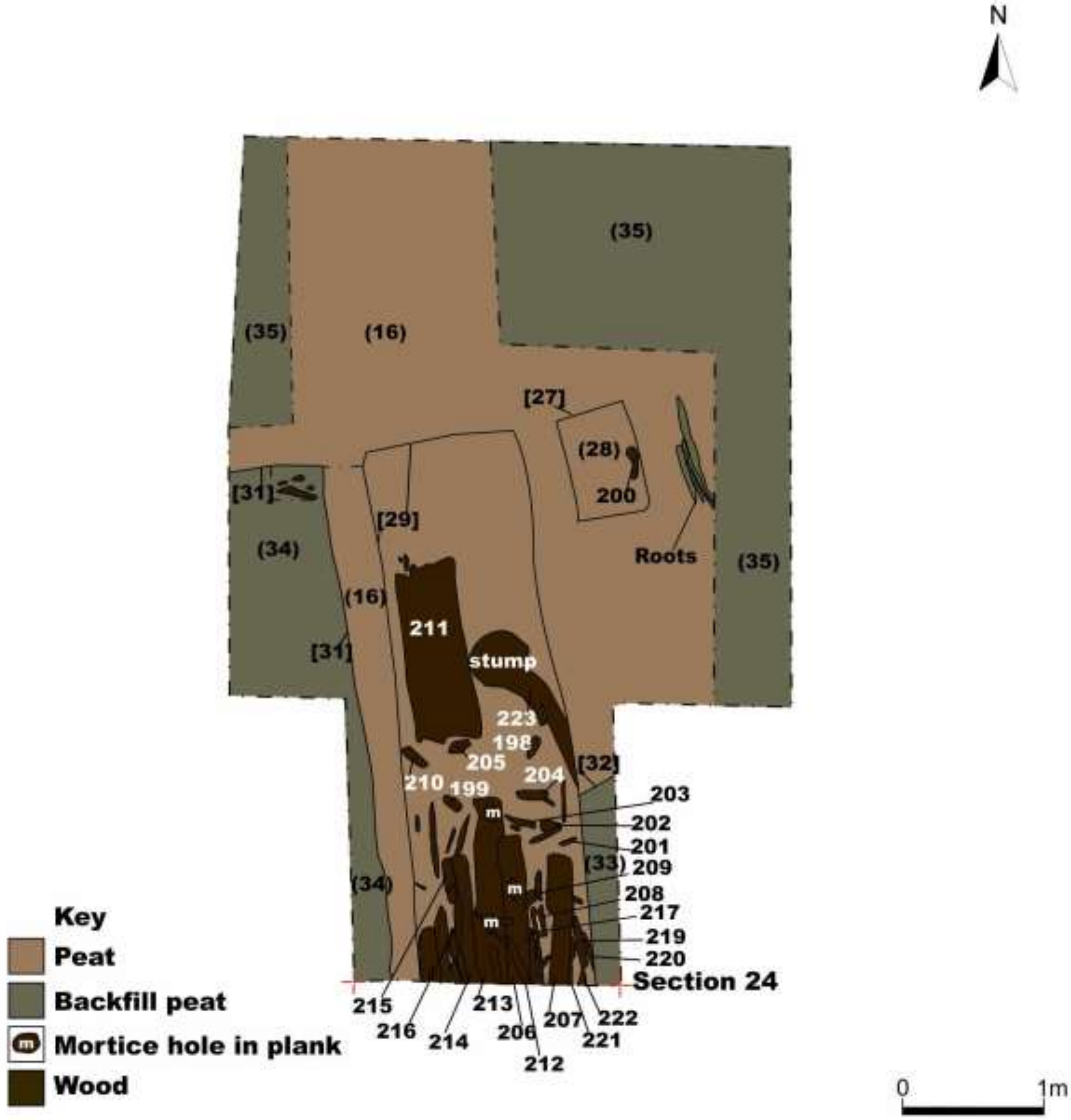

Figure 21 Plan of trench 3

Two larger trenches ran parallel to 27, aligned NNW to SSE, all three of them sharing a common line to their northern ends. Between the three trenches were baulks of undisturbed peat roughly 20cm wide. This suggests that the reburial trenches were regularly laid out and that the excavation may have encountered the northern side of the reburial area.

Trench 31 was at least 3.7m long and 0.62m wide and 22cm deep. It was filled with a yellow clay with orange mottles (31). Trench 29 was at least 4.2m long and was 1.14m wide. It was very shallow, being only c.12cm deep. On its south-eastern side it cuts another cut feature

[32] that was filled with a mixed fill of redeposited peat with patches of yellow clay with orange flecks (33). That feature was not excavated but may represent another reburial pit.

The ground surface undulated in the area of the trench between 4.17 and 4.34mOD. The undisturbed peat beneath the Bulleid and Gray excavation was between 3.82 and 3.83mOD. The bottom of the reburial trenches were at 3.66mOD [31], 3.65mOD [27] and 3.67-3.70mOD [29]. The reburied wood in trench 29 was between 3.67m and 3.79mOD.

4.3.2 The reburied wood

Trench 31 contained only a few small scraps of very decayed material at its north-western end within the backfill. The remainder of trench 31 contained no wooden material under the backfill. Comparison with the adjoining trench 31 suggests that this should not be taken as indicating a lack of timbers in the unexcavated remainder of the trench.

Trench 27 contained only one small piece of poplar or willow (200). This was poorly preserved but appeared to be part of a root based on its morphology.

In contrast to the other trenches, cut 31 contained a large quantity of redeposited timber in addition to a small poplar or willow root (223). The northern part of the trench contained a large oak timber (216) laid beside an *in situ* tree stump. The southern half of the trench was full of large and small timbers aligned along the long axis of the trench. Near the southern baulk they were up to three layers deep. Smaller fragments of wood were scattered in a seemingly random order just beyond the northern end of these timbers. The timbers were quite thin and had suffered from vertical compression and some decay. These timbers and woodchips are discussed in the woodworking section below.

Figure 22 trench 3 viewed from the south. Scales 1m

Examination of the Bulleid and Gray wood reports failed to find timbers whose measurements and descriptions matched the reburied ones in Trench 3. However, examination of the published plans enabled a match for two of the timbers - 206 and 213, based on their size and the location of mortice holes in the timbers. Timber 206 matches the dimensions of one from Mound 6 on the east side of the substructure (Plan plate 12) and timber 213 matches a timber recorded in the Mound 57 substructure (Plan Plate 29). Both these timbers were from the 1896 excavation season which could explain how they ended up being reburied directly on top of one another.

Figure 23 Reburied timbers at the southern end of the trench. Scales 1m

The reburial of the waterlogged wood did manage to preserve the timbers for over a century (see section 7). This action by Bulleid and Gray may represent the only deliberate reburial of waterlogged wood that is known to have been successful after 118 years.

4.4 Trench 4: Mound 9

This trench was positioned to catch the western edge of the roundhouses of mound 9 where the entranceway was located. It was 3m N-S by 4m E-W. Mound 9 was excavated by Bulleid in 1896 along with three and a half other mounds. Mound 9 was the most prominent on the site, with a series of nine superimposed clay floors forming deposits 1.8m thick at the centre. The upper seven floors were of yellow clay and the lowest two of blue clay. The floors were not perfectly round, but were instead slightly pear shaped, with the elongation towards the western edge where an entranceway was recorded (Bulleid and Gray 1911 plate XII opp. p.76). The largest floors were the last two which measured 8.84m by 10.97m.

Each floor was associated with a series of central hearths. The lowest of the two hearths associated with floor 4 was decorated with a series of circle impressions. That hearth and all the ones underneath it, were left in place and that column of *in situ* material was exposed in later years for groups visiting the excavations. The edges of the floors were 'well defined', especially floors 4, 5 and 6. Bulleid recorded that *'along their margins, and more*

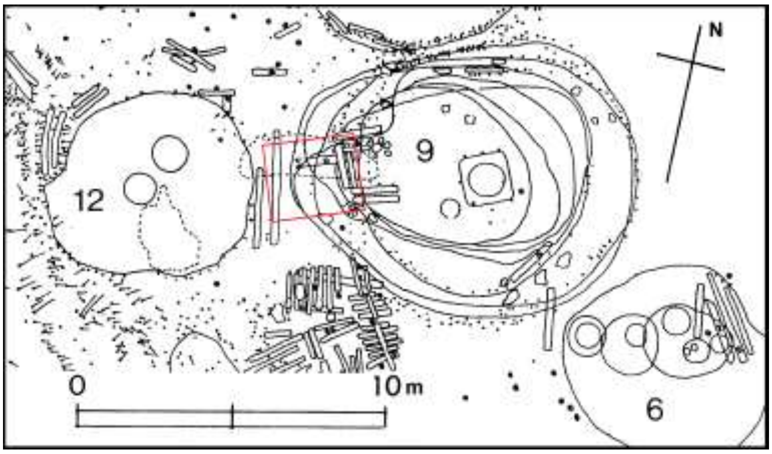

Figure 24 Trench 4 (red) superimposed on Bulleid's plan as redrawn by Coles and Minnitt

especially on the s. side, a layer of fire-ash, brushwood, and bracken fern was found, resembling the "bedding-layer" in the foundations under Mound LXII' (Bulleid and Gray 1911, 79-80). Various objects, including a bill-hook, ladle and basket fragment were found on the southern side among this material. The wall posts of floors 1, 3 and 8 'were distinctly seen' but the lines of the others were 'incomplete or wanting' (ibid p.80).

The earliest two floors were associated with a complex timber doorway on the western side of the mound (Bulleid and Gray 1911 plate XII opp. p.76). This comprised two groups of E-W orientated horizontal timbers, roughly 1.5m apart, with some planks underneath at right angles. A rubble stone pathway connected Mound 12 to the edge of floor 8 of mound 9 through this entranceway.

In the centre of the mound the substructure was recorded as being c.90cm thick, composed of 30cm of brushwood and 60cm of peat. The latter '*was an artificially arranged layer, restricted to the area enclosed by the inner line of wall posts, and distinctly recognizable from the naturally-formed beds of peat lying below it'* (Bulleid and Gray 1911, 80). On the western side of the mound the substructure was recorded as composed of brushwood and the planks of the entranceway.

Coles and Minnitt attribute floors 8 and 9 to their middle phase, floors 7-4 to their late phase and floors 3-1 to their final phase of occupation of the settlement (1996, 83-5). To the north and south of the western entranceway were a pair of features composed of oak piles and planks. These did not have recorded floor levels but may represent earlier activity in the area.

The ground surface undulated in the area of the trench, between 4.47m OD and 4.71m OD. Bulleid's excavation generally ceased between 3.60-3.74m OD although there were deeper areas. The tops of the in situ wall posts were mainly between 3.74-3.80m OD and the top of the flooring 3.70-3.75m OD.

4.4.1 The 1896 excavations and backfill

The backfill from the original excavations was removed in planar fashion across the trench irrespective of the variations that were clearly evident (contexts 20-22). It was assumed that the whole area had been exposed in one open area in 1896 when mounds 9, 10, 11, 12 and part of 13 were all excavated. Various tip lines of peat and yellow and grey clay backfill material were evident, especially those radiating out from the north-western corner of the

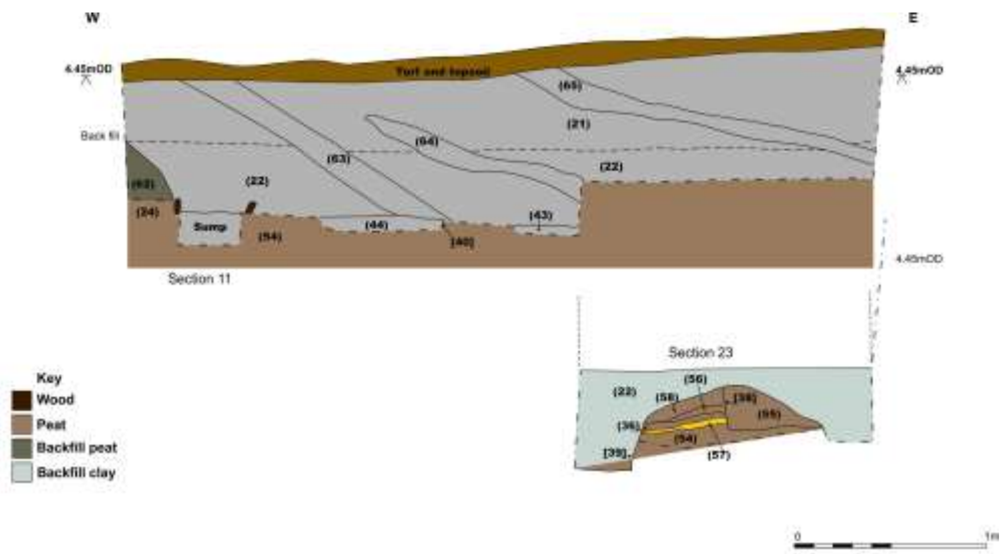

Figure 25 Sections 11 and 23

trench, but no attempt to record them in detail was made as it was beyond the scope of the project (sections 11 and 13 figures 25 and 27).

There were some slight differences between the southern and northern half of the backfill, which may reflect the backfilling material being derived from two spoil heaps. The presence of a 10-20cm deep east-west step at the base of the Bulleid excavation and the observable difference of the lower deposits of backfill on either side of that step, suggest that some backfill material had been deposited in the area to the south before the northern half of the trench was fully excavated.

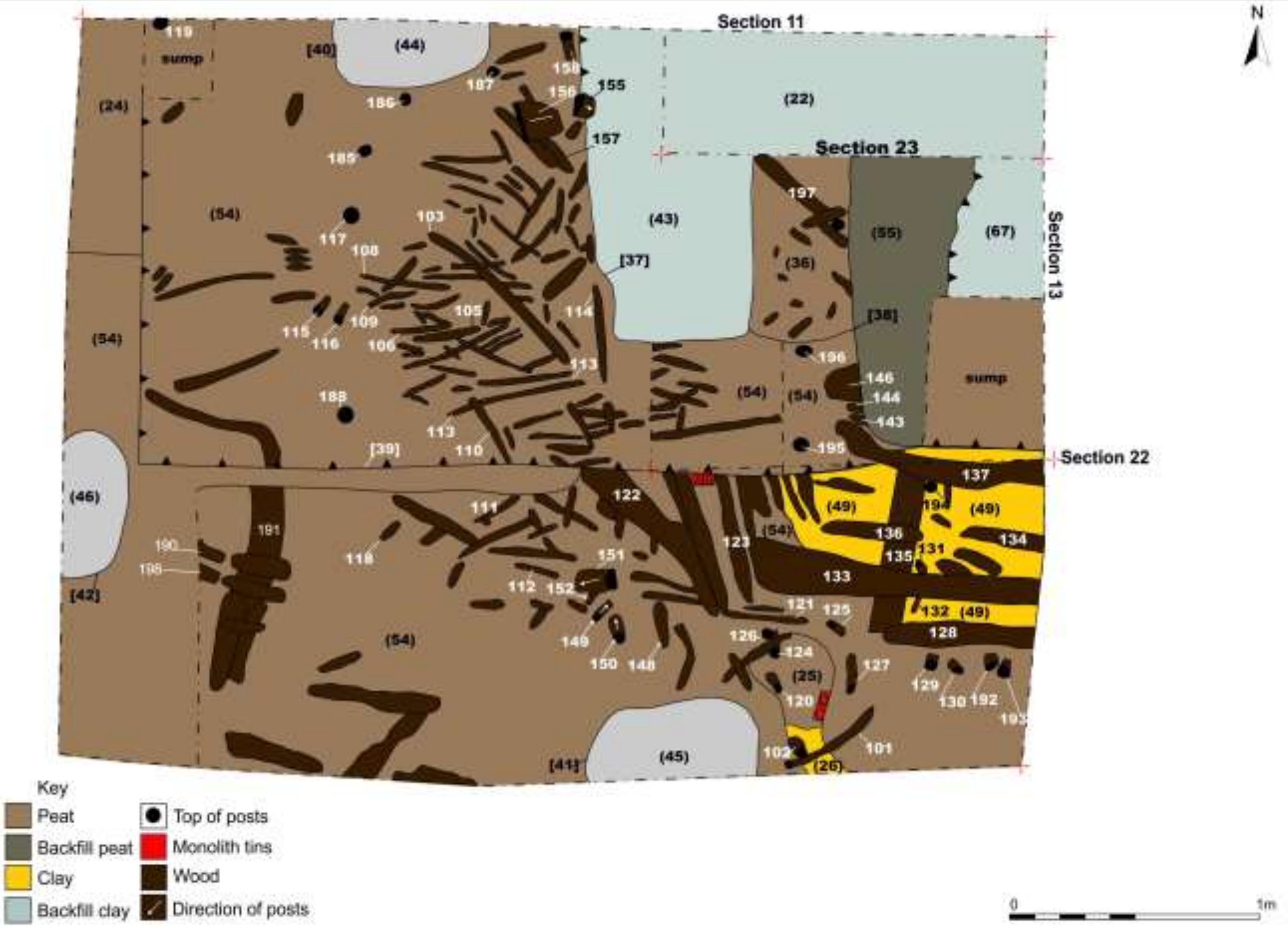

Figure 26 Plan of Trench 4

The deeper excavation in the northern half seems to have been focused on the complex doorway structure recorded in the mound. This was substantially removed in the northern area along with its associated flooring and the pathway of small stones that joined it to mound 12 to the west. The edge of the deeper excavation [39] may correlate with the southern boundary of the excavated stone spread. On the inside of the doorway the foundation material had also been removed by two deep parallel trenches, [37] and [38], in the northern side of the excavated area. Trench [37] was 60cm wide and at least 1.2m long, disappearing into the northern baulk. Trench [38] was at least as long and was over 70cm wide, its edges on two sides extending beyond Trench 4 limits. The depth of [37] is unknown but [38] was 20cm deep (section 13 figure 27).

Amongst the curving western line of wall posts (Gp. 13) there was a softwood marker stick (115), 280mm long, by 21mm by 25mm. This is the type of marker that can be seen showing the position of wall posts on some of the excavation photos. This one was obviously not retrieved before the backfilling.

Further to the west a 60cm wide cut [40] was present against the northern baulk, extending 30cm into the excavated area and filled with a dirty grey clay (44). This may have been an isolated pit or another narrow excavation trench similar to [37].

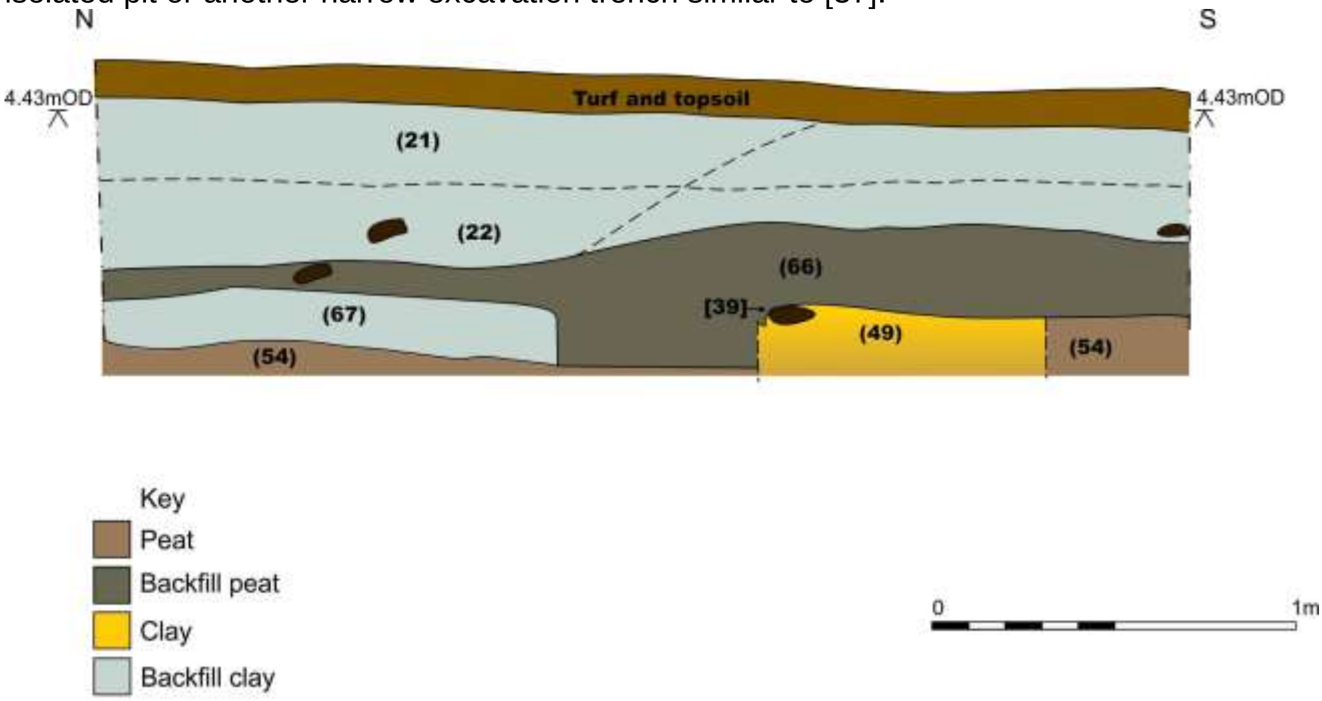

Figure 27 Section 13

It is uncertain what happened further into the mound. The published section (Bulleid and Gray 1911, fig.17 p.80) ran north south, a short distance back from the doorway into the interior of the mound, and westwards of the central hearth which was left *in situ*. The deeper excavation in this area probably represents Bulleid's attempts to fully understand the complex doorway structure and the substructure of the mound.

In the southern half of the trench, Bulleid's excavation had been carried below the lowest floor of the mound. It was especially deep in the south-eastern corner of the trench and in two isolated pits on the southern [41] and western [42] baulks of the 2014 trench. The cuts were filled with blue grey clay backfill, but neither were excavated to their base. The southern hole [41] was at least 20cm deep and was 60cm wide and lay directly to the south of trench [37]. This suggests that it might be the end of a longer north-south orientated trench running off to the south. The western hole [42] was also 60cm wide, which suggest the possibility that it is the end of another narrow trench running westwards towards Mound 12.

4.4.2 *In situ* Iron Age remains

The *in situ* archaeological features in this trench consisted of foundation material, the walls and floors of buildings and an occupation layer outside the building. The lowest layers were only seen in one smaller place (sample Area 1) next to the central section where paleoenvironmental samples (Tina A and B) were extracted to attempt to elucidate the character of the area before the first roundhouse was created. The 20cm deep sample column from this area was divided into two units either side of an intermittent layer of brushwood at 9-10 cm depth (see section 4.5).

<u>*In situ* peat</u>

The lowest organic deposit in Area 1 was an anthropogenically disturbed peat (see 4.5.3), of at least 10cm depth. Radiocarbon dating shows that it formed over several hundred years prior to the establishment of the lake village (see 4.5).

Mound 9 foundations (Gp 12, contexts 36 and 54)
The brushwood layer (Group 12) seen in the Area 1 sample column and on plan 26 is thought to be a component of the foundations that underlies the whole mound. It dips down to the east towards the centre of the mound, as depicted by Bulleid in his section drawing. The western fringe of the brushwood foundation was visible as an arch of material in the northern half of the trench where Bulleid's excavation had uncovered it (wood 103, 105-114, 121-123).


Figure 28 Trench 4 looking west. The deeper excavations by Bulleid and Gray in the northern half of the trench are apparent. Flags mark wall posts. Scales 1m

Only five wood samples could be identified to species, because of the compressed and degraded condition of the material. They were a mixture of alder and willow or poplar. The diameters of the brushwood varied between 8mm and 30mm, with an average of 21mm, although because of compression they appeared wider and flatter than that. No clear facets were observed on the ends during the excavation, although the brushwood was not lifted or carefully examined.

In the southern half of the trench Bulleid's excavation had stopped at a slightly higher level, so it is likely that the brushwood was never fully exposed in the original excavation. The peat (54) above the brushwood is thought to be redeposited from a nearby source as part of the foundations. This is discussed further in the section on palaeoenvironmental analysis below. Where the brushwood ends to the west it is unclear if the continuing peat (still context 54) more closely resembles the peat below or above the brushwood.

In one small area (75cm N-S by 40cm E-W) of the foundations is a dense patch of woodchips (36) truncated on the east and west sides by Bulleid's excavation trenches [38] and [38] and its northwards continuation extending under Bulleid's clay backfill (22) (section 23). On its southern side the woodchips peter out, giving way to a peat (54) with some east-west orientated timbers (144, 143 and unnumbered timber) that appear to be a lower foundation of the 'floor' timbers in context 49 (below). The woodchip layer extends either side of a row of three posts (195, 196 and 197) and appears to be lower than the early floor (49) to the south. It is therefore interpreted as part of the initial mound foundations. A total of 74 woodchips were recovered from the small area of context 36 that survived in Trench 4. They have all been identified as alder or willow/poplar. Their form and species composition are consistent with material produced during the preparation of wood for the construction of the first building on the mound. This is discussed further in the woodworking section.

Figure 29 Dense woodchip layer, context 36, surviving on a baulk of peat left in situ by Bulleid between deeper excavations. Scales 1m and 40cm

Early buildings and floors on Mound 9

Although Bulleid's excavation had removed virtually all the clay floor deposits, the bottoms of numerous small posts still survived *in situ*. Some of these formed distinct curving lines running around the mound and comparison with the wall posts recorded in Trench 2 suggests that they probably represent the sequential walls of the buildings erected on the mound.

Some of the deeper pits created during the original excavations must have removed wall posts and it is impossible to know how many posts had been completely excavated. The shallow depth of the posts suggests that it would have been easy to remove the posts. Bulleid recorded that there was not always a complete ring of wall posts to accompany each floor. Again, it is impossible to know how many of the slender posts were destroyed without record during Bulleid's rapid excavations. The presence of several posts in Area 2 that Bulleid could not have seen, suggests that many posts may have gone unrecorded.

With the sole exception of one post (101) there is no surviving stratigraphic relationship between the upright posts and the horizontally laid floors of the mound. It is however possible to attempt to match the observed lines of posts with the ones recorded by Bulleid. In most cases the lines of posts follow the perimeters of the sequentially laid floors in that mound. Using that information, it is therefore possible to assign posts to differing phases of build and rebuild on the mound. It is on this basis that Bayesian analysis has been applied to the dating of the wall posts in this trench.

Figure 30 Early clay and wood floor revealed in Bulleid's section. Two roundhouse wall posts are visible to the right. Scales 1m and 40cm

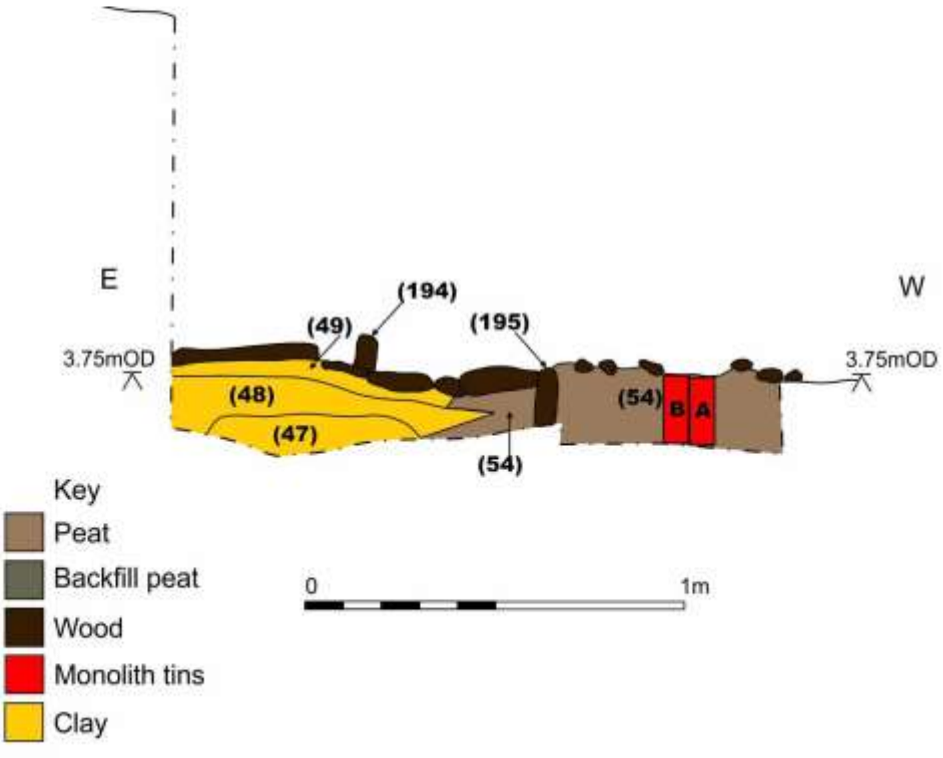

Figure 31 Section 22, showing the early floor levels and the position of the environmental sampling tins

In the southern half of the trench, a cluster of horizontal timbers (Gp 11. 128, 133-37) set within a thick clay deposit (49). The timbers were recorded in plan and the underlying clay in section (figures 30 and 31). The clay thickened as it dipped eastwards towards the centre of the mound. This probably represents the earliest floor created on the mound, as there is no trace of any previous flooring below it. It is probably a remnant of the timber structure in the doorway that Bullied recorded in association with the earliest floors (8 and 9). Of the nine samples that could be identified to species, seven were alder, one willow/poplar and one either alder or birch. The logs were all whole roundwood in a poor state of preservation and suffering from significant compression. Their original diameters probably ranged from 38mm to 120mm, with an average of 75mm.

On either side of the doorway structure Bulleid had recorded a small cluster of split timber and roundwood. These may be represented by structural groups 15 (155-157) and 16 (148-152). The northern cluster (Gp.15) was composed of three short pieces of split oak there were probably once vertically set, but were now at an angle of 60°, sloping downwards towards the NE. Timber 157 was little more than a big tangential woodchip, 154mm long, 51mm wide and 15mm thick. At its upper end it was little more than bark so could not have been a longer timber. Timber 156 was a half log 190mm long, 120mm wide and 34mm thick, with a broken bottom end and very decayed top. The third timber (155) was radially split, 152mm long, 95mm wide and 26mm thick. At its upper end the top was bent over, which may have happened during a rebuilding phase after it no longer served a useful function. None of the oak had more than 25 years of annual rings.

The southern cluster (Gp. 16) consisted of three roundwood stakes (149, 150 and 152) and two pieces of split oak. The split oak was only shallowly set beneath the backfill, inclined downwards to the east. They were 178mm and 220mm long, widths of 130mm and 120mm and thicknesses of 55mm and 44mm. Two of the roundwood stakes (149 and 150) were willow or poplar and the third was alder or hazel. They survived to lengths of 250mm to 410mm and had diameters of 34mm, 58mm and 21mm.

Near the south-east corner of the trench another very small pocket of *in situ* flooring had survived (figure 32). This was sampled for paleoenvironmental evidence as Area 2 (see below). It contained a basal peat overlain by a clay unit (context 26) which, in turn, was overlain by an upper layer of woodchips in a peaty matrix (context 25).

Figure 32 Wall posts (red arrows) associated with roundhouse floor (26) being sampled with kubinea tins. Later wall posts (green arrows), one of which (left) has collapsed over the floor. Scale 30cm

Micromorphological analysis (see section 4.5 below for fuller details) has further clarified the sequence of deposits. The lower peat (Unit 7) probably represents the same redeposited peat used in the initial mound foundations as Unit 1 in Area 1, which is less than a metre away. Overlying that peat was a trampled surface (Unit 6) possibly representing the creation of a floor. Over this surface were a series of embedded microlaminations of silt loam, silty clay loam and sandy silty loam (Unit 5), interpreted as a trampled occupation surface.

The occupation surface was covered by a well sorted loam (Unit 4/Context 26) with no microlaminations or anthropogenic inclusions, suggesting a floor surface deliberately laid in one event. Diatom analysis of the clay floor reveals a freshwater source for this deliberately laid clay surface, suggesting the clay was sourced from a shallow lake or floodplain setting.

Above the unit 4 floor and the associated posts (see next section), was an anthropogenic peat (Unit 3/Context 25) containing large amounts of bark, leaves, seeds, twigs and wood (some charred), phytoliths and herbivore dung. Microlaminations show formation through the accumulation of organic material and sediment. This is thought to represent an occupation layer. A dense layer of woodchips was excavated at the top of this context. This may represent the residue of woodworking within the roundhouse or a more deliberate attempt to provide a firm dry floor.

Early wall lines (Gp14)

The Unit 4/Context 26 floor appeared to respect a line of small posts (102, 120, 124, 126) to the west, suggesting that they may represent a contemporary wall line. Another line of wall posts existed to the east (125, 127, 101), one of which (101) had been pushed over onto the top of Unit 4/Context 26. This probably represents a rebuilt wall line. This sequence of deposits and posts may be associated with the earliest floors 8 and 9.

Wall posts possibly associated with floors 5, 6 and 7 exist south of the earlier entranceway and running across its inner face (129-131 and 192-196). Two other probable wall posts (153 and 154) could not be definitively assigned to either group. As the lines of posts were quite fragmentary it is difficult to assign a typical spacing between posts. Some seem to have been spaced about 250-300mm apart, similar to the spacing in Group13, but others appear to be more closely set, for example the line of four posts (193, 192, 130 and 129) extending westwards from the eastern edge of the trench. Because the original excavations removed the overlying stratigraphy it is unknown if this proximity is because they represent posts from sequential post lines. This would be entirely possible in this area, judging from the wall lines planned by Bullied.

The species composition consisted of 12 willow/poplar and single examples of alder, birch/alder and cherry/blackthorn. Their surviving lengths varied from 43mm to 462mm (average 266) and diameters of 29-56mm (average 41mm). Many of the stakes were angled downwards to the north at angles of 75° to vertical. Four stakes were inclined at shallower angles, 197 at 30° to the north-west, 127 at 45° to the north and 101 at 45° to ENE with the top part completely flattened. Stake 102 was inclined at 30°to the north and its top 64mm had been flattened on one side where it had been squashed against a large flat timber. There was some trace of buckling at the top. One probable wall stake (132) was compressed under horizontal timber 133. Its ends were broken, and it is possible that its cut end was not retrieved. It had a distinct semi-circular impression on one side as though it had been squashed against a roundwood of 24mm diameter at right angles to it.

Later buildings on Mound 9

Further west, beyond the earlier walls and floors is another line of posts (Gp. 13: 116-118, 158, and 185-188) all of which were willow/poplar. These probably represent the walls associated with one of the last floors (1 and 2) that extended out into this area. The surviving lengths varied between 235mm and 430mm (average 326) and diameters of 31-48mm (average 40mm). The posts were spaced roughly 250-300mm apart.

<u>Occupation layer west of Mound 9</u>
In the north-west corner of Trench 4 a small (1m N-S by 30cm E-W) area of occupation deposit survived the Bulleid excavation (context 24). This consisted of a peaty matrix containing animal bone, pottery, charcoal and charred grain (see 4.5 below for fuller details).

In the remainder of the trench west of the mound 9 deposits Bulleid seems to have excavated below any other occupation deposits onto the underlying peat (54). Pieces of poorly preserved unworked wood (Gp 18) were present where the Bulleid excavation ended, one of which (191) may represent the southern half of a large N-S orientated timber planned by Bulleid. Towards the north-west edge of the trench was an isolated post (119 – Gp. 17) which may equate to one planned by Bulleid in that location. It was an 8 year old stem of willow or poplar, 35mm in diameter, that was inclined down towards the south-west at an angle of c.45°.

4.5 Trench 4: Palaeoenvironmental analysis *Tom Hill, Geoff Hill, Rowena Banerjea, Ralph Fyfe, Julie Jones, Marta Perez and David Smith*

The detailed results of the individual specialist reports are published as an article (Hill et al 2018, Appendix B) where the methods of analysis (Appendix A) appeared as supplementary information. The summary below incorporates the combined conclusions of the different specialists.

4.5.1 Previous palaeoenvironmental work

Bulleid made useful observations on the environmental remains on the site and had the significant benefit of being able to view the deposits across the whole of the excavated area. He recorded that the village had been built on an area of wet woodland shown by the presence of numerous tree stumps and the presence of a leafy peat, readily distinguished from a rushy peat outside the village perimeter. The leafy peat contained numerous woodchips and 'became less marked as a layer the nearer the Village margin was approached' (Bulleid and Gray 1911, 47). 'The superficial layers near the palisades consisted of a heterogeneous mass of vegetable debris, containing bones, pottery, and other evidence of human occupation: the quantity varying according to the particular area under examination, and diminishing in direct proportion to the distance at which the peat was explored from the palisading' (Ibid 47). Fragments of pottery were found 18m from the palisades and sling shots even further out. Fresh water shells and river-weed were plentiful

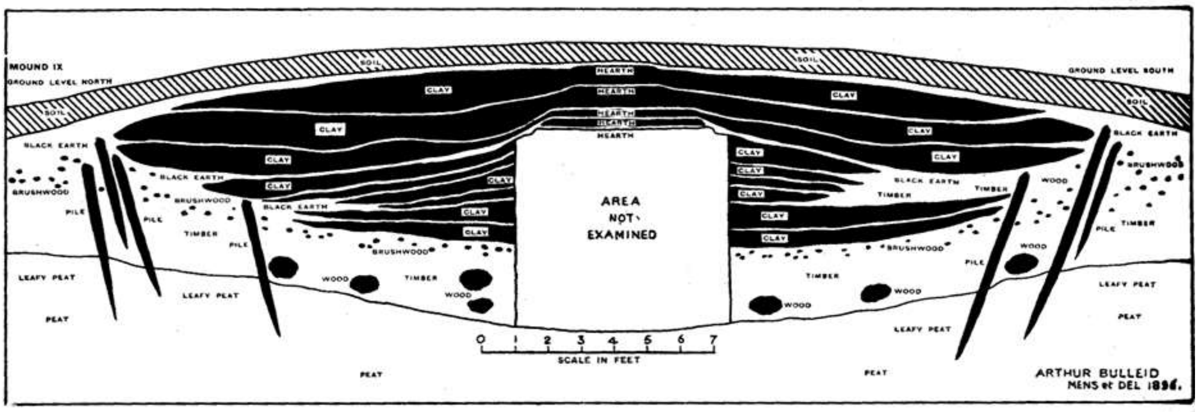

Figure 33 Bulleid's section through Mound 9. The section runs N-S, whereas this study's section ran broadly E-W. The weight of the mound has caused compaction, which has resulted in the top of the 'leafy peat' layer being lowered. It would originally have been level.

on the east side of the village and decreased towards the west, while fresh water mussels and water-lily roots were common on the east and north-east sides. The palisading was also less strong on the western side.

There have been several palaeoenvironmental investigations of the area of the settlement (Housley 1988, 1995; Aalbersberg, 1999; Housley *et al* 2000, 2007; Brown 2006; Aalbersberg and Brown, 2011), but the peat underneath the village has only been studied once, from an undated core extracted through Mound 5 (Figure 1) by Godwin (1955). His interpretation supported Bulleid's observations, concluding that the village had been built on a 'floating fen carr' with open water beside it, although Housley (1995) suggests that at least the initial 600mm of sediment in Godwin's column was disturbed backfill associated with original excavations at the site.

The most recent, well dated, reassessment (Tinsley and Jones 2013) was from outside the southern palisade (figure 6), roughly 40m south of Mound 9. That sequence showed evidence for the presence of an alder-willow-birch fen wood in the late Bronze Age and early Iron Age (from OxA-16233 and OxA-16234 weighted mean 2865+/-21 BP, 1125-940 cal BC Brunning, 2013; fig. 168) with a rich swamp community of reeds and sedge. In the later Iron Age (OxA-16237 and OxA-16238 weighted mean 2118+/-21 BP, 200-50 cal BC, Brunning, 2013; fig. 168) an organic mud formed, representing deeper water conditions and a decline in willow pollen is suggested as representing the clearance of the trees for the creation of the settlement. The presence of worked wood and sling shots in the early Iron Age peat deposits was taken as evidence that they had sunk down into the soft peat from higher levels.

Wider landscape studies highlighted the diversity of wetland habitats in the first millennium BC, with raised bog to the west, estuarine conditions to the north and around the settlement shallow open water with extensive reedswamp, sedge fen and fen carr, cut through by deeper water channels (Housely 1998, 1995, Housley et al 2000, 2007). The early medieval course of the River Brue runs along the eastern edge of the field containing the settlement, its course downstream surviving as a roddon. Analysis of that roddon has shown that it represents a large tidal channel in the late Iron Age (Aalbersberg 1999, Aalbersberg and Brown 2011).

4.5.2 Sampling

Palaeoenvironmental samples were taken from three areas in Trench 4 (Areas 1-3). In Area 1 duplicate monolith tins (A and B, top at 3.71 m OD) and a series of bulk samples were taken from the peat underlying wooden flooring material between 3.71 and 3.69m OD (figures 26 and 31). The monolith tins were used for pollen, non-pollen palynomorph (NPP), micromorphological and diatom analyses, while the bulk samples were used for Coleopteran and plant macrofossil analyses.

Radiocarbon determinations were obtained from six bulk peat samples (c.300g; radiometric measurements) from the area immediately north of the monolith tins and two samples of bulked waterlogged plant macrofossils (AMS measurements) from Tin B. At the time of sampling it was thought to represent *in situ* peat deposits, but a layer of small brushwood was encountered at a depth of 10cm in the 20cm deep sample column, dipping slightly towards the east. That orientation is consistent with other brushwood foundation material recorded nearby at a slightly higher height, which suggests that the samples above, and possibly also below, that brushwood may represent redeposited peat used in forming the foundation of mound 9. The inability to form a scientific dating chronology for the sample column and the presence of synanthropic species in the samples also suggested that redeposited material might be present. For this reason, micro-morphology was undertaken on the sample column, together with analysis of insect remains, pollen and non-pollen palynomorphs.

Table 2 radiocarbon results for palaeoenvironmental sample column trench 4

Laboratory number	Sample reference	Material & context	$\delta^{13}C$ (‰)	Radiocarbon Age (BP)	Calibrated Date (95% confidence)
Wk-41234	10–20 mm	Peat, humic fraction from 10–20 mm at the western side of Mound 9	−29.1 ± 0.2	2216 ± 23	
Wk-41229	10–20 mm	Peat, humin fraction from 10–20 mm at the western side of Mound 9	−28.5 ± 0.2	2193 ± 23	
Weighted mean	10–20 mm	$T' = 0.5$; $T'(5\%) = 3.8$; $\nu = 1$		2205 ± 17	365–195 cal BC
Wk-41235	40–50 mm	Peat, humic fraction from 40–50 mm at the western side of Mound 9	−30.8 ± 0.2	2392 ± 29	
Wk-41230	40–50 mm	Peat, humin fraction from 40–50 mm at the western side of Mound 9	−30.1 ± 0.2	2401 ± 24	
Weighted mean	40–50 mm	$T' = 0.1$; $T'(5\%) = 3.8$; $\nu = 1$		2397 ± 19	540–400 cal BC
UBA-28844	40–50 mm	Waterlogged plant remains, Cladium mariscus nutlets x2, Hydrocotyle vulgaris x 3 (J Jones) from 40 to 50 mm at the western side of Mound 9	–	2133 ± 29	350–50 cal BC
Wk-41236	80–90 mm	Peat, humic fraction from 80 to 90 mm at the western side of Mound 9	−31.5 ± 0.2	2332 ± 21	
Wk-41231	80–90 mm	Peat, humin fraction from 80 to 90 mm at the western side of Mound 9	−29.7 ± 0.2	2413 ± 24	
Weighted mean	80–90 mm	$T' = 6.5$; $T'(5\%) = 3.8$; $\nu = 1$		2367 ± 16	415–395 cal BC
Wk-41237	120–130 mm	Peat, humic fraction from 120 to 130 mm at the western side of Mound 9	−30.8 ± 0.2	2216 ± 29	
Wk-41232	120–130 mm	Peat, humin fraction from 120 to 130 mm at the western side of Mound 9	−28.0 ± 0.2	2260 ± 33	
Weighted mean	120–130 mm	$T' = 1.0$; $T'(5\%) = 3.8$; $\nu = 1$		2235 ± 22	385–200 cal BC
UBA-28845	120–130 mm	Waterlogged plant remains, Solanum dulcamara x 1, Eleocharis palustris/ uniglumis x 1 + 3 halves, Ranunculus lingua x 1, Potentilla anserina ½, Stellaria media x 1, Carex x 1, Urtica dioica x 5, Rubus Glandulosus 1 fragment (J Jones) from 120–130 mm at the western side of Mound 9		2211 ± 35	390–170 cal BC
Wk-41238	160–170 mm	Peat, humic fraction from 160 to 170 mm at the western side of Mound 9	−29.1 ± 0.2	2297 ± 26	
Wk-41233	160–170 mm	Peat, humin fraction from 160 to 170 mm at the western side of Mound 9	−29.3 ± 0.2	2268 ± 31	
Weighted mean	160–170 mm	$T' = 0.5$; $T'(5\%) = 3.8$; $\nu = 1$		2285 ± 20	400–260 cal BC

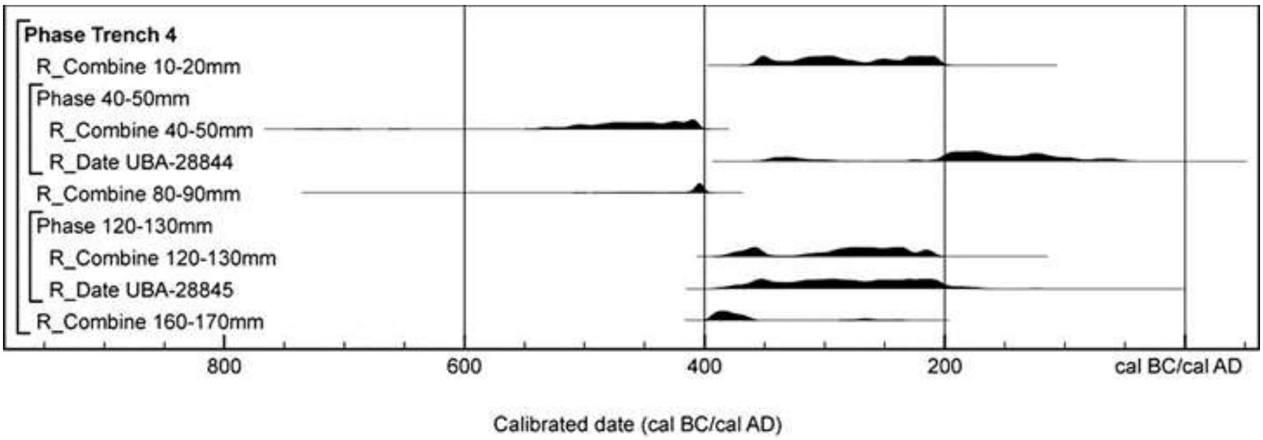

Figure 34 Probability distributions of dates from Glastonbury Lake Village – Area 1, Trench 4. The distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

Depth (mm)	Stratigraphy & Micromorphology	Beetles	Pollen	NPP	Plant Macro	Diatom
00–10 *10–20 20–30 30–40 *40–50 50–60 60–70	Natural peat 90% organic matter. Vughy and spongy microstructure. Organic matter aligned linear and parallel orientated to basal boundary forming microlaminations 'Unit 1' Fig. 7	Aquatics + Wetland taxa avg. 55% MNI S.V. avg. 59 Foul Material taxa avg. 46% tMNI Dung taxa avg. 7% tMNI Woodland taxa avg. 8% tMNI	Cyperaceae 10–15% Alnus up to 18% C. avellana type up to 25%, Salix c. 5% Charcoal in abundance	Contains evidence of dung/human disturbance (55A, 113) and 30% of settlement indicator Chaetomium (Type 7A) towards top of profile	50% assoc. with waste/ disturbed ground. Pale persicaria at 38%. Woody fragments abundant Aquatic and bankside/marsh species dominate (c. 90%). 10% disturbed ground.	Freshwater benthic epiphytes dominate (>90% TDV). Most species pH > 7. Typified by an abundance of Epithemia sp. Eunotia sp. and Synedra sp., Cocconeis placentula
70–80 *80–90 90–100			Cyperaceae 40%, Alnus & C. avellana type c. 10%	Type 729 (27.5%), Type 12 (16%), Type 10 (12%)	Aquatic and bankside/marsh taxa dominate, Disturbed ground species at 4% + less woody fragments than in uppermost samples	As 00–10 mm
100–110	Brushwood layer					
110–120 *120–130 130–140 140–150 150–160 *160–170 170–180 180–190 190–200	Anthropogenic peat High organic content, similar to natural peat but organic settlement materials accumulated rapidly in high groundwater table. Anthropogenic residues include large fragments of angular charred wood, bone and herbivore coprolites. Aligned linear and parallel, strongly orientated to basal boundary forming microlaminations. 'Unit 2' Fig. 7	Aquatics + Wetland taxa avg. 65% MNI S.V. avg. 45 Foul Material taxa avg. 35% tMNI Dung taxa avg. 8% tMNI Woodland taxa avg. 6% tMNI	Cyperaceae 30–40% Alnus & C. avellana type c. 10% Salix 5–10%	Chlamydospores (Type 10 & 12) encountered throughout profile but most abundant towards the base. Found in the leaves of heathers (Calluna and Erica). Dung indicators Sordaria (Types 55A) and Type 206 also present	Aquatic and bankside/marsh taxa dominate (c. 85%). Occasional woody fragments Aquatic and bankside/marsh taxa dominate (c. 80%)	Sparse remains & poor preservation. Freshwater.

Table 3 Overview of palaeoecological changes in Area 1 (Tins A and B, bulk samples).

Samples were also obtained from the south-western corner of the trench (Area 2) where a small patch of *in situ* floor deposit had survived (figs. 26 and 32). The lowest deposit here was a peat overlain by a thin clay layer (context 26) which appeared to respect a line of small posts to the west. It was therefore interpreted on site as representing a floor surface inside a house. Another line of wall posts was present to the east, one of which had been pushed over onto the clay floor. This was thought to represent a rebuilt wall line. Overlying the collapsed post and the other posts was a wood rich peaty layer (25) that was interpreted as a deliberately laid floor.

Two kubiena tins (C & D) were taken vertically through contexts 25 and 26 and the underlying peat (figure 32). The top of tin C was 3.73mOD and the top of tin D at 3.72mOD. They were utilised for pollen, NPP and soil micromorphological analyses. Diatom analysis was also carried out on the clay layer (context 26).

From area 3 a bulk sample was taken from context 24, that was thought to represent the remnant of an undisturbed occupation layer equidistant between the entrances to Mound 9 and Mound 12. This context was slightly higher than the main sample column at 3.79-3.71m OD and was stratigraphically later than the deposits analysed there in Area 1.

4.5.3 Sample Area 1 results – below the roundhouse

The radiocarbon results (Table 2; Figure 34) are conventional radiocarbon ages (Stuiver and Polach 1977), and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). Four of the five sets of replicate measurements on the humic/humin of bulk peat samples are statistically consistent at 95% confidence (Table 2) with the other consistent at 99% confidence. These individual results are thus just out of line with statistical expectation but are statistically consistent enough to allow a weighted mean to be calculated to provide the best estimate for the age of peat formation in each case (Table 2).

Palaeoenvironmental proxy results are summarised in Table 3. A thin layer of small ‘brushwood’ was recorded in the trench and palaeoenvironmental analyses at a depth of approximately 80–100mm. Differences above and below the brushwood are noted in the pollen, coleopteran and micromorphology results, and (to a lesser extent) in the plant macrofossil evidence (Figs 35-37). In the pollen analysis (Fig. 35) the lower levels of the sequence are characterised by wet or waterlogged conditions, with abundant *Cyperaceae* (sedge) pollen and a range of herbs that can be associated with fen conditions, for example *Filipendula* (meadowsweet), *Galium* type (bedstraw) and *Hypericum* (St John’s Wort). The micromorphology assessment indicates that the peat towards the base of the sequence also accumulated in a high groundwater table (Fig. 36). In addition, the micromorphology revealed anthropogenic residues within the peat, including large fragments of angular charred wood, bone and herbivore coprolites (within Unit 2, Figure 36). A greater abundance of coleopteran taxa is encountered within the lower section, containing aquatic and wetland functional groups. The plant macrofossil assemblages reveal more taxa representative of marshland and aquatic plants below the brushwood layer when compared to those from above it.

Above the brushwood layer, a change in process of the peat accumulation and associated palaeohydrology is recorded in the micromorphology with a transition from a peat unit deposited under high water table to one under a lower regime. Interestingly, the micromorphology suggests the upper peat is ‘natural’ in origin (figure 36 Unit 1), in marked contrast to the underlying peat unit full of anthropogenic residues (Table 3). This is due to the vughy and spongey microstructure of the peat and the very high (>90%) organic matter content. Within the pollen assemblages Cyperaceae proportions decline and trees indicative of drier conditions, particularly *Corylus avellana* type (hazel) increase, notably towards the upper levels (Fig. 35). This may be indicative of a drying phase within the local environment. This trend is reflected in the Coleoptera, which are found in lower abundances and record a drop in aquatic and wetland taxa by c. 10% on average (Fig. 37). The sustained presence of Chlamydospores (Type 12) throughout the NPP profile is also noted, which are found in leaves of heathers (such as *Calluna* and *Erica* sp.) and suggest dry conditions, although they can also be found on the leaves of mosses such as *Aulacomnium palustre*. (Van Geel 1978, 45). Charred wood fragments are rare, but when present they are well rounded, which suggests the transportation of charred remains to the site from sources further afield. Plant macrofossil assemblages display an increase in frequency of woody fragments (woodchip, twigs and bark) and a significant increase in disturbed ground taxa (e.g. pale persicaria) in the uppermost deposits. Diatoms were most abundant in the uppermost sample (0–10mm) and were dominated by freshwater and benthic epiphytes (Table 3). Many of the diatom genera encountered, in particular *Gomphonema*, *Synedra* and *Eunotia*, contain species that are found to prefer depositional environments that remained flooded by groundwater for much of the year (Gaiser et al., 2001).

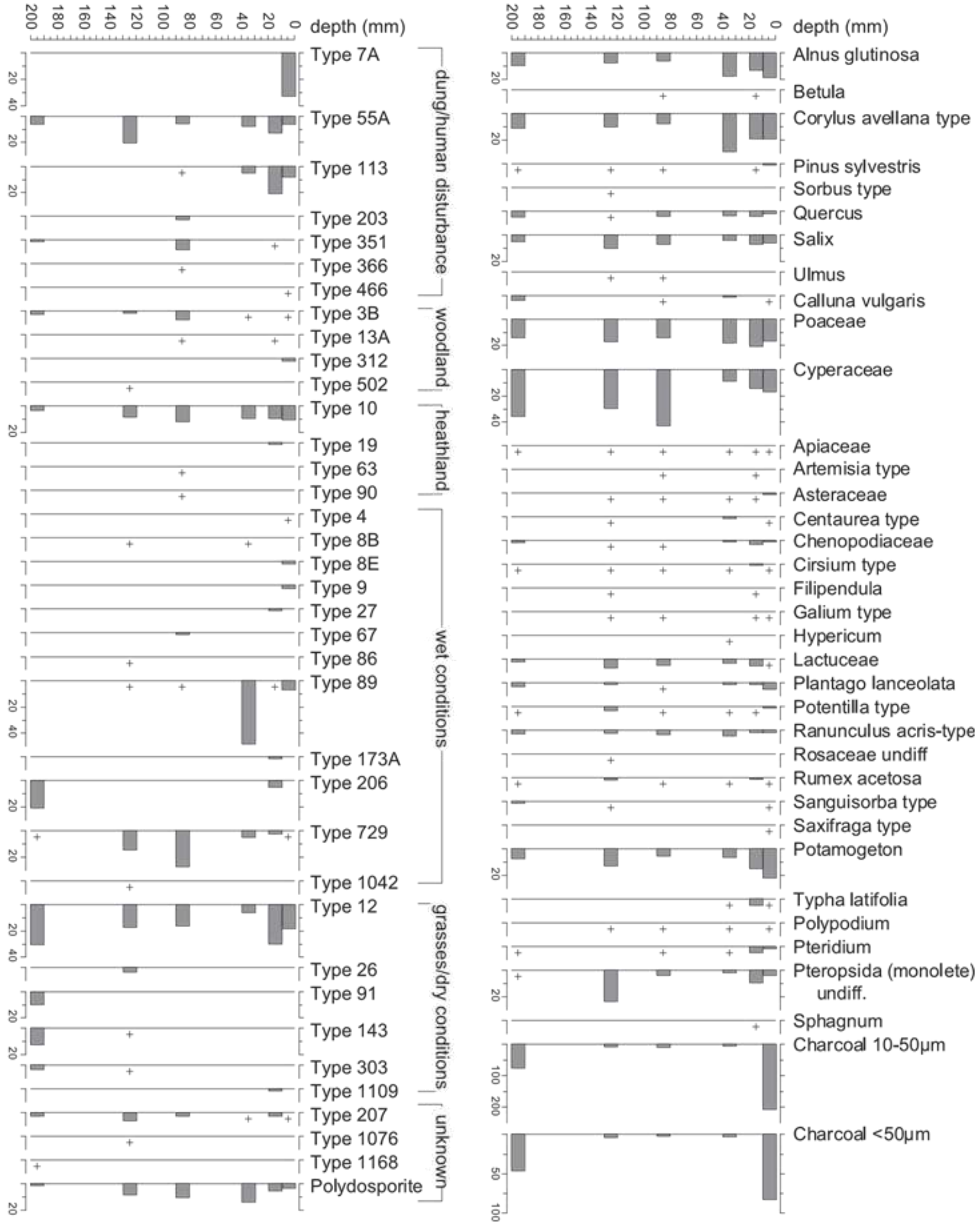

Figure 35 Results of pollen and charcoal (left) and non-pollen palynomorph (right) analysis from Monolith Tin A, Area1. The brushwood layer was at 80-100mm depth

4.5.4 Sample Area 2 results – roundhouse floors

Area 2 (Table 3) contained a basal peat overlain by a clay unit (context 26) which, in turn, was overlain by and upper layer of woodchips in a peaty matrix (context 25). Micromorphological analysis classified the base of the peat deposit (Unit 7 fig. 36) as a ‘natural’ peat containing similar microstructure to that described in Unit 1 (Area 1). The pollen assemblages associated with the basal unit is dominated by Cyperaceae, Poaceae (wild grasses), *Salix* (willow), *Alnus* (alder) and *Corylus avellana* type.

Overlying the natural peat was a trampled possible floor surface (Unit 6) characterised by compacted microlaminations where finer sediment is mixed with organic material, with quartz as the dominant inclusion. Above this surface were a series of embedded microlaminations of silt loam, silty clay loam and sandy silty loam, with lenticular platey bed formation, phytoliths of grass leaves and stems (Unit 5). This is interpreted as a trampled occupation surface.

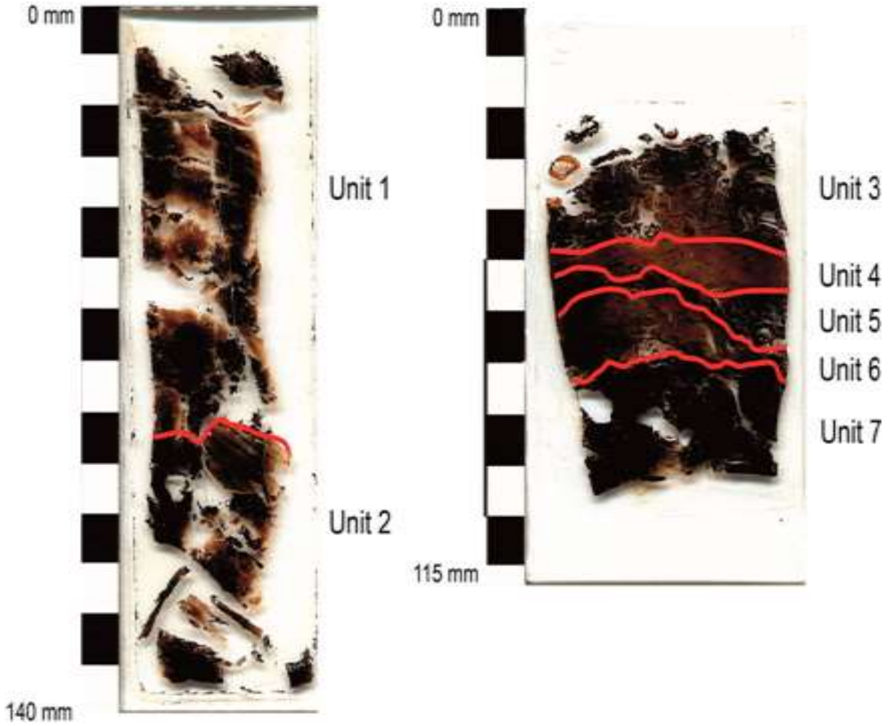

Figure 36 Scanned image of the thin-section for Monolith Tin A from Area 1 (left) and of the thin section for Kubinea Tin C from Area 2 (right). Please note, approximately 5 cm of shrinkage affected Tin A and 2.5 cm of shrinkage affected Tin C during drying and resin impregnation. The scale bars provided therefore reflect the size of the thin sections after shrinkage, but the impact of this shrinkage has been accounted for in subsequent analyses and interpretations.

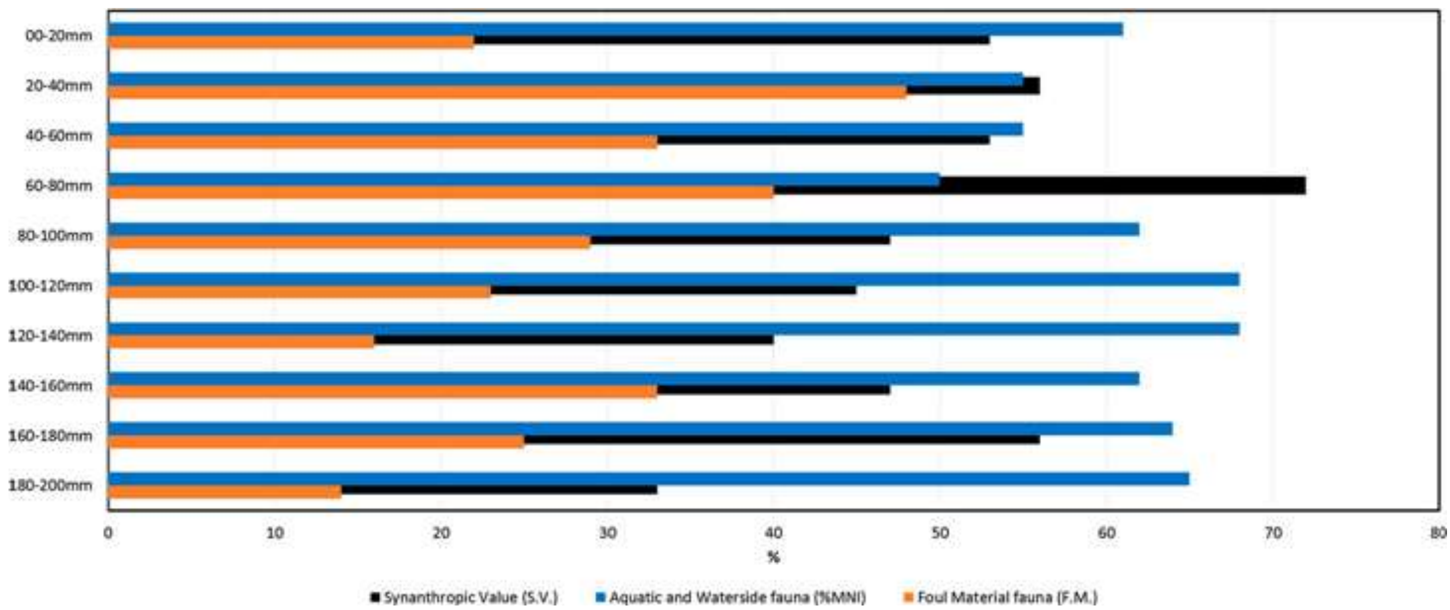

Figure 37 Relative proportions (%) of key coleopteran functional groups encountered in samples from the Area 1. Aquatic fauna have been calculated as percentage of the total faunal assemblage, whereas Foul Material fauna have been calculated as % of terrestrial only assemblage. The Synanthropic Value (S.V.) for each coleopteran assemblage is also displayed.

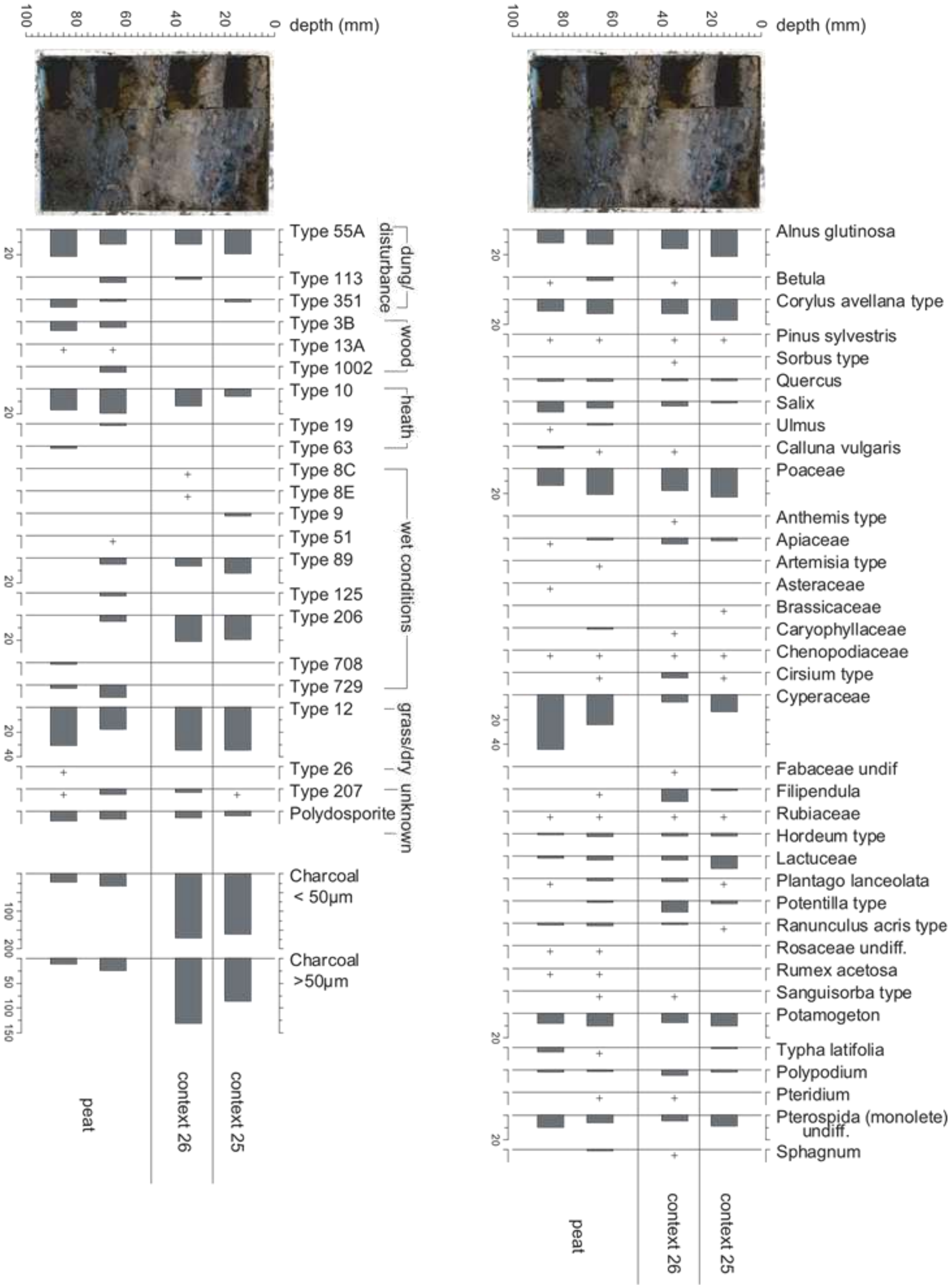

Figure 38 Results of pollen and charcoal (left) and non-pollen palynomorph (right) analysis from Tin D, Area 2. An image of the sample Tin is included, and horizontal lines across the panels indicate the different contexts sampled.

This was covered by a well sorted loam (Unit 4/Context 26) with no microlaminations or anthropogenic inclusions, suggesting a floor surface deliberately laid in one event. Context 26 has a diverse pollen assemblage which includes several herbaceous taxa recorded at levels between 3 and 8% TLP. Notable are Apiaceae (Carrot family), *Cirsium* type (thistles), *Filipendula*, Lactuceae (dandelion family) and *Potentilla* type (cinquefoil). Diatom analysis of the clay floor reveals a freshwater source for this deliberately laid clay surface, with a suite of epiphytic and aerophilous taxa (including, but not restricted to, *Epithemia turgida*, *E. adnata*, *Synedra ulna*, *Pinnularia viridis* and *Hantzshia amphioxys*) suggesting the clay was sourced from a shallow lake or floodplain setting.

Above the unit 4 floor was an anthropogenic peat (Unit3/Context 25) containing large amounts of bark, leaves, seeds, twigs and wood, some of which was charred, phytoliths and herbivore dung. Microlaminations show formation through the accumulation of organic material and sediment. A dense layer of woodchips was excavated at the top of this layer.

4.5.5 Sample Area 3 results – outside the roundhouse

The bulk samples excavated from Area 3 (context 24) were assessed for plant macrofossil and coleoptera, however coleoptera were found to be absent. Plant macrofossil analysis revealed an abundance of charred cereal. Some cultural material was retrieved from the bulk sample including pottery, occasional small bone fragments, including some burnt examples. Fragments of hard yellow clay were encountered, which were interpreted as the remnants of daub, with one blackened piece showing Poaceae stem fragments embedded into the matrix.

Charcoal fragments were abundant, estimated to account for 50% of the 2mm fraction. Fragment size was large with many pieces >8mm in transverse section. Although abundantly preserved, the condition of the material was relatively poor, with heavy iron staining and evidence for vivianite. This indicates that the charcoal derived from waterlain deposits. Four taxa were positively identified: *Quercus* sp. (oak), *Alnus glutinosa* (alder), *Populus/Salix* (poplar/willow) and Maloideae (hawthorn, apple, service etc.). No differentiation between poplar and willow was attempted in this material.

Context 24 charcoal		Fragment count
Quercus sp.	oak	1h
Alnus glutinosa Gaertn.	alder	33 (11r)
Alnus/Corylus	alder/hazel	2
Populus/Salix	poplar/willow	11
Maloideae	hawthorn group	2r
Indeterminate	bark	1
Total		50

Table 4 Charcoal species from context 24. H=heartwood, r=roundwood

Charred cereal grain included several hulled wheat (*Triticum* sp.) and barley (*Hordeum* sp.) grains, with 68 wheat glume bases well enough preserved to show the presence of spelt (*Triticum spelta*). There were also wheat/barley awns, oat (*Avena*) grains and soft/rye brome (*Bromus* c.f. *hordaceus ssp hordaceus/secalinus*). Despite this abundance of cultural material, much of the waterlogged plant macrofossil assemblage largely reflects the natural environment with 60% bankside/marsh taxa, c. 30% aquatics, but only 6% species typical of disturbed habitats.

4.5.6 Chronology and sequence

The relative chronology of the settlement developed by Coles and Minnitt (1995) suggested that Mound 9 was built later than the earliest roundhouses to the north and south although there was no definitive stratigraphic proof of this. The substrate upon which Mound 9 was built could therefore have been exposed to anthropogenic influences prior to construction.

A robust chronology could not be established for the sample column in Area 1. The brushwood layer is of anthropogenic origin, as part of the foundations under the mound. The micromorphology suggests the overlying upper peat is ‘natural’, yet the coleopteran, plant macrofossil and NPP signatures within the same upper unit reveal considerable anthropogenic influences. The presence of a stratigraphic boundary was identified proximal to the brushwood layer by micromorphology at c. 90mm (figure 36) and within this ‘natural peat’, radiocarbon dating indicates the presence of organic material that is older than that underlying it (figure 34 40-50mm depth). It is proposed that such an age reversal and contradictory palaeoenvironmental signatures were achieved through the artificial introduction of a layer of redeposited peat on top of the brushwood in advance of laying the first floor. This is consistent with Bulleid’s description of the foundations of Mound 9 of 30cm of brushwood below 60cm of redeposited peat at the centre of the mound (Bulleid and Gray 1911, 80).

Below the brushwood layer, scientific dating obtained from samples at 120-130mm, 160-170mm and 190-200mm can be used to provide a robust chronology suggesting deposits forming over the 200 years prior to the beginning of the settlement.

As anthropogenic influences have been identified throughout all sequences under investigation, it is important to clarify the chronological relationship of the three areas under assessment relative to one another. Area 1 is located at the entrance to Mound 9 and was capped by the first (and hence earliest) floor layer (Bulleid’s floor 9). Area 2 was located

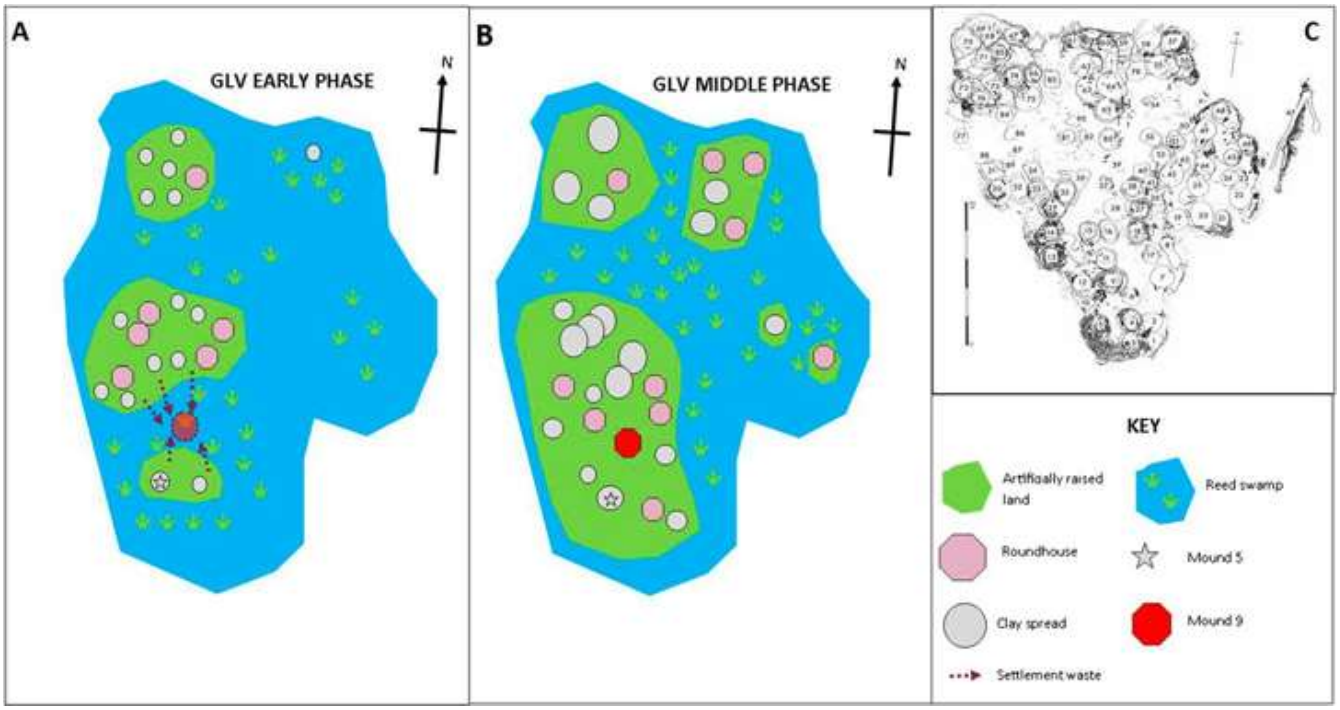

Figure 39 Schematic reconstruction of the environmental setting at Glastonbury Lake Village during its initial establishment at a time when the site of Mound 9 was under water (A) and the subsequent construction of Mound 9 (B). Please note that the positioning of specific roundhouses and clay spreads in A and B are to provide a general understanding of Lake Village layout and hence not accurate. Please refer to (C) for a summary of mound locations within the Lake Village (from Coles and Minnitt 1995).

proximal to a line of small posts and flooring also associated with one of the earliest phases of mound occupation (Floors 9 or 8), preserving a sequence of deposits before during and after the formation of those earliest floors. Area 3 (context 24 is outside Mound 9 and is believed to represent the external ground surface at a point in the occupation before a rubble path was built between mounds 9 and 12 at some point after the creation of floor 8 and before floors 1-3.

4.5.7 The environment prior to mound 9 construction

As discussed above, the lower half of the sample column in Area 1 represents the build-up of organic layers over roughly 200 years prior to the known beginning of the settlement. The palaeoenvironmental evidence confirms the presence of patches, or channels, of freshwater of variable depth up to 2–3 metres, of generally still-to-slow-flowing waters. Aquatic Coleoptera such as *Limnebius aluta*, *Hydrophilus piceus* and *Dyops luridus* are particularly associated with freshwater in fen and marsh land and are still found in the Somerset Levels. While a wood carr was present locally, it did not form a dense canopy. The range and quantity of marsh plants encountered via the plant and beetle macrofossil analyses instead highlights a diverse and open, freshwater wetland habitat. Alongside rushes, sedges, pondweed and sweetgrasses, marsh spike rush, water mint, arrowhead, branched bur-reed, lesser water-parsnip gypsywort, common reed, white water lily, six-stamen waterwort, great fen-sedge and bulrush are present. We can therefore picture such a freshwater setting existing on the Mound 9 site prior to its creation.

Throughout the sediment column in Area 1, palaeoecological indicators strongly associated with human settlement are abundant. Whilst there is an overall increase in the strength of the anthropogenic signal towards the top of the column in Area 1, indicators for human activity are encountered at all depths. Micromorphology has characterised the deposit below the brushwood as an anthropogenic peat in accordance with a formation process that has also been observed in lakeshore settlements from the Neolithic in Switzerland (Ismail-Meyer et al. 2013), and the late Bronze-early Iron Age in Lithuania (Ismail-Meyer 2014). This shows similar characteristics to natural peat forming processes, but where organic materials from around the settlement have rapidly accumulated where there is a high groundwater table, which has preserved the organic matter (Ismail-Meyer et al. 2013, 331). Whilst aquatic taxa dominate within this anthropogenic peat, the ecological group ‘Foul Material’, incorporating those taxa living upon varying types of decaying organic material (although not obligate dung beetles), contributed some 35% tMNI, increasing to 46% tMNI near the top of the sequence (Figure 9). While this group is not exclusively synanthropic, their presence in such proportions is typical of occupation sites (Hill, 2015; Smith et al, in prep). The presence of charred wood in the micromorphology samples, NPP taxa associated with dung and charcoal in the basal pollen/NPP sample, all give credence to an anthropogenic influence on this deposit.

What remains uncertain is whether some of the anthropogenic signal preserved below the brushwood relates to earlier human activity in the vicinity prior to the construction of the settlement remains recorded by Bulleid and Gray. Bulleid’s excavations largely stopped at the mound foundations so it is unknown if any evidence of earlier human activity may exist underneath. In the MARISP trench 2 worked wood and sling shots were found up in layers dated to the early Iron Age (Brunning 2013, 185-191). That report suggested that they may have sunk down into soft sediment, but an alternative is that they were a product of an earlier phase of activity on the site.

Another explanation for the anthropogenic signal is that some of the mounds were occupied before mound 9, as suggested in the Coles and Minnitt model. Waste material from the surrounding occupation could have entered the area later to be occupied by mound 9 (figure 39).

4.5.8 The construction and occupation of mound 9

The brushwood layer at c.80mm depth in the Area A sample column is thought to represent the lowest part of the mound 9 foundation. The overlying peat is probably material redeposited from nearby to help raise the ground level before the first floors were created. Unit 7 in Area 2 is thought to represent the same deposit.

Taxa associated with the ecological grouping ‘Foul Material’, also belong to an indicator group collectively referred to as the ‘House Fauna’ (Kenward and Hall 1990). These show an increase in abundance up-column into the overlying ‘natural’ peat. This group comprises a suite of beetles with a particular affinity to human habitation and settlement. Consistently present in these assemblages are *Ptinus fur*, *Latridius minutus* (grp.), *Atomaria* spp. and *Cryptophagus* spp. – all of which are particularly attracted to the dry moulding conditions of organic detritus made available within sheltered structures, including bedding, roofing and wattle and daub cavities. The furniture beetle, *Anobium punctatum* and *Lyctus linearis* are frequently found in the structural timbers and posts of wooden structures.

The presence of all typically dry loving indicators in a naturally accumulating wetland peat is, on face value, incongruous. Furthermore, a general increase in the samples overall synanthropic value (S.V.) and Foul Material taxa throughout the column (figure 37) suggest that their presence increased in temporal proximity to the overlying occupation layers of mound 9. The pollen evidence associated with the upper peat unit also suggests a dry woodland and wood carr was expanding in the local environment. However, apart from wood fragments, which may be part of the brushwood, or other local construction, there was no evidence (seeds or fruits) for any woody fen carr species being near. Combined with the ‘natural’ peat characteristics identified through soil micromorphological analyses, it is suggested that the brushwood layer and overlying ‘natural’ peat was in fact transported on to site, perhaps through the relocation of peat from a nearby source.

In both the NPP and Coleopteran analyses, dung indicators are present throughout the samples. *Sordaria* sp. (Type 55A and 351) are present which, given their limited dispersal, would indicate that herbivores were close by and managed rather than wild, particularly above the brushwood layer where *Sporormiella* sp. are also present and abundant. Dung beetles, largely from the scarab *Aphodius* genera, were consistently present throughout the column but only c.7–8% of the terrestrial species. These proportions are considerably smaller than has been recovered from Iron Age pastoral sites across the UK (Smith et al. forthcoming).

The uppermost 10mm of the sample column have a slightly different character. The plant macrofossil assemblage changes considerably with disturbed ground plants such as pale persecaria, fig-leaved goosefoot, common nettle and fat-hen dominating. These plants are all associated with rich disturbed soils, often near habitation, and near manure heaps where there are elevated levels of phosphate and nitrogen. The top sample is also the only one to contain the Type 7 NPP taxa associated with human habitation, and there is also a distinct spike in the charcoal fragments record in the pollen analysis.

Shortly after the addition of a layer of brushwood and peat (to level the site and/or raise the surface elevation sufficiently above the water table), the first walls and clay floors would have been created. This was followed by a rebuilding sequence of eight further floors, central hearths and associated walls over the life of the building. The micromorphological results from Area 2 have exposed the complex character of this deposition with a (presumably redeposited) peat (Unit 7) as the top of the foundations overlain by a trampled, possible floor surface (Unit 6) with trampled occupation material above (Unit 5). A replacement floor (Unit 4) was laid down over that, with an anthropogenic peaty matrix (Unit 3, Context 25) on top, again probably formed during occupation of the building, containing both charred wood and herbivore dung. The latter suggests that some animals may have been kept within the buildings. The overlying layer of woodchips possibly represents a deliberate consolidation of the floor and/or a reflection of the activities taking place inside the building. All occupation layers above this woodchip layer had been subsequently removed by Bulleid's excavations. The palynological investigations revealed the presence of barley pollen in all samples analysed, which is perhaps unsurprising considering the abundance of charred cereal encountered on the site in Area 3. The abundance of possible NPP heather indicators within the trodden anthropogenic layers also highlight the likely use of heather on site in the roundhouse possibly as flooring or bedding materials. Bulleid recorded comparable accumulations along the margins of floors 4, 5 and 6 consisting of 'a layer of fire ash, brushwood and bracken fern' (Bulleid and Gray 1911, 79-80).

Diatom analysis of one of the earliest floors (Unit 4 context 26) confirms the source of the clay. Although the blue-grey nature of the clay suggested an estuarine source, analysis has proved a freshwater origin. While freshwater benthic diatoms dominated the assemblage, aerophilous taxa (including *Pinnularia viridis, Synedra ulna* and *Hantzshia amphioxys*) were also notable suggesting the clay unit was from a location that experienced cyclic aerial exposure, possibly in response to fluctuations in the relative water table, or flooding. The diatoms and sedimentary properties suggest the depositional setting would require very slow moving or stagnant water, to enable the deposition of such a fine-grained sedimentary matrix. This would suggest that either the margins of a shallow lake or a flood plain setting are likely scenarios. The taxa were broadly similar to the assemblages encountered in the 'natural' peat underlying the floor layers in Area 1 which suggests that, despite one being minerogenic and the other organic, both these two units originated from a similar source location. This indicates that during the construction of the foundations and floors, the builders were using the same source, likely in close proximity to the settlement, to obtain both the organic and minerogenic materials.

4.5.9 Outside the mound 9 buildings

The plant macrofossil remains encountered within Area 3 (context 24), located between Mounds 9 and 12, were found to include charred cereal grain and chaff. Mound 5 (close to Mound 9 to the south) was found to contain "quantities of wheat and peas" (Coles and Minnitt 1995, 36). Clearly cereal grain was used by the inhabitants of the village and the finds of charred grain and chaff from Area 3 add to this picture. Although these finds are few they show the presence of both spelt wheat and barley. The oats may have been an additional crop or part of the arable weed flora along with brome, although this too may have been used at times to bulk out the diet, or to provide animal fodder. The presence of spelt glume bases, with a few awn and cereal stem fragments indicates that cereal was brought into the village as spikelets and were probably stored in this way until ground into flour or used as a seed crop for the next year. Across Glastonbury Lake Village, structural evidence suggests 10 square structures that may be granaries or storehouses, which would have provided excellent protection above the ground to keep the cereals dry and pest free.

Alder was the main source of fuelwood identified in the charcoal sample. Alder is often considered a poor fuelwood unless well-seasoned (Edlin 1949) but was commonly used in the absence (or avoidance) of preferred taxa. Its use here, in a context resulting from domestic activities, suggests that it was readily available and convenient to use.

4.6 Trench 5: Southern palisades

Trench 5 was 9m N-S by 2m E-W. It was positioned across the southern perimeter of the settlement. The plans and photographs of the original excavation show multiple lines of palisade stakes in the area running around the perimeter of the settlement. The area immediately west of Mound 3 was selected because three different groups of palisade stakes could be discerned. It was hoped that a sequence of palisade rebuilding could be established and thus permit the use of Bayesian analysis on radiocarbon dating.

Bulleid noted that the palisade posts were mainly alder, with some birch, oak and 'other' species (Bullied and Gray 1911, 50). He recorded that the palisades had generally been pushed outwards by the weight of the material inside them, usually with those closest to the outside slumping the most. In some instance the posts were recorded as having snapped a few feet below their tops, with the remaining lower sections still being vertical. He presumed that the lines of more vertically orientated post represented later rebuilds of the palisade. In many places he recorded that *'coarse wattle-work bound together the upper portions of the palisade'* (ibid 51). Bulleid was convinced that the palisade posts would have had a defensive role in addition to the function they played in retaining the foundation material because 'by raising the more horizontally placed piles in line with the border, it was found that they projected several feet above the adjoining floor level (ibid).

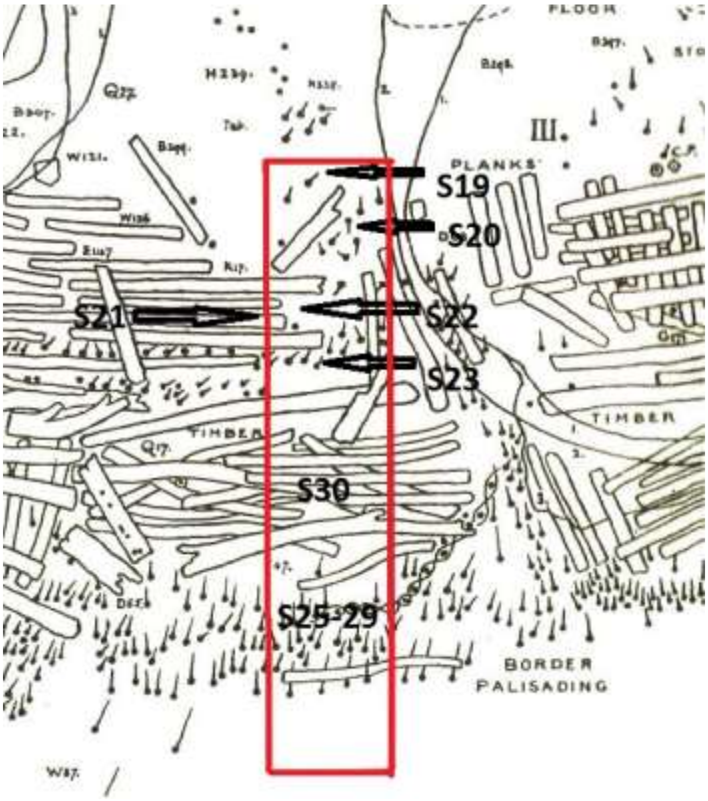

Figure 40 Trench 5 location superimposed on Bulleid's plan with the main structural groups from 2014 identified

Coles and Minnitt attribute the southern palisades to their middle, late and final phases (1995 figs. 4.9-4.12). They considered that the most northerly line was the earliest with later palisade lines extending sequentially further south into the wetland surrounding the settlement.

The ground surface at trench 5 was c.4.29 m OD. The top of the in situ horizontal wood was between 3.85-3.91 M OD and the tops of the palisade stakes at the southern end of the trench were 3.82-3.89 m OD.

4.6.1 The 1897 excavations and backfill

Bulleid carried his excavation [69] down to the level of the wooden remains comprising the palisades and associated timbers. In several places excavation was taken further, either simply removing the peat deposits between timbers, or extracting sections of larger timbers to examine the deposits beneath. Towards the northern end of trench 5, Bulleid's depth of excavation was deeper in places, possibly because of the absence of significant wooden remains to impede it. Bulleid's plan of the area shows little wood in these areas of deeper excavation.

4.6.2 *In situ* Iron Age remains

The Iron Age features in this trench consists of a series of collapsed palisade lines and their associated material. They can be broadly grouped into three, a northern group, a middle group and a southern group. There is no clear stratigraphic relationship between the differing palisades but analogies with Scottish and Irish crannogs (O'Sullivan 1998, Crone 2000) would suggest that gradual expansion outwards (ie. south) is likely, making the northern palisades probably the earliest in date.

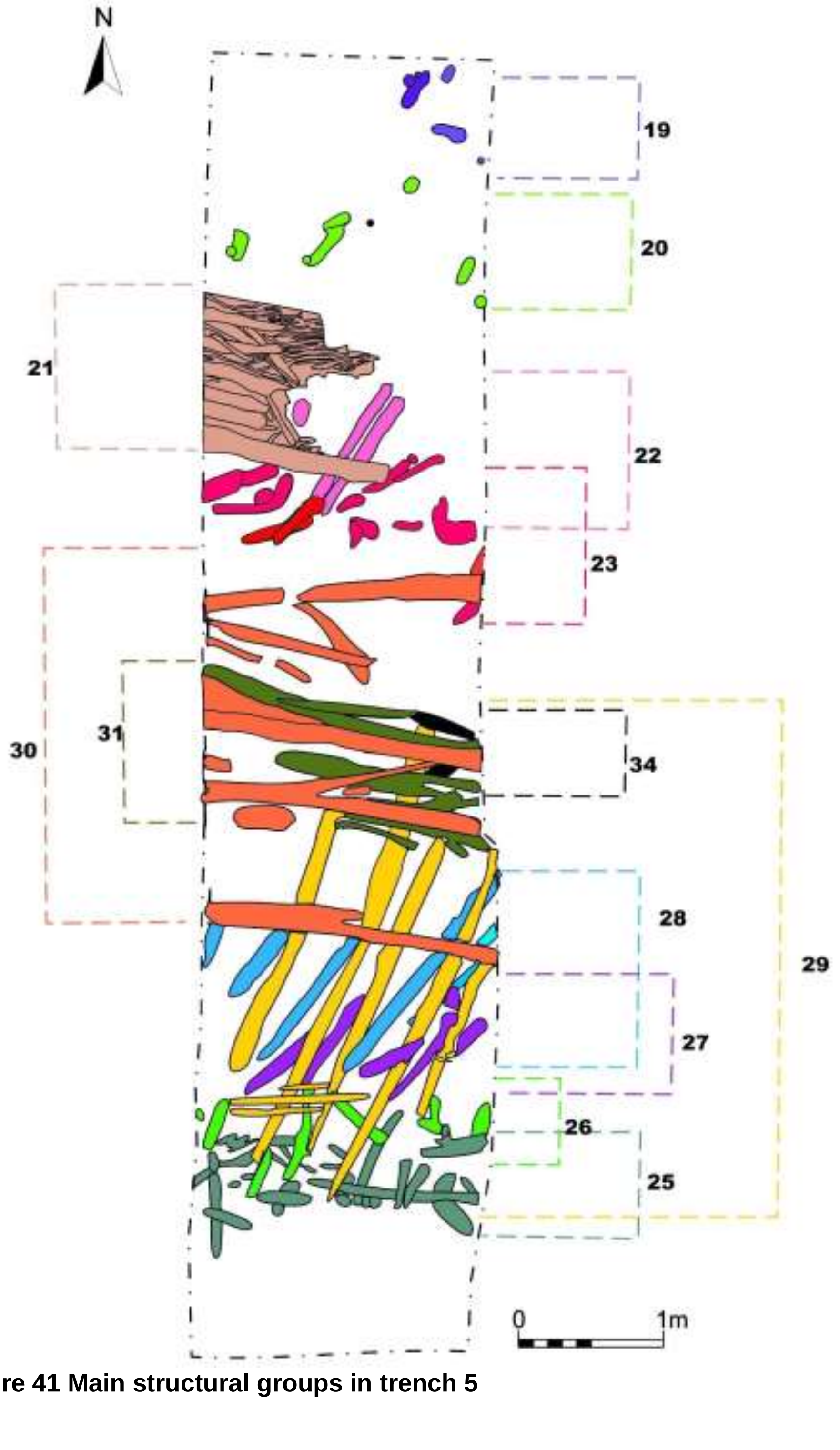

Figure 41 Main structural groups in trench 5

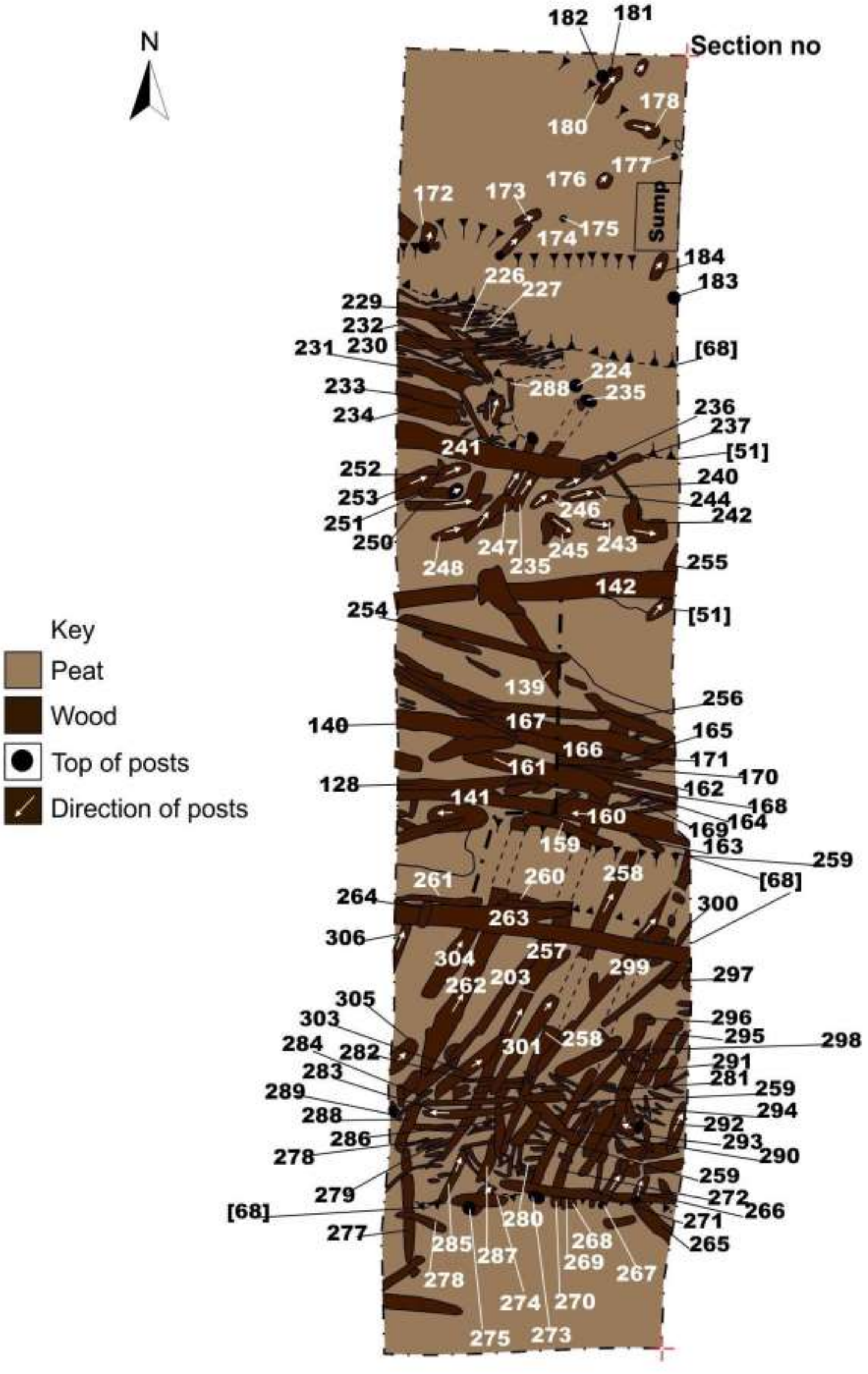

Figure 42 Plan of trench 5

Northern palisades (Gp. 19 and 20)
The northernmost group of palisade timbers (Gp. 19) consists of seven roundwood alder posts (177-182 and one unnumbered) running at a slight angle across the north-east corner of the trench. The diameters of the posts varied from 42mm to 89mm. The tops of several of the posts had been removed during the Bulleid excavation. Three posts remained *in situ*, two pushed over towards the south-west and the other to the west. The deeper level of the Bulleid excavation away from this corner of Trench 5 may have removed other associated posts. There is therefore a possibility that they were originally part of a broader east-west line that has been largely removed by Bulleid.

The remains of another line of palisade posts (Gp. 20) survived towards the southern edge of the area of deeper excavation by Bulleid at the northern end of the trench. Seven roundwood posts survive in this group (172-176, 183-4). All the posts were again alder, apart from one (184), that was willow or poplar. Where the post tops survived, they appear to have been pushed over towards the south-west. The size of the posts varied between 55mm and 92mm apart from one smaller post (175) that was only 33mm diameter.

Figure 43 Northern and central structural groups (19-23) from the North. Scales 1m

Central palisades and walkways (Gp. 21, 22 and 23)
At the southern edge of the deep area of Bulleid's excavation, a dense layer of horizontal wood (Gp. 21) survives. The abrupt and obviously truncated northern and eastern edges of this material suggest that it originally extended in those directions, before its removal by Bulleid. The material consists of small brushwood overlain by larger timbers running east-west from the western baulk of the trench. Only one piece of the brushwood was identifiable (226 – willow or poplar) but all the larger roundwood logs (229-234 and 241) were all alder except for a single piece of buckthorn (232). It is hard to be precise about the original diameters of the logs, as they had suffered from considerable vertical compression that had flatted their original circular profiles. The largest logs (231 and 241) were probably around

130mm in diameter, with 234 being only slightly smaller. The others were broadly 40-70mm diameter.

This horizontal material overlay another line of alder roundwood posts (Gp. 22) that had been partially removed by Bulleid. The original concentration of the posts is unknown as only three survived Bulleid's investigations. The tops of all three surviving posts had been pushed over towards the south-west. The post diameters varied from 69mm to 84mm. The stratigraphic relationship between the posts and the overlying horizontal timbers had been removed in the original excavations except where the collapsed tops of posts 224 and 235 were sealed underneath log 241. Bulleid had removed a section of both posts as he dug down, but the vertically set post bottoms still survived. This suggests that this palisade line had collapsed before the overlying horizontal material (Gp. 21) was laid down.

The horizontal wood (Gp. 21) may have been bounded and retained by a line of palisade posts (Gp. 23) along its southern edge. Thirteen roundwood posts (236-7, 242-248, 250-253) had been vertically set but their tops had all been pushed over towards the east. The posts that could be identified consisted of eight alder and six willow or poplar. Their diameters ranged from 40mm to 160mm, with the larger posts dispersed along the line.

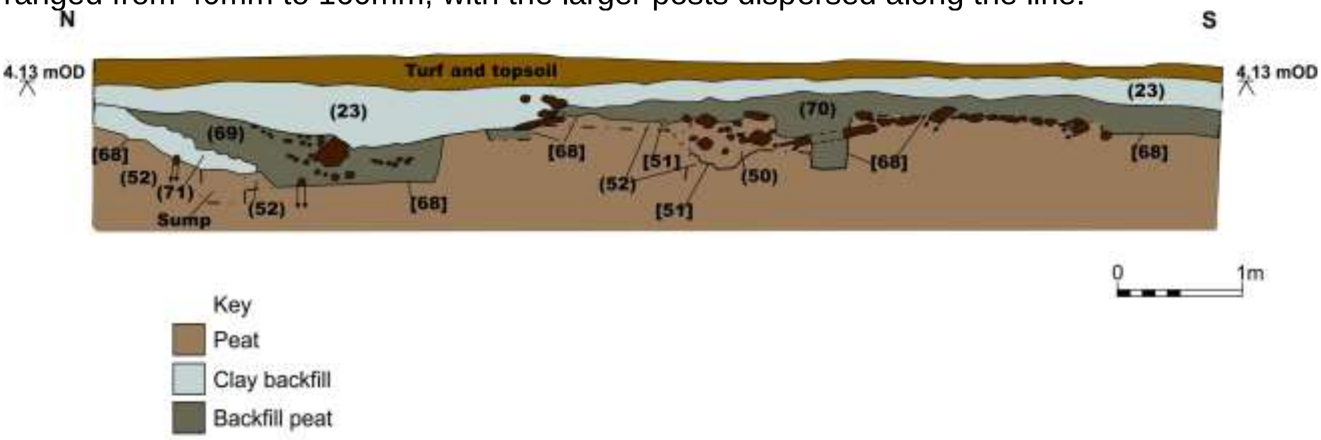

Figure 44 west facing section Trench 5

<u>Southern palisades (Gp. 25-31 and 34)</u>
A complex of collapsed palisades occupied the southern half of the trench. There appear to have been up to five separate palisade lines constructed over a small distance. The sequence of their construction is complicated because they have all collapsed towards the south and several pieces of wood were undoubtedly removed during the original excavations. In addition, the project brief did not permit the dismantling of the structures to more fully reveal the complexities of their relationships to each other. The sequence of construction provided below must therefore be regarded as provisional.

The earliest feature (Gp. 25) was a collapsed palisade, running east-west, and associated horizontal wood that it may have been retaining. The palisade comprised nine roundwood posts (266, 267, 268, 269, 270, 272, 273, 275 and 277) that had slumped downwards to the south/southwest. Their upper ends were at angles of 20-40 degrees from the horizontal, but it is not known if their bottom ends were still vertical as only the top ends were visible, the longest (277) being over 860mm. A piece of alder roundwood (265) lying horizontally next to the top of one of the posts (266), may be the broken off top of the post. It has very similar dimensions and age and both are alder. The horizontal extends into the baulk so its full length is unknown, but it does suggest that the posts may have been at least another 210mm long. Six of the nine posts were alder and the other were either poplar or willow. The larger diameter posts (90-115mm, for 277, 275 and 273) were towards the eastern side of the trench, with a cluster of smaller posts (38-50mm diameter for 268, 269, 270, 272) in the centre and two posts (266 and 277) at the western end of 80mm and 70mm diameter. The posts were all formed from young stems of only 10-17 years growth.

Figure 45 Collapsed palisade at the southern end of trench 5. In the foreground are the posts of the early palisade line (group 25). The north arrow rests on the wood woven around the top of the birch palisade (group 29). Scale 50cm

The posts retained horizontally material on their northern side that had been laid down in an east-west orientation. Immediately against the northern side of the posts were some large roundwood timbers. One of these (274) was an alder of over 25 years growth and another (271) a willow or poplar of over 33 years growth, both originally being roughly 60mm in diameter. The horizontal material was in a poor condition and had been compressed out of shape. Behind and underneath this larger roundwood was a mass of fragmentary brushwood (278, 279, 280) of 14mm to 20mm diameter and 6 to 10 years of age. None of the brushwood could be identified to species because of the poor preservation.

The next palisade to be created was probably group 29. This consisted of five large roundwood posts (257, 258, 259, 262 and 291) which had all slumped down to the SSE and were had come to rest at shallow angles of about 30° from the horizontal. The posts ranged in diameter from 85mm to 135mm. The full length of the posts could not be established because their bottom ends lay under other horizontal material to the north. Post 257 could be traced over the longest distance and was at least 3.4m in length, with no sign of the beginning of any cut end at the northernmost visible location. This suggest that the posts were originally over 4m in length. The top ends are in a poor state of preservation but may represent the original length. Some small pieces of roundwood (281-284) may originally have been woven between the tops of the posts. It is hard to be conclusive because they are in poor condition and have also suffered during the original excavations. This possibility would fit with Bulleid’s plan and description of this area, which is shown to have a palisade line with roundwood woven between. The woven roundwood was originally c.26-33mm in diameter but had been considerably distorted by compression. When the palisade was vertical it must have formed a considerable barrier well above the contemporary ground level. None of the wood could be identified to species because of its poor condition, but large well preserved stretches of bark had the characteristics of birch. That species rots very quickly in the wet.

Figure 46 Palisade sequence at the S end of Trench 5, with a long timber of group 29 exposed. Scales 1m

It is difficult to determine the order of construction of the next three phases of palisade construction. From north to south they are Groups 28, 27 and 26, all of which appear to overlie the posts of group 29.

Group 28 consists of six alder roundwood posts (297, 299, 300, 302, 304 and 306) that had slumped down towards the south-west. The four posts on the eastern side of the trench were younger (6-7 years) and had smaller diameters (42-53mm), than the two nearest the west side that were older (16+ and 18 years) and larger (100mm and 102mm). Another difference is that the four smaller posts (297, 299, 300 and 302) exhibited long slumped tops, up to over 1.8m in length. The two larger posts (304 and 306) only had slumped tops of up to 540mm (304). In the case of post 304 it was apparent that the remainder of the post was still vertically set in its original location. The top section had broken and slumped almost horizontally. This suggests that that 540mm length represents the height of the post above the contemporary ground surface. For two of the posts (300 and 302) it was apparent from side branches that the posts had originally been put in upside down, ie. opposite to how they grew. One post (297) was put in the other way up. That post (297) was recovered intact. It had a length of 748mm and, although roundwood, had a slightly oval cross section 39mm by 33mm. The post had a slight natural bend 500mm from the cut end.

The Group 27 palisade ran east-west 50-75cm south of group 28. It consisted of six alder roundwood posts (295, 296, 298, 301, 303 and 305) formed form 12-14 year old stems. The posts were 82mm to 108mm in diameter. The tops of the posts had slumped down almost horizontally, to the south-west. In several cases (295, 296, 298 and 305) it was observable that the top part had broken off the remainder of the post, that was still vertical *in situ*. The lengths of the broken and slumped post tops varied between 440mm and 800mm, suggesting that this was how far they projected above the contemporary ground surface.

The remaining palisade line (Gp. 26) was c.40-60cm south of the Group 27 palisade. It consisted of nine posts, all roundwood apart from one (294) that was half split. The tops of the posts had collapsed in a variety of directions from South-south-east to South to South-east, at angles that ranged from almost flat (to 294) to between 45-60° for the others. The collapsed tops were between 300mm and 800mm in length. As it appears that the remaining bottom parts of the posts were still vertically set *in situ*, it appears likely that these lengths represent the heights of the posts above the contemporary ground surface. Of the eight identified posts, four (285, 286, 287, and 293) were alder, three either alder, birch, hazel or hornbeam (288, 289 and 294) and one (292) poplar or willow. Their diameters varied between 75mm and 107mm and the age of the stems ranged from 13 years to over 19.

The other two structural groups from trench 5 were an upper (Gp. 30) and lower (Gp. 31) group of horizontal timbers that ran broadly east-west across the trench in the area between the middle and southern groups of palisades. They probably represent material that was deliberately laid behind palisade line 28 or 29 and may have shifted slightly southwards when those palisades collapsed in that direction. Smaller elements of the upper layers may have been removed during the original excavations.

The seven large roundwood timbers in the upper layer (Gp. 30) consisted of three oak logs (139, 254 and 263), three alder (140-142) and one poplar or willow (138). Four of them were between 90mm and 97mm in diameter and the other two (140 and 263) were larger at 163mm and 174mm. The age of the logs varied from 16 to over 45 years.

The lower horizontal material (Gp. 31) consisted of 15 roundwood timbers, of which nine were poplar or willow, four alder, one birch and one oak. The single oak piece (160) was a large (110mm diameter) log with a large broken side branch. Three other timbers (161, 167 and 170) were also quite large, between 130 and 140 mm. At the eastern end of 170 several axe facets were visible on one face, but they could not be recorded in detail because the timber was underneath several other ones. The other roundwood varied between 22 and 70 mm in diameter and mostly between 50 and 60 mm. All the material was quite young, between 9 and 30 years of age. Some of it may represent branch material rather than main trunk.

One possible alder post (256), c.85mm in diameter, was just visible amongst the lower wood. Its top section, c.300mm long, had been pushed over towards the east. It is possible that other collapsed posts were covered by the horizontal material.

Figure 47 post 256 (centre beside vertical scale) exposed after sampling. Scales 1m

5 Artefacts and structural material

The vast majority of the excavation was confined to the removal of the backfill from the Bulleid and Gray excavations. Although artefacts were retained from the backfill no attempt was made to separate out the numerous layers of the backfill and contexts were assigned on the basis of spits of varying depths. The backfill was rapidly removed by spading so the artefacts retrieved from the backfill must underrepresent the quantities that are actually present within it.

The only *in situ* Iron Age deposits that yielded artefacts were those where excavation was undertaken to allow the removal of samples for dating or species identification. These represent very small areas.

5.1 Small finds

The only stratified small find from a secure Iron Age context was a small rim sherd of late Iron Age Glastonbury ware from context 24 in trench 4. All the other small finds were derived from the backfill of the Bulleid and Gray excavations. They are summarised here in two tables, 5 and 6.

Figure 48 Bone, pottery and daub finds from Bulleid backfill context 22, Trench 4

The quantity of Iron Age pottery, daub and animal bone contained within the backfill was somewhat surprising. The pottery in the backfill included rim sherds and decorated pieces. The size of the finds seems to have been a key factor in retention during the Bulleid and Gray excavations, presumably because the labourers didn’t bother to keep smaller pieces or didn’t see them while spading out the deposits.

Trench	context	Iron Age pottery			Iron Age daub		
		No	Weight gm	Comments	No	Weight gm	Comments
1	1	24	125	1 decorated with ring of small dots under the rim	10	46	1 piece has impressions of two adjoining pieces of c.8mm diameter roundwood on one side
1	2	17 –	125	2 rims I decorated body with horizontal and diagonal lines	4	49	1 piece has curved outer edge with surface incisions that may be decorative
1	3	3	16				
2	9	1	5	horizontal and diagonal incised decoration	3	12	All irregular lumps
2	10	1	5		7	192	1 piece shows rough finger impressions on outer surface. 1 piece shows impression of c.13mm roundwood and at right angles to that a flat impression 13mm wide with a flat terminal
2	11	-	-		1	15	Flat bottomed lump with charcoal flecks
4	20	5	64	1 rim			
4	21	11	63	3 rim sherds			
4	22	6	45	2 rims, 1 decorated body sherd with incised horizontal lines	8	73	2 pieces have finger impressions
		2	11				
5	23	25	235	1 rim	3	164	1 piece with at least 3 finger impressions. 1 piece has the impression of part of an ammonite fossil 22mm by 13mm
4	24	2	18	1 rim	12	90	
		95	701	TOTAL	48	641	TOTAL

Table 5 Iron Age pottery and daub

In the five trenches a total of 95 pottery sherds (701 gm.) and 48 pieces of daub (641 gm.) were recovered from the backfill, in addition to 225 fragments of animal bone (see below). As the five trenches represent approximately 1.38% of the backfilled area, the total finds that may have ended up in the backfill could include 6,884 pieces of pottery (50.80 kg), 3,478 pieces of daub (46.45 kg) and 16,304 pieces of animal bone. These are probably underestimated, because the recent excavations did not attempt to recover every item from the backfill, only retaining obvious pieces as the backfill was rapidly removed.

The daub fragments suggest that there may be useful information contained in the assemblage from the site that would repay further investigation. The impressions of wooden elements, the finger impressions and the differential finishing and composition all indicate that material recovered from in situ deposits would be suitable for analysis.

Trench	context	Flint, stone and clay		
		No	Weight gm	Comments
1	1	1	3	Clay pipe stem 7mm, hole 1.8mm
1	2	3	27	3 pieces of flint - largest piece burnt. No clear signs of working on any
2	9	1	33	Handmade Fe nail, 8mm by10mm stem. Elongated head 13mm by 37mm. 74mm long
2	11	1	1.3	Small burnt worked flint flake
4	20	1	59	Modern tile
4	22	2	11	Late 19th century china
5	23	1	1.5	Clay pipe stem 7mm, hole 2mm
		2	50	Late19th or early 20th century nails
		1	42	Fe blade fragment? 80 x 34 x 12mm
		1	16	Modern wooden marker stick 250 x 21 x 5mm
		1	250	Stone with ammonite fossils

Table 6 other small finds

Figure 50 Ammonite from trench 5

Figure 49 Ammonite impression on daub from trench 5

Although unworked stone was not retained form the backfill deposits, a piece with ammonite fossils, from context 23 of trench 5, was almost certainly from Iron Age deposits on the site as it would have had to have been brought from a considerable distance. This is supported by the impression of an ammonite on a piece of daub from the same context (figures 49 and 50). This indicates the probability that the stone with prominent fossils was deliberately collected and brought to the site in the Iron Age.

5.2 Animal bone *Lorrain Higbee*

The assemblage comprises 227 fragments of animal bone (Table 7). Bone was recovered from Iron Age contexts 3, 24 and 50, and from the backfill of trenches excavated at the site between 1892 and 1907 by Bulleid and Gray.

5.2.1 Methods

The following information was recorded for each identifiable fragment; species, element, anatomical zone (after Serjeantson 1996, 195–200; Cohen and Serjeantson 1996, 110–12), anatomical position, fusion state (after O'Connor 1989; Silver 1969), tooth eruption/wear (after Grant 1982; Halstead 1985; Hambleton 1999; Levine 1982; Payne 1973), butchery marks (after Lauwerier 1988; Sykes 2007), metrical data (after von den Driesch 1976; Payne and Bull 1988), gnawing, burning, surface condition, pathology (after Vann and Thomas 2006) and non-metric traits. Caprines (sheep and goat) were differentiated based on the morphological criteria of Boessneck (1969), Payne (1985) and Halstead *et al* (2002). The assemblage has been quantified in terms of the number of identified specimens present (or NISP).

5.2.2 Preservation condition

The bones recovered from Iron Age deposits are well-preserved while a significant proportion of those from backfill deposits show signs of physical and chemical weathering due to fluctuations in temperature and moisture because of exposure and re-deposition. The lack of gnawed bones indicates that the assemblage has not been significantly biased by scavenging dogs.

5.2.3 Iron Age deposits

The Iron Age assemblage comprises just 32 fragments, only 12 of which are identifiable to species. Most of the identified bones belong to sheep/goat and cattle. Sheep/goat is represented by fragments of skull, mandible, scapula, rib, lumbar vertebra and first phalanx, while cattle is represented by fragments of skull, mandible and pelvis. The sheep/goat mandible is from an animal aged between three to four years of age (mandible wear stage, or MWS, F). Fragments of horse mandible and cormorant (*Phalacrocorax carbo*) tibiotarsus came from deposit 50. The unerupted state of some of the teeth indicates that the horse was between two to three years of age.

Species	Iron Age deposits	Bulleid and Grey backfill	Total
cattle	4	14	18
sheep/goat	6	52	58
pig	-	12	12
horse	1	3	4
wild boar	-	1	1
otter	-	1	1
cormorant	1	-	1
Total identified	**12**	**83**	**95**
Total unidentifiable	**20**	**142**	**162**
Overall total	**32**	**225**	**257**

Table 7 Animal bone: number of identified specimens present (or NISP)

5.2.4 Bulleid and Gray backfill deposits

A total of 225 fragments of animal bone came from backfill deposits but only 83 fragments (or 37%) can be identified to species. Most (63%) of the identified bones belong to sheep/goat and all parts of the carcass are represented. Common bones include the mandible, radius and tibia, all elements that show a good survival rate in most archaeological assemblages. Only four of the sheep/goat mandibles retain two or more teeth with recordable wear, and these are from an adult aged between four to six years and three yearlings aged between six to twelve months (MWS C and G). Analysis of the epiphyseal fusion state of post-cranial bones also indicates the presence of immature animals and a few neonates.

The small cattle bone assemblage includes several loose teeth and fragments of humerus, radius, metapodia, atlas vertebra and rib. Cattle bones from the original excavations were noted as being highly fragmented because they had been extensively processed for marrow (Dawkins and Jackson 1917, 641). The pig bone assemblage is largely composed of bones from the forequarters.

Less common species include horse, wild boar and otter. The horse elements came from deposits 10 and 22 and include two deciduous teeth and an astragalus. Wild boar is represented by a canine tooth from a large male and otter by a radius from an immature animal. Both elements came from deposit 23.

A horse astragalus and two teeth from came from backfill deposits 10 and 22. The elements are all from an immature animal. The left radius from an immature otter and the canine from a large male wild boar were recovered from backfill deposit 23.

5.2.5 Discussion

The range of species and their relative frequencies are comparable to those recorded from Bulleid and Gray's excavations at the site. The pastoral economy of Glastonbury Lake Village was based on sheep-farming. Both adult and immature sheep were selected for slaughter to provide meat (Dawkins and Jackson 1917, 655), and the relatively high cull rate amongst yearlings indicates that the flock was managed in a way that complemented other pastoral and arable activities (Hambleton 1999, 70; 2008, 56). Cattle and pigs were also exploited together with an array of other animals including many wetland mammals (e.g. otter and beaver) and birds (see Andrews 1917).

*5.3 **Wood species identification** Dana Challinor and Zoë Hazell*

Bulleid recorded the species that he thought were used for some structural elements of the settlement. The presence of oak piles and morticed oak planks was noted in the foundations. The logs of the foundations were said to be mainly alder but with some ash, oak, willow and birch (Bulleid and Gray 1911, 52-3). The palisade was also said to have been chiefly alder, augmented by birch, oak and 'other' species (ibid, 50).

The full species identification for the 2014 excavation is available as a separate Historic England report (Hazell and Challinor 2018). That should be referred to for the full results listing and for the methodology. The main results and discussion are included here.

In total 248 fragments were examined and recorded by Hazell, 53 by Challinor, and 24 by Brunning or Nayling (totalling 325, including a few duplicates). The results are summarised in Figure 51 (without duplicates).

5.3.1 Wood identifications

Seven taxa (or taxa types) were identified, all of which are hardwoods: *Alnus, Betula, Fraxinus, Populus/Salix, Prunus, Quercus and Rhamnus*. In addition, undifferentiated Betulaceae and unidentifiable ('Indeterminate') wood types were present. Samples were dominated by (cf) *Alnus* and (cf) *Populus/Salix* types, with fewer occurrences of *Betula, Fraxinus, Prunus, Quercus and Rhamnus. Alnus* was present in 22 of the 29 Structural Groups (SGs) and *Populus/Salix* in 23. All the remaining wood types (excluding the Betulaceae and Indeterminate groups) are present in only two or three of the 29 SGs.

Of the less common wood types recovered:

• *Fraxinus* was recovered only from the reburied/backfill material (Trench 3) of Bulleid and Gray's original excavation, so its provenance is unknown;

• most of the Quercus remains derived from the backfill material (Trench 3), but those that were from in situ features were from SG2 (the palisade main line), SG10 (oak posts associated with oak beam south of mound 74), SG15 (stake cluster north of doorway), SG16 (stake cluster south of doorway), SG29 (collapsed birch [sic] palisade and associated woven elements) and SG30 (horizontal material between central and southern palisades over 29 – top layer);

• a single *Prunus* fragment each was identified from both SG14 (the eastern stake line) and SG25(from/associated with the large palisade at the northern end);

• *Rhamnus* was identified from SG2 (the palisade main line), SG21 (horizontal timbers and brushwood (beneath) at north end) and unknown affiliations in Trench 5;

• *Betula* remains were recovered from SG25 (from/associated with the large palisade at the northern end) and SG31 (horizontal material between central and southern palisades over SG29 – lower layer), as well as the backfill material (Trench 3).

The wood chip assemblage consists of only *Alnus* and *Populus/Salix*. This is not surprising, given the dominance of these two wood types at the site.

Preservation condition was variable at the site. Where it was not possible to identify wood types, this was due to:

• compression of the remains (many samples had been compressed into an oval cross-section, meaning that a lot of the wood features required for identification were distorted, and/or lost) and/or
• degradation of features (diagnostic features – particularly perforation plates – were not always preserved).

Trenches 1 and 2 contained the highest proportions of 'Indeterminate' identifications, with up to half of the samples unidentifiable. This compared with just over 10% of those sampled from Trench 3 and Trench 4.

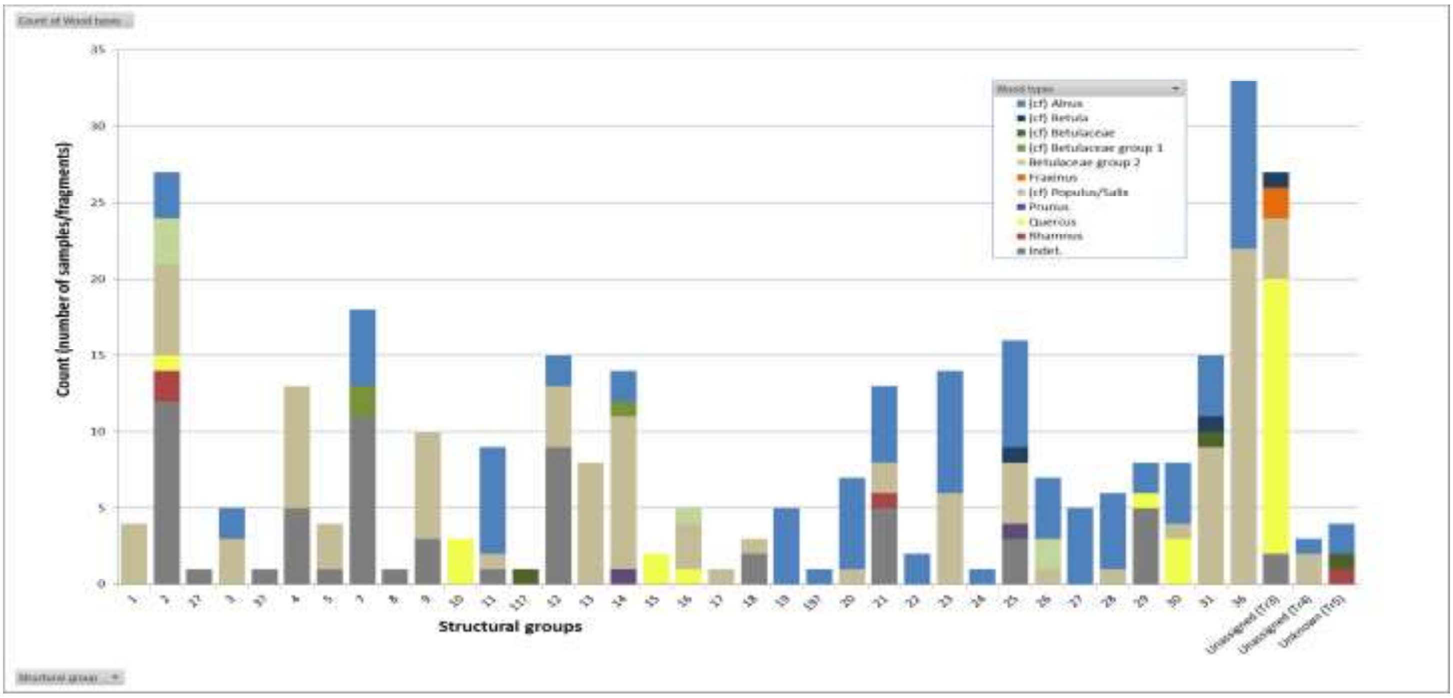

Figure 51 Summary wood identification result (as counts), by structural group (n = 320)

<u>Growth rings and measurements</u>

Results relating to the number of growth rings and their widths are summarised in Table 8, and then presented in more detail below. Unless stated otherwise, the results are only those from fragments that had both the pith and the bark present ie. from a complete radial section; no fragments of *Fraxinus* fitted that criterion.

Wood types	Number of samples (n)	Number of growth rings			Average ring width (mm)			Radius (mm)		
		Min.	Max.	Av.	Min.	Max	Av.	Min.	Max.	Av.
(cf) *Alnus*	38	3	31	13	0.90	4.26	2.46	6.01	69.89	29.52
(cf) *Betula*	1	-	18	n/r	-	3.42	n/r	-	61.58	n/r
(cf) Betulaceae[a]	3	8	17	14	2.12	2.49	2.27	17.62	39.82	31.15
Fraxinus	0	-	-	-	-	-	-	-	-	-
(cf) *Populus/Salix*	55	5	33	12	0.42	4.45	1.75	4.16	61.20	20.22
Prunus	1	-	17	n/r	-	0.95	n/r	-	16.17	n/r
Quercus	1	-	9	n/r	-	3.07	n/r	-	27.59	n/r
Rhamnus	4	10	16	13	0.99	2.70	1.68	15.80	35.07	19.9

Table 8 Summary growth ring data (counts and average ring widths) for samples where a complete radial section was present (ie where the pith and bark were present) (n = 103). a = amalgamated (cf) Betulaceae, Betulaceae group 1 and Betulaceae group 2, n/r = not relevant (where only one fragment was suitable, hence no average can be calculated).

<u>Number of growth rings</u>

Figure 52 shows the count of the number of growth rings for each sample. *Alnus* and *Populus/Salix* have the broadest spread of results (although they are by far the most abundant wood types of those remains sampled), with both tending to cluster between 5-15 total rings. For the assemblage as a whole, most results fall between 5-20 growth rings.

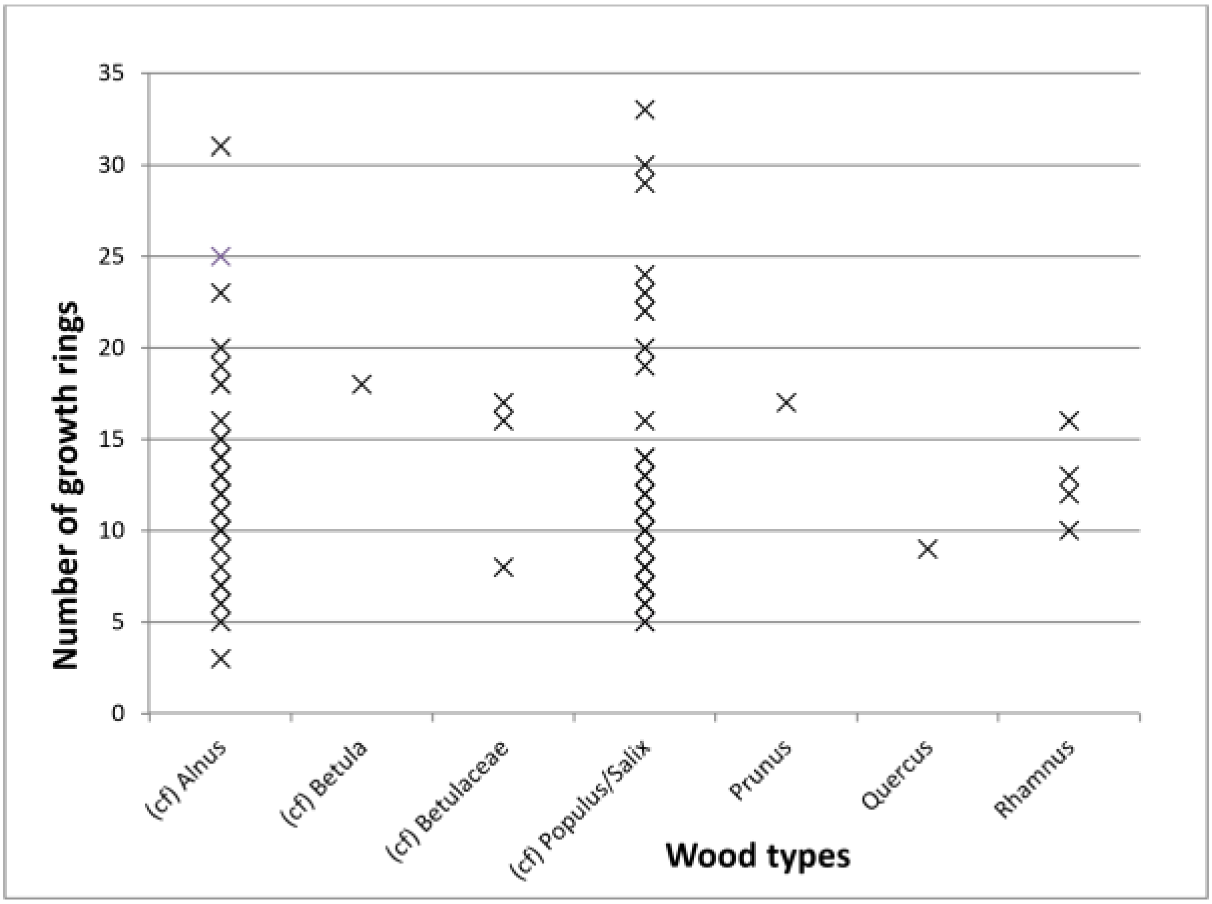

Figure 52 Growth ring counts, for fragments with the bark and pith present (n = 103).

Because the results in Table 8 and Figure 52 only show those fragments with a complete radial section, it does not provide information on the maximum number of growth rings for samples that may have more rings but are only partial remains; that information is presented in Table 9. It shows that the wood type with the greatest number of growth rings present in any fragment, is *Quercus*, which is not surprising given the long-lived characteristic of this wood type. *Alnus* has the next greatest number of rings in any sample, with 37.

Wood types	**Maximum number of growth rings**
(cf) *Alnus*	37
(cf) *Betula*	25
(cf) Betulaceae*	17
Fraxinus	25
(cf) *Populus/Salix*	33
Prunus	17
Quercus	45
Rhamnus	16

Table 9 The maximum number of growth rings observed, irrespective of pith and bark presence, from all the samples recorded by ZH and DC (except the woodchips). * = amalgamated (cf) Betulaceae, Betulaceae group 1 and Betulaceae group 2

Figure 53 shows the radial measurements of the fragments (calculated as an average of multiple measurements made on single (compressed) fragments). All are under 70mm, which would equate to a maximum diameter of 140mm. *Alnus* and *Populus/Salix* have wide ranges, from *c* 5mm to 60/70mm. The *Populus/Salix* measurements cluster under 30mm, whereas the *Alnus* results may have two clusters, between c 17-26mm and c 38-50mm.

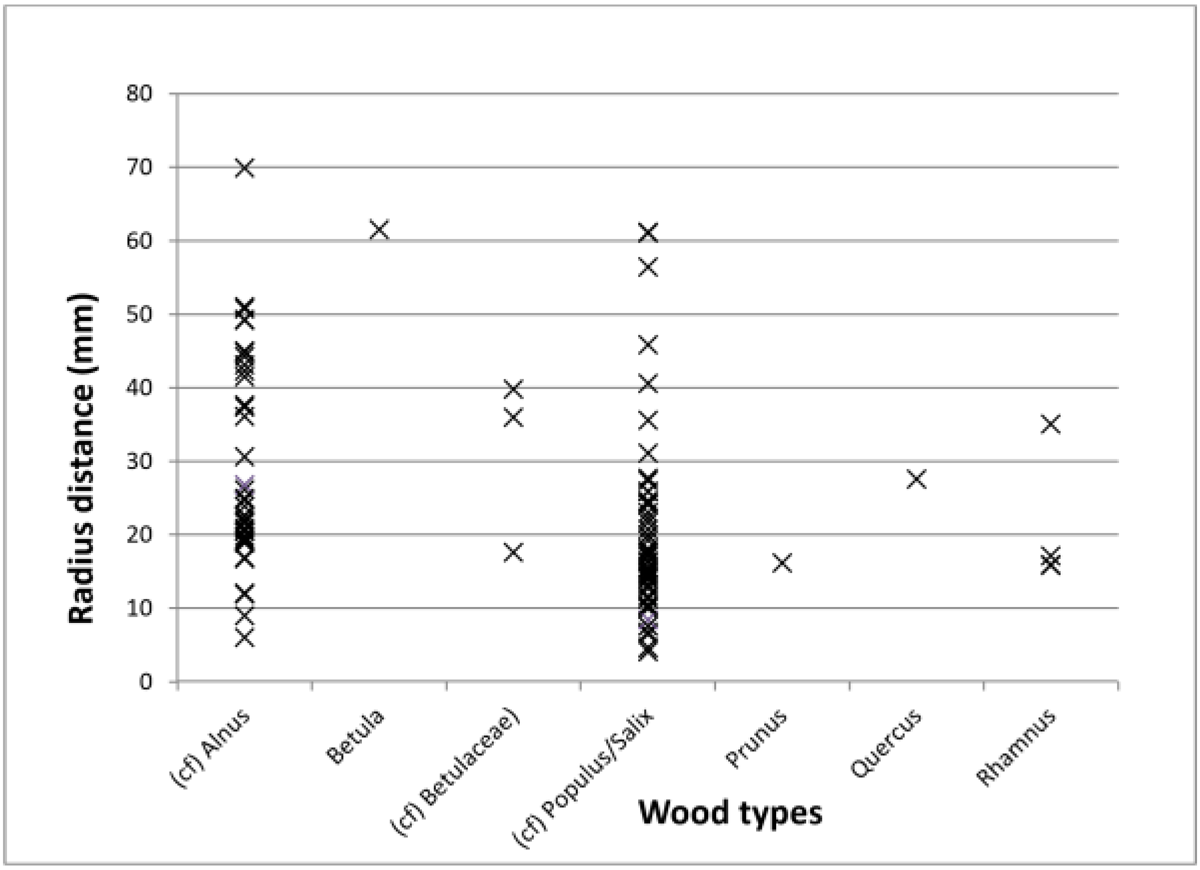

Figure 53 Radial distances, for fragments with bark and pith present (n = 103).

Figure 54 shows the average ring widths of the same 103 fragments, calculated from the previous measurements. Again, Alnus and Populus/Salix have the largest ranges, from c 1.0-4.5mm and 0.5-3.0mm, respectively. The remaining fragments are between c 1.0-3.5mm.

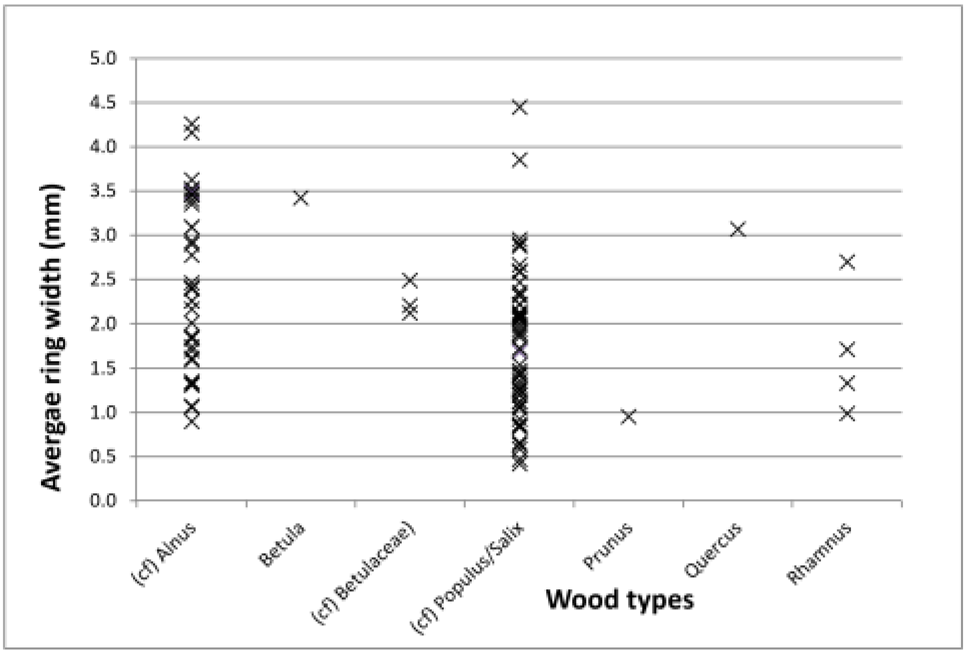

Figure 54 Average ring widths, calculated for fragments with bark and pith present (n = 103).

Figure 55 shows the graphs of growth rings and radial measurement. Overall, there is a broad spread of measurements, not displaying patterns typically associated with coppicing. This would concur with Brunning (pers. comm.) who did not identify any morphological evidence of coppicing in the material during the excavation and sampling stages. However, the data for the Alnus and Populus/Salix fragments do seem to demonstrate some degree of clustering, particularly those remains with fewer than 15 rings and less than 30mm radius (extrapolated as a roundwood diameter of up to 60mm).

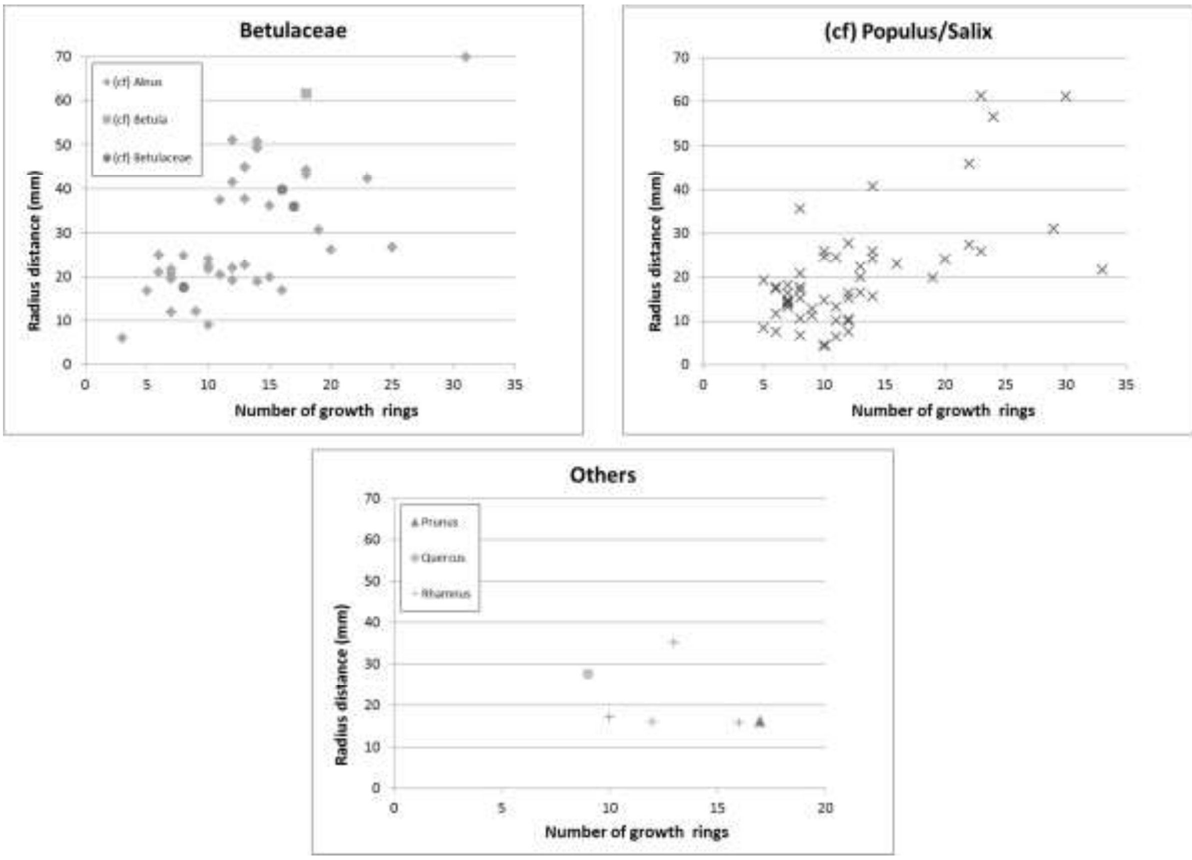

Figure 55 Growth ring counts radial distance, for fragments with bark and pith present (n = 103).

<u>Season of felling</u>

For most of the fragments, the season of felling could not be reliably determined due to a variety of the following reasons: absence of bark, degradation of the outer wood edge, compression of the wood, and/or the outer growth ring being too narrow. For some fragments, the data were not available. Figure 56 shows the results of the fragments which had an outermost growth ring suitable for determining the season of felling (based on the presence/absence of larger earlywood vessels and smaller latewood vessels). For both Alnus and Populus/Salix the majority were felled later in the growth year, when (at least some) latewood growth had occurred.

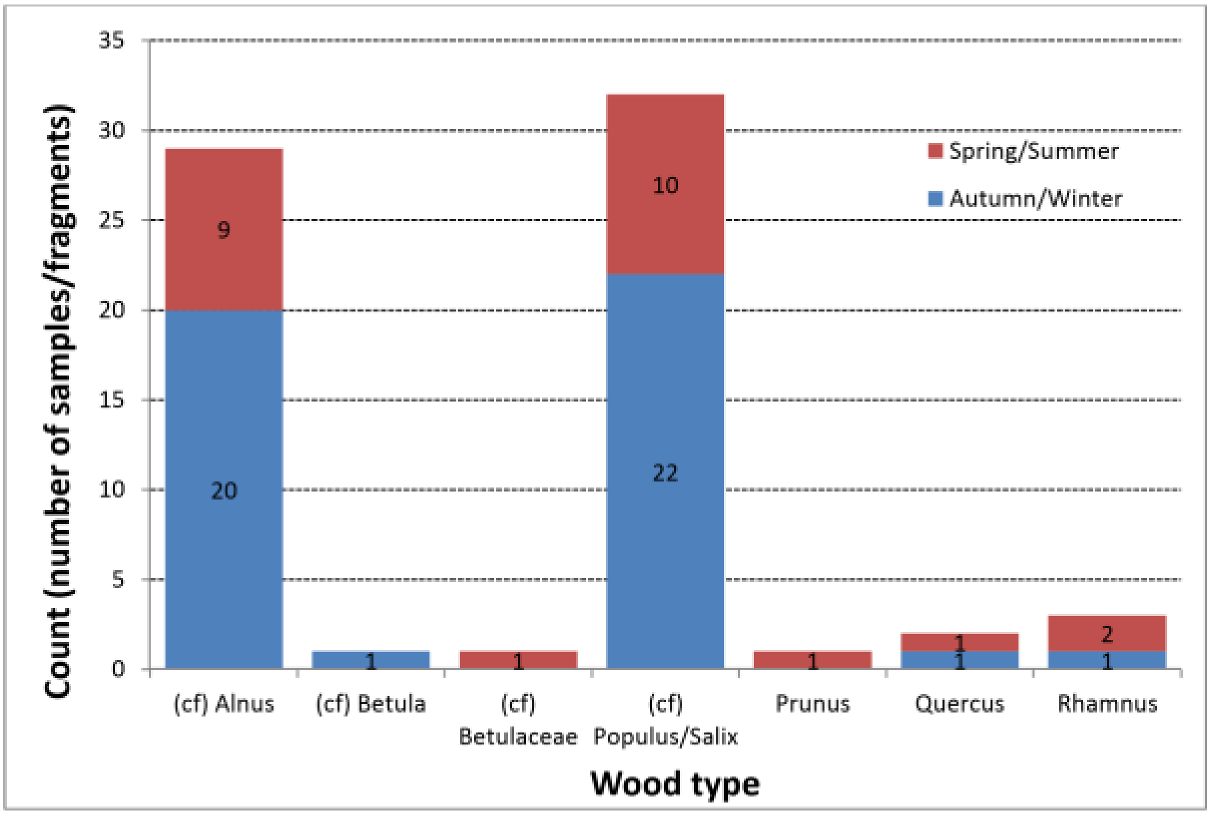

Figure 56 Felling season information, for samples that were identifiable, not including 'Indeterminate' felling season results.

<u>Insect degradation</u>
Three fragments showed evidence of degradation by beetles, in the form of their galleries within the wood. These fragments were: 199, 204a and 204b, all of which were remains of wood reburied by Bulleid and Gray from Trench 3. The wood appears to be compressed, suggesting that identifying the beetle types may not be possible, as the shape and size of the galleries has been altered (less circular and more oval). It is not clear whether this damage was already present when the timbers were first used at the site, or whether it has occurred subsequently, such as at the time of the 1800-1900 excavations.

<u>Compression of the remains</u>
A compression ratio was calculated for the fragments that had more than ¾ of the bark remaining around the outside edge (n = 75). Any less than this amount of bark meant that it was less likely that the cross section being measured for the two diameter measurements was complete – if any part of the wood was missing (decayed/eroded) then that would have underestimated the diameter. Where both ends of the wood sample had been measured due to different amounts of compression along the fragment, the results of the most compressed end were plotted. Figure 8 shows the results, by taxa. Most of the wood types show a range in the amount of compression, with fragments with average diameters below 80mm showing greater compression. Most of the indeterminate samples tend to be smaller diameter pieces, with compression ratios as low as 0.3-0.4; reason in itself for making them hard/impossible to identify.

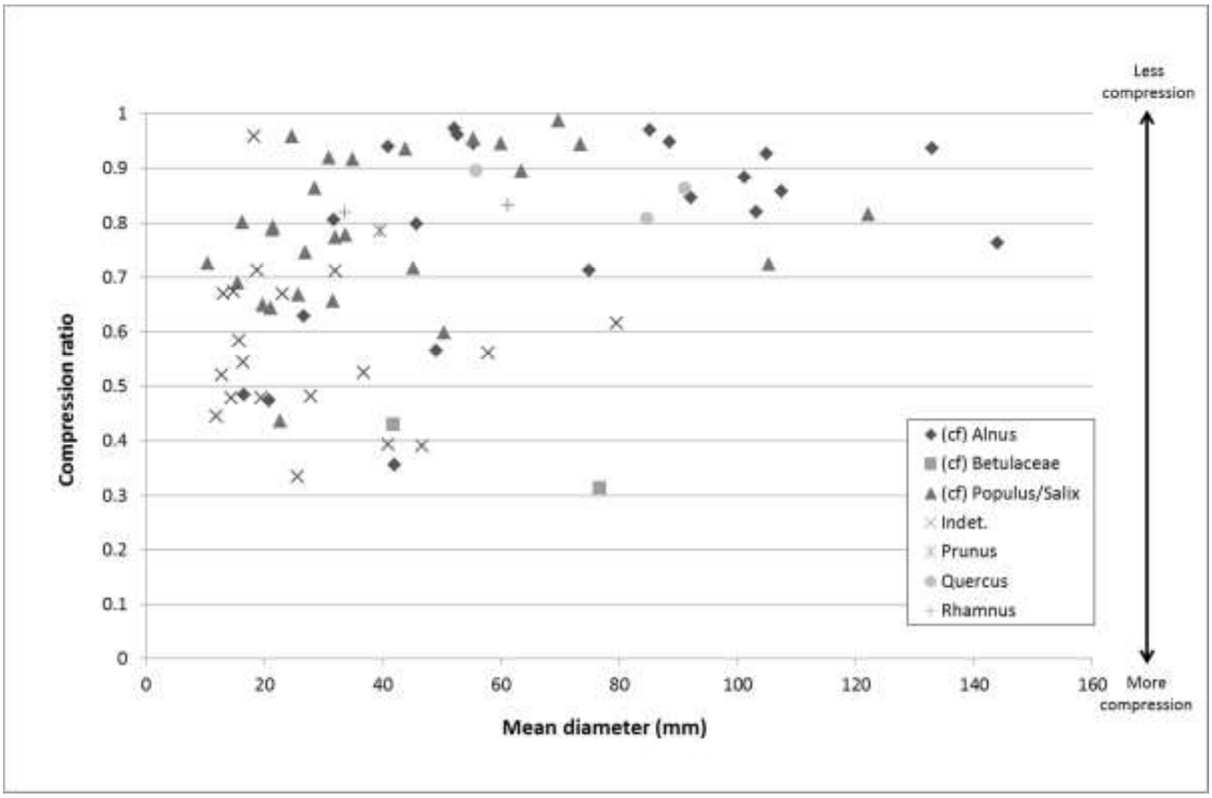

Figure 57 Wood compression data for the suitable fragments (n = 75).

<u>Summary and Conclusions</u>

The results of the wood identifications and wood recording of the samples recovered from the 2014 excavations at Glastonbury Lake Village, show the dominance of Alnus (alder) and Populus/Salix (poplar/willow), together with some Betula (birch), Fraxinus (ash), Prunus (cherries), Quercus (oak) and Rhamnus (buckthorn). Alder and poplar/willow, together with birch and buckthorn, are all taxa associated with damp and/or peaty soils, and so are likely to have been sourced from, or very near to, the site. The large sample size (c 300) suggests that the limited number of wood types identified at the site as a whole (seven) is real, rather than a result of a small sample size.

Of the fragments with a complete radial section, the majority had between 5-20 growth rings. Of those that had a clear outer ring for determining the felling season, most had at least some latewood vessels present, suggesting that they could have been felled in Autumn/Winter, as would be expected when the tree is dormant. Although it seems unlikely that coppicing was taking place (an absence of morphological evidence, together with a broad spread of sizes and ring counts), and rather that unmanaged alder/willow carr was being exploited (possibly with the assistance of beavers (Brunning, pers. comm.)), much of the material examined (particularly of Alnus and Populus/Salix) seemed to derive from stems younger than 15 years and less than 60mm in diameter. This selection was likely driven by the requirement for similar- and regularly-sized timbers for the production of uniform structures, such as the palisade.

The highest proportion of unidentifiable remains (not identifiable due to poorly preserved wood) is in Trenches 1 and 2, in the north of the site. Reasons for this are likely to be a complex mix of factors, including the site's hydrological conditions both at the time of use and at the time of the Bulleid and Gray excavations, and the extent and duration of the remains' exposure (degree of desiccation) during those works (Brunning, pers. comm.).

5.4 Woodworking

5.4.1 Trench 1

Wall post of roundhouse 59

Only one stake (41) was fully excavated from this roundhouse, associated with floor 3 of that mound. It was a 57mm diameter roundwood with bark on and survived to a length of 300mm. It was cut to a chisel point over 143mm by a series of axe blows at 2-20° angles, leaving flat facets up to 77mm long and 45mm wide.

Figure 58 Worked end of roundhouse post 41

Palisade post 87

None of the worked ends of the posts were recovered but one of the posts (87) retained evidence that its top end had been cut to a pencil shaped point. This had been achieved by a series of axe blows delivered on all sides at angles of 3-10° leaving facets a maximum of 79mm long and 16mm wide.

Figure 59 The cut top end of post 87

Vertical post 46

Post 46 was a radially split piece of oak 756mm long, 100mm wide and 85mm broad. It retained its sapwood on one side and had been carefully cut into a vaguely oval shape. The tip had broken across a circular or oval perforation, 30mm across, which was going through the timber tangentially on the heartwood side. This suggests that it was originally was a larger radially split timber with a circular hole that had subsequently been cut to a point to produce a post.

5.4.2 Trench 2

Roundhouse wall posts (Group 9)
Five of the wall posts were excavated and displayed cut ends (67, 68, 70, 73 and 75). All had been cut on several sides to form a pencil shaped point, over lengths of 120-170mm. The condition of the toolmarks varied from good to poor. Where they were well preserved, the axe facets were flat in character and had clean junctions. Maximum facet widths varied between 12mm and 35mm and maximum facet lengths of 110-140mm. The surviving facets had been delivered by axe blows at 1-10°.

Figure 61 Post 67

Figure 60 post 75. Scale 5cm intervals

Oak timbers (Group 10)
Three of the oak piles in this group exhibited evidence of working. Pile 50 was a quarter split timber and piles 48 and 49 were radial splits. Pile 50 retained its sapwood and bark on its outer edge. The other two pile shad been cut down on all their sides to produce a roughly circular cross section. Only the tops of the piles were lifted, the worked ends remaining *in situ.*

5.4.3 Trench 3

Wood reburied by Bulleid and Gray
The material reburied by Bulleid and Gray consisted entirely of pieces of oak. The condition of the material moderately poor with evidence of decay and in many instances modern roots penetrating through the wood. Despite this, and the proximity to the surface some sapwood survived on many of the pieces, albeit in a shrunken and diminished condition.

Of the 25 reburied items, 18 were oak, 2 ash, 2 willow/poplar, 1 birch and 2 unidentified (table 10). Woodworking waste accounted for most of the material, with 13 probable woodchips and 4 offcuts or split fragments. Most of this part of the assemblage was radial in cross section with a few tangential items. This suggests that the woodworking waste was produced from the production and finishing of large substantial timbers, mainly of oak and ash. This is in marked contrast to the material seen in the walls and flooring of the roundhouses, which are smaller roundwood of different species. This material therefore represents evidence of woodworking that may have been connected to the production of finer pieces of furniture or more complex construction, such as the planking seen in the causeway on the site.

The remaining 8 timbers were all oak planks or plank fragments, six of them radially split and two tangentially split or axed. Most of the larger planks were recorded and sampled in situ but were not lifted. Two of the planks had a perforation or notch and two others had a mortice hole.

Table 10. Details of reburied timbers from Trench 3. Where the lengths are given with a '+' symbol this is because the timber was cut off at the baulk to permit its removal.

Wood No.	Species	Length mm	Width mm	Thick mm	Conversion	Function	Note
198	Oak	164	66	20	radial	woodchip?	1 cut end, 1 broken
199	-	160	82	13	radial	woodchip	Axe cuts both ends
201	Ash	125	35	16	intermediate	woodchip?	Roots growing through
202	Oak	165	60	7	Radial	woodchip	Bent over end
203	Oak	180	54	24	Tangential	woodchip	Root damage
204a	-	90	77	11	Radial	woodchip	
204b	birch	135	66	18	Radial	woodchip	
205	Willow Poplar	160	70	29	Intermediate	woodchip	Ends broken
206	Oak	1100+	165	30	radial	Plank	
207	Oak	970+	185	30	radial	Plank	
208	Oak	255	90	19	Radial	plank frag.	Perforation at one end
209	Oak	146	51	12	Tangential	Woodchip	1 end broken, 1 cut
210	Willow Poplar	155	53	33	Radial	Woodchip?	
211	Oak	1309	480	64	tangential	Large plank	Broken ends
212	Oak	375+	73	4	Radial	Container	Perforation at one end
213	Oak	1340+	210	48	Tangential	plank	
214	Oak	948+	170	20	radial	plank	
215	Oak	215	74	12	Radial	woodchip	
216	Oak	390	55	12	Radial	Plank frag.	In many pieces, v. decayed
217	Oak	92	44	12	Radial	Woodchip	v. decayed
218	Oak	74+	64	16	Radial	Woodchip?	Roots growing through
219	Oak	145+	60	18	Radial	Split frag.	
220	Oak	110+	63	12	Radial	Offcut?	Sapwood shrunk
221	Oak	170+	58	10	Radial	Offcut?	Bad root damage
222	Ash	160+	39	22	Intermediate	Split frag.	Root damage

One radial oak timber had a 'U' shaped perforation at one end, 43mm along the plank and 24mm across it. As that end was broken, it is possible that this represents part of a rectangular mortice hole. Another radial piece (222) had a notch, 15mm deep and 23mm along its length, at the end where it had been cut to permit removal from the trench. It does not appear to have been part of a complete perforation.

Plank 206 had a rectangular mortice, 140mm by 60mm, about 300mm from one end. Plank 213 had a roughly rectangular hole with rounded corners, 100mm by 60mm, 55mm from the end of the plank. Based on the size of the timbers and the location of the perforations on them, it is possible to identify probable matches with timbers recorded by Bulleid. Timber 213 appears to be the timber depicted on the plan of mound LVII (excavated 1896) (Bulleid and Gray 1911 plate XXIX opp. p.140). Timber 206 may be a timber originally recorded in the foundations of the east side of Mound VI (*ibid* plate XII opp.p.76), which was also excavated in 1896. The large timber (211), which is separate from the other reburied material, may be the timber shown in the west wall foundation of mound IV (*ibid* plate VII opp. p.64) that was excavated in the next year, 1897.

One very thin (3-4mm) radial oak timber (212) had been finely shaped and may be part of a container. One end is incomplete (where it left the trench), but the other end is cut to a shallow 'V' shape across the timber (fig.62). A 5mm diameter perforation exists 45mm from the point of the 'V'. On one side a shallow depression or dent leads away from the hole, as though made by a binding that passed through it. Bentwood box side plates are known from the site (*ibid* 311-4, 318-9, Plate L and fig. 78) and it is possible that this fragment represents part of a similar container. The long edges of the plank are somewhat irregular, so it is possible that other stitching holes may have been present and subsequently broken. The other bentwood boxes from the site had intricate decorative patterns on them, so it is possible that undecorated examples may have been missed during the original excavation.

Figure 62 Possible bentwood box fragment (212)

Figure 63 Close up of the stitch hole in the possible bentwood box fragment, with the impression left by the binding on the left-hand side of the hole

5.4.4 Trench 4

Posts beside the doorway (Groups 15 and 16)
Only one of these items had toolmarks surviving. Wood 157 had been cut on its narrow (17 wide) face over 30mm at one end at 30° leaving a single flat facet.

Wall posts (Groups 13-16 and 18)
When recovered whole, the wall posts all had bottom ends that had been cut to a point. In many cases the toolmarks were in a poor state of preservation. Wedge shaped points predominated with 8 examples compared to 4 each of pencil and chisel shaped points. The points had been fashioned by blows by axe or billhooks over lengths of 50-200mm, delivered at angles which ranged from 1-40°. Facet lengths were 30-80mm, and facet widths, largely

determined by the small diameters of the material, were 27-44mm. Where the facets survived well, they were flat in cross section, reflecting the use of a narrow iron blade.

Figure 64 Posts 120 126 and 129

Woodworking waste (context 36)

Wood chips were recovered from several contexts in this trench. The main assemblage consisted of 74 woodchips and small offcuts from Context 36, where they appeared to be part of an early peaty floor level, or sub-floor foundation. They were present in a compact layer suggesting that they were all deposited at the same time. The species composition was limited to just alder (12 examples) and willow/poplar (22 examples), which also suggests that they may have been produced from one burst of activity.

Their sizes and dimensions are listed in table 11 and shown in figures 65 and 66. Their lengths ranged between 26mm and 180mm, widths 15-110mm and thicknesses of 3-27mm. Most of the woodchips were 30-100mm in length and 3-10mm in thickness. There were 27 radial woodchips, 32 tangential of which 15 were mainly bark, 9 of intermediate conversion and 7 roundwood.

Facets made by the tools which created the woodchips survived on 12 examples although 5 of there were in very poor condition. Most of the woodchips were broken at the ends. The facets on two of the woodchips (318 and 321) were deeply concave across their width, suggesting that they had been made with a narrow, curved blade such as a small adze, rather than an axe or billhook.

The morphology of the woodchips suggests that they could have been created through the cutting of small roundwood to a point but also possibly through the working of small logs to create a flatter surface. This would be consistent with the processing of material for the walling of the roundhouse and for the dressing of logs used in the flooring foundations.

Figure 65 woodchips from context 36

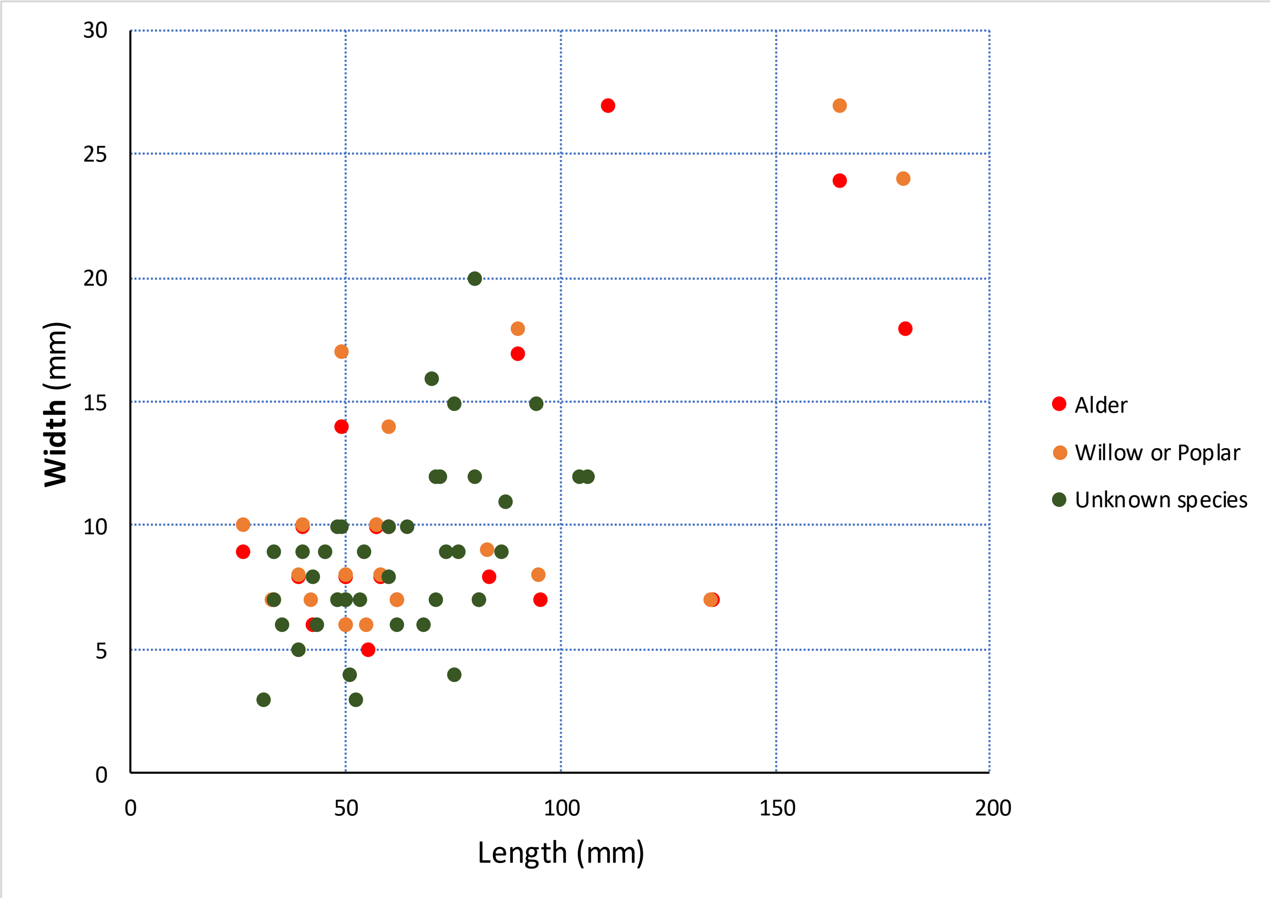

Figure 66 Dimensions of woodchips from context 36

Table 11 context 36 woodchips and offcuts

No.	Length (mm)	Width Diam max/min	Thick (mm)	Conversion R-Radial I-Intermediate T-tangential	Comments
307	80	77	20	T	Axe cut one end, other broken. From outer edge of c.120mm log
308	70	12/20	-	Whole	Compressed, broken ends
309	70	31	9	I	Woodchip
310	180	110	18	R bark	Cut in a curve (adze?) on one end, rest is just split face
311	165	28/19	-	Whole	Compressed. If cut at ends, very eroded. No clear facets.
312	53	35	7	R	No facets. Small triangular fragment
313	40	38	9	R bark	Cut one end, broken at the other
314	90	65	17	T	No bark. Poss cut facet on outer edge – not clear
315	135	31	7	T bark	Slither of bark and outer ring
316	71	45	12	R	Small woodchip. Poss axe cut one end
317	48	24	7	R	Small woodchip. cut one end
318	94	40	15	T Bark	Woodchip from outer face. Both ends cut. Facet 35mm wide and curving – like a curved adze blade – 10mm deep across the 35mm
319	72	44	12	T	Fragment from outer rings under the bark. Ends broken.

No.	Length (mm)	Width Diam max/min	Thick (mm)	Conversion R-Radial I-Intermediate T-tangential	Comments
320	64	52	10	T bark	Broken woodchip, bark and first two rings. No toolmarks
321	49	50	14	T bark	Woodchip. Mainly bark with slither of sapwood. Cut one end, 46mm wide and 2.5mm deep. Curving cut like an adze
322	106	50	12	T	Woodchip, cut both ends so one of a series. Facets not v. sharp
323	95	58	7	T bark	All bark, axe cut on one corner
324	85	17	8	Whole	Compressed roundwood, no axe cuts
325	55	31	5	I	No facets, ends broken
326	58	33	8	T	Ends broken
327	52	28	3	I	Ends broken
328	50	15	6	T bark	All bark. Small frag no cuts
329	68	21	6	T bark	Bark and inner ring, no cuts
330	83	42	8	R	Ends broken. Broken woodchip
331	80	34	12	R	No facets
332	63	37	8	R	Small woodchip. No facets, one broken end
333	111	35/20	-	Whole	One end broken, one eroded
334	75	22/9	-	Whole	Compressed roundwood, broken ends
335	81	23	7	R	Small broken frag
336	48	26	7	R	Small broken frag
337	38	28	4	T bark	Small bark frag
338	62	30	6	T bark	Small bark frag with first couple of rings
339	84	20	5	T bark	Small bark frag
340	60	22	8	I	Small frag, no facets
341	48	63	10	T bark	Small bark frag with first couple of rings
342	50	33	8	T	Broken tangential frag, no facets
343	42	48	8	T	Broken ends of tang woodchip
344	51	26	4	R	Small radial woodchip, ends broken
345	81	21	7	T	Small broken frag, no facets
346	45	27	9	T	Small eroded woodchip, no clear facets
347	57	43	10	T	Broken one end, probable facet other end. Eroded surface
348	79	20/11	-	Whole	Compressed roundwood, broken ends
349	60	45	10	R	Small woodchip, broken ends
350	50	24	7	T	Small woodchip, broken ends
351	76	26	9	R	Small woodchip, broken ends
352	50	26	7	T	Small woodchip, broken ends
353	35	27	6	I	Small woodchip, broken ends
354	31	37	3	R	Small woodchip, broken ends
355	26	32	9	T bark	Small piece of bark
356	39	41	5	R	Small woodchip
357	60	38	10	R	Small woodchip, broken ends
358	73	36	9	R	Small woodchip, broken ends
359	57	41	10	R	Small woodchip, broken ends
360	39	33	8	R	Small woodchip, poss cuts at both ends
361	33	43	9	R	Small woodchip, broken ends
362	50	35	8	I	Small woodchip, broken ends

No.	Length (mm)	Width Diam max/min	Thick (mm)	Conversion R-Radial I-Intermediate T-tangential	Comments
363	54	40	9	T	Small woodchip, broken one end other may be cut
364	33	30	7	R	Small woodchip, broken ends
365	37	47	8	T	Small woodchip, one broken end the other cut
366	43	43	6	R	Small woodchip, broken ends
367	47	28	7	R	Small woodchip, broken ends
368	40	20	10	T	Broken fragment of larger woodchip
369	62	30	7	T bark	Small bark frag with outer couple of rings, no facets
370	75	26	4	R	Small woodchip, one end cut poss complete
371	33	33	7	R	Small woodchip, one end cut,poss complete
372	165	64	19	T bark	Large bark strip, ends broken, outer couple of rings too –cut off
373	87	51	11	T bark	Bark and outer couple of rings, must be woodchip
374	86	75	9	I	2 cuts on one face, one at the end
375	42	32	6	T	Small wodchip, one broken end one cut but damaged
376	49	50	10	I	Small woodchip, broken ends
377	104	52	12	R	Woodchip, part of cut at one end
378	125	49	19	I	Woodchip, broken ends but cut on longer sides
379	73	49	9	R	Small woodchip, poss complete but no good facets
380	71	43	7	T	Woodchip, ends broken

5.4.5 Trench 5

Only one of the palisade posts was completely lifted and none of the other worked ends of the posts were visible during the excavation. All the posts and horizontal material recovered from the trench were roundwood, apart from post 294 that was half split. The one complete timber was a post (297) from palisade 28. It had been cut to a chisel shaped point over 85mm, with a series of three flat axe facets visible, up to 39mm wide and 51mm long. The 39mm wide facet had a perfectly flat jam curve across its whole width.

Figure 67 Post 297

Figure 68 post 297 cut end

6 Scientific dating *Peter Marshall, Nigel Nayling, Roderick Bale, Christopher Bronk Ramsey, Elaine Dunbar, Paula Reimer*

6.1 Previous dating exercises

Dr Robert Munro after reviewing the artefactual evidence in his introduction to the first monograph (Bulleid & Gray 1911), concluded that the date of the settlement ‘should be, at least provisionally, restricted to a period of 150 years, extending from 100 B.C. to 50 A.D’ (Munro 1911, 35; Fig 69). Further attempts to provide timings for the settlement variously suggested a beginning in c 250–200 BC and abandonment in c AD 50 (Tratman 1970, 164–6) and duration of about 100 years from c 150±50 to 50±50 BC (Clarke 1972, 829). Although two radial oak planks from the 1984 SLP excavations produced tree ring series of 99 and 117 rings (Coles et al. 1988, table 17) they failed to date, as have subsequent attempts using the original ring-width measurements (C Tyers pers comm). The first two radiocarbon dates from the site (Q-2618–9) were obtained in 1984 on samples from a fairly woody Carex and Cladium fen sedge peat that the Causeway was constructed on (Housley 1988, 81, fig 83) and confirmed a late Iron Age date for the occupation.

The first attempt to provide a comprehensive independent scientific chronology for the date of the site was undertaken in 1993–5 (Coles & Minnitt 1995). Nine determinations (Table 16; Bronk Ramsey et al. 2002) were obtained from the 15 samples submitted to the Oxford

Radiocarbon Accelerator Unit with the calibrated dates providing ‘a potential maximum time span of 792BC to AD145 or a minimum span of 472–8BC’ (Coles & Minnitt 1995, 176; fig 6.16). The authors concluding that the ‘structural and artefactual evidence do not support either possibility’ (Coles & Minnitt 1995, 176).

Based on the extremely rich assemblage of artefacts from the site, Coles & Minnitt (1995, 176–8) concluded it was established in about 250 BC and abandoned in c. 50 BC. Subsequently a further review of the currency of the brooches (Haslegrove 1997) argued for a slightly later date for middle and late settlement phases (Fig 69) that Coles and Minnitt (2000, 178) used to derive an estimate for its occupation of 170 years.

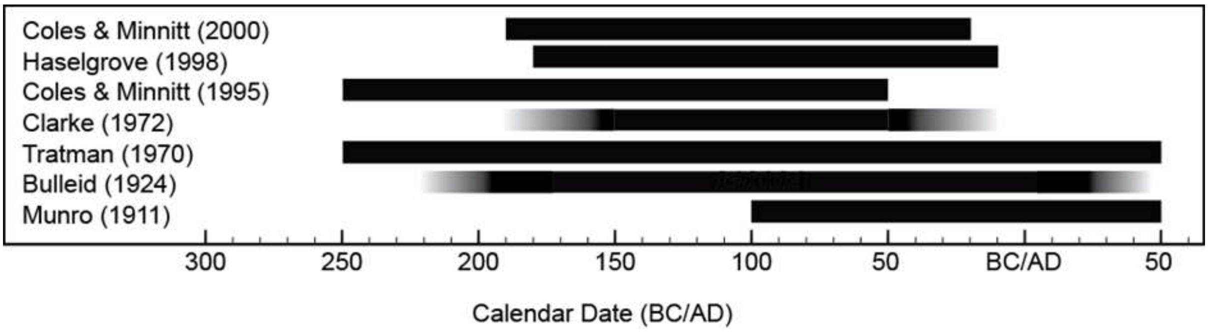

Figure 69 previous estimates for the date of Glastonbury Lake Village

6.2 Dendrochronology and radiocarbon wiggle matching of oak timbers

The detailed methodology and supplementary information, such as raw ring-widths, can be found in the Historic England scientific dating report (Nayling et al. 2017). Five oak samples were deemed suitable for tree-ring analysis from the 16 samples of large roundwood obtained from the site (Table 12). None of the five measured samples cross-dated with the two previously measured samples from the site (Coles et al 1988, table 17) or with external reference chronologies, so it is not possible to provide calendar dates for any of the timbers. However, two sets of two samples (GLV 206 and 214 and GLV 207 and 213) crossmatch against each other (Tables 13 and 14; Figs 70 and 71). Unfortunately, none of these samples contained sapwood or definite heartwood/sapwood boundary. The relatively high t-values between the two timbers from each of the two sets of relatively-dated timbers suggest that the parent trees in each of the two groups were growing in relatively close proximity and, based on visual observation of the samples and the ring series, a possible same-tree derivation cannot be discounted. The failure of GLV 211 to cross date against the other timbers may be a result of it being attributed by Coles and Minnitt (1995) to the ‘early phase’ of occupation rather than the ‘late phase’ from which the two other groups of samples were derived.

Sample	Conversion	Cross section (mm)	Number of rings	Sapwood	ARW (mm)	Date range	Interpretation
GLV 206	Radial	150 x 30	157	+?HS	0.99	1–157	167–203?
GLV 207	Radial	160 x 20	150+11h unmeasured	-	1.07	1–150	after 171
GLV 211	Tangential	280 x 50	113	+?HS	1.48	1–113	123–59?
GLV 213	Radial	200 x 35	159	-	1.14	13–171	after 181

GLV 214	Radial	110 x 20	122	-	0.92	35–156	after 166

Table 12 Details of samples analysed from Glastonbury Lake Village

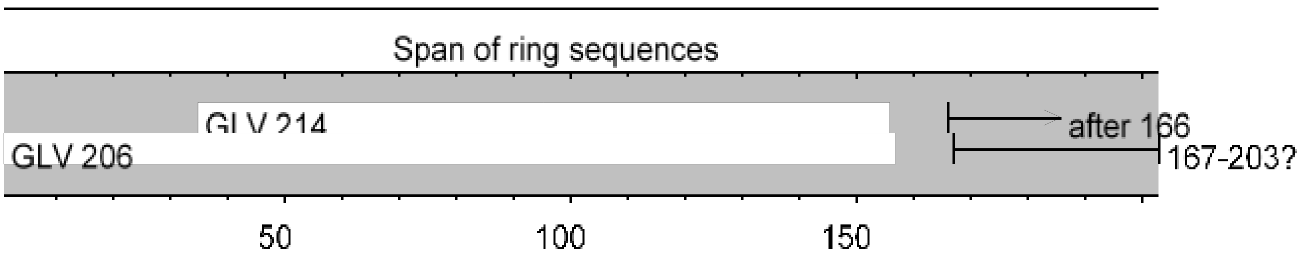

Figure 70 Bar diagram showing position of matching between GLV 206 and GLV 214 and the individual relative felling dates.

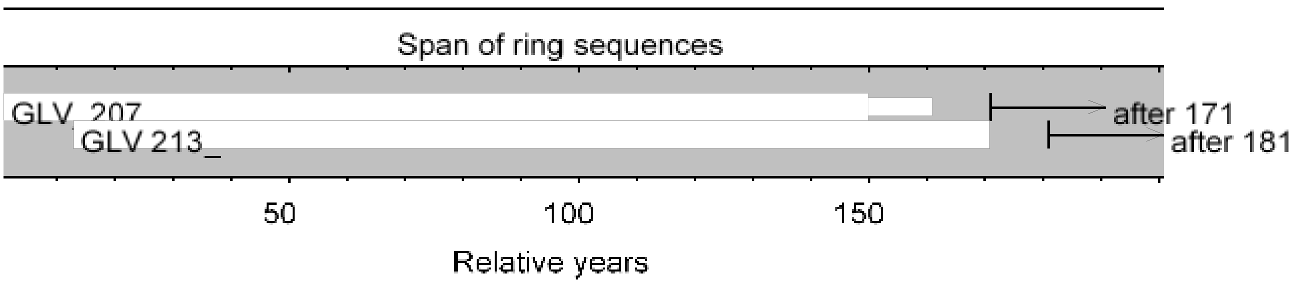

Figure 71 Bar diagram showing position of matching between GLV 207 and GLV 213 and the individual relative felling dates

Filenames	-	-	GLV 206	GLV 214
-	start	dates	1	35
-	dates	end	157	156
GLV 206	1	157	*	7.18
GLV 214	35	156	7.18	*

Table 13 t-value and position of match between GLV 206 and GLV 214

Filenames	-	-	GLV 213	GLV 207
-	start	dates	13	1
-	dates	end	171	150
GLV 213	13	171	*	8.99
GLV 207	1	150	8.99	*

Table 14 t-value and position of match between GLV 207 and GLV 213

Following the tree-ring analysis described above, two samples (each of five annual rings) were taken from oak timber GLV 206, for radiocarbon wiggle matching (Galimberti et al 2004). These were taken from the beginning (rings 1–5) and end (rings 153–157) of the 157-year sequence of GLV 206 with a possible heartwood/sapwood boundary. These range finder dates would enable us to better understand where the actual date of the timber fell on the radiocarbon calibration curve and whether submission of further samples might be merited to help in dating the occupation of the site.

In addition, samples of five-year blocks of annual growth rings for radiocarbon wiggle-matching were submitted from timbers GLV 47 and GLV 48(1), two oak posts that had been driven through the mortice holes of a substantial oak beam excavated in Trench 2 (Fig 1). As these lie underneath the floors of Mound 75 and under the later floor of Mound 74, dating them will provide a constraint for the construction of the floors on these mounds. GLV 47 contained 13 rings including two sapwood rings and possible bark edge. Two samples (rings 1–5 and 9– 13) were dated. GLV 48(1) contained 33 rings including six sapwood rings. Two samples (rings 1–5 and 29–33) were dated from timber GLV 48(1).

The results are conventional radiocarbon ages (Stuiver and Polach 1977; Table 15) and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). Two pairs of replicate measurements are available on samples that were divided and submitted for dating to different laboratories. Both these pairs of measurements are statistically consistent at 95% confidence (Table 15; Ward and Wilson, 1978) and have been combined by taking a weighted mean before calibration (Ward and Wilson 1978) and inclusion in the wiggle-matches.

Laboratory number	Sample reference	Material & context	$\delta^{13}C$ (‰)	Radiocarbon Age (BP)
		GLV 47		
UBA-28809	GLV 47, rings 1–5	Waterlogged wood, *Quercus* sp. heartwood rings 1–5 (R Bale) from timber GLV 47 one of three oak posts that had been driven through the mortice holes of a substantial oak beam. These lie underneath the floors of Mound 75 and under the later floor of Mound 74	−27.1±0.22	2177±39
UBA-28810	GLV 47, rings 9–13 – sample A	Waterlogged wood, *Quercus* sp. heartwood (3) and sapwood (2) rings 9–13 (R Bale) from timber GLV 47 one of three oak posts that had been driven through the mortice holes of a substantial oak beam. These lie underneath the floors of Mound 75 and under the later floor of Mound 74	−27.0±0.22	2172±31
OxA-31792	GLV 47, rings 9–13 – sample B	Replicate of UBA-28810	−25.1±0.2	2245±30
		^{14}C: 2149±19 BP, T'=0.3; $\delta^{13}C$: −26.0±0.15‰, T'=40.8		
		GLV 48(1)		
SUERC-59108	GLV 48(1), rings 1–5	Waterlogged wood, *Quercus* sp. heartwood rings 1–5 (R Bale) from timber GLV 48(1) one of three oak posts that had been driven through the mortice holes of a substantial	−24.6±0.2	2223±29

Laboratory number	Sample reference	Material & context	δ[13]C (‰)	Radiocarbon Age (BP)
		oak beam. These lie underneath the floors of Mound 75 and under the later floor of Mound 74		
UBA-28811	GLV 48(1), rings 29–33 - sample A	Waterlogged wood, *Quercus* sp. sapwood rings 29–33 (R Bale) from timber GLV 48(1) one of three oak posts that had been driven through the mortice holes of a substantial oak beam. These lie underneath the floors of Mound 75 and under the later floor of Mound 74	−27.4±0.22	2140±25
OxA-31793	GLV 48(1), rings 29–33 sample B	Replicate of UBA-28811	−25.2±0.2	2158±26
^{14}C: 2210±22 BP, T'=2.9; δ^{13}C: −26.2±0.15‰, T'=54.8				
		GLV_206		
SUERC-59112	GLV 206, rings 1–5	Waterlogged wood, *Quercus* sp. heartwood rings 1–5 (R Bale) of a 157 rings sequence, from timber GLV 2016, from a collection of worked timbers that were excavated by Bulleid and Grey and reburied on-site. Originally possibly a timber from the east side of Mound VI.	−24.9±0.2	2425±29
UBA-28812	GLV 206, rings 153–157	Waterlogged wood, *Quercus* sp. heartwood rings 153–157 (R Bale) of a 157 rings sequence, from timber GLV 2016, from a collection of worked timbers that were excavated by Bulleid and Grey and reburied on-site. Originally possibly a timber from the east side of Mound VI.	−26.8±0.22	2154±24

Table 15 Glastonbury Lake Village radiocarbon and δ13C measurements. Replicate measurements have been tested for statistical consistency and combined by taking a weighted mean before calibration as described by Ward and Wilson (1978; T'(5%)=3.8, v=1).

GLV 206 wiggle-match

The chronological model for the dating of timber GLV 206 is shown in Figure 72. This incorporates the information that the centre of the block dated by SUERC-59112 (ring 3) is 152 years earlier than the centre of the block dated by UBA28812 (ring 155) and that there is then two years to the possible H/S boundary. The radiocarbon dates and prior information derived from the tree-ring analysis (the relative number of years between the samples) have good agreement (Acomb=106.7%, An=50.0%, n=2). The model provides an estimate for the formation of the last ring of the tree-ring sequence (?H/S boundary) of the timber of 355–285 cal BC (95% probability; GLV 206_HS; Fig 4), probably 350–315 cal BC (68% probability).

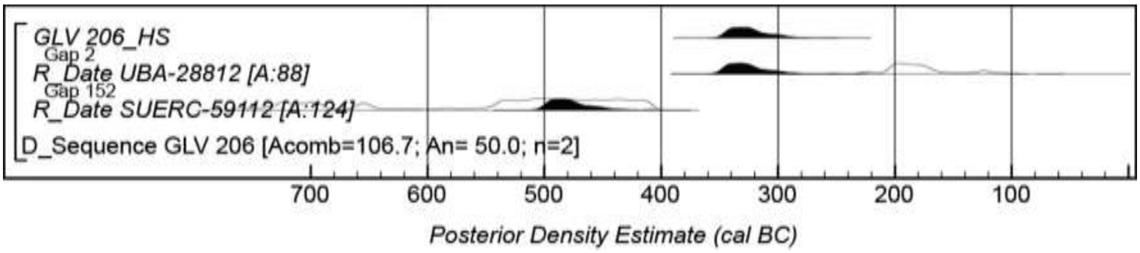

Figure 72 Probability distributions of dates from timber GLV 206. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the simple radiocarbon calibration, and a solid one, based on the wiggle-match sequence. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

GLV 47 wiggle-match

The chronological model for the dating of timber GLV 47 is shown in Figure 73. This incorporates the information that the centre of block dated by UBA-28809 (ring 3) is eight years earlier than the centre of the block dated by Combine rings 9–13 (ring 11) and that there is then two years to the ?bark edge. The radiocarbon dates and prior information derived from the tree-ring analysis (the relative number of years between the samples) have good agreement (Acomb = 105.6%, An=50.0%, n=2). As the timber had possible bark edge, the model provides an estimate for the felling of the timber of 355–195 cal BC (95% probability; GLV 47_felling; Fig 5) and probably 340–275 cal BC (46% probability) or 245–200 cal BC (21% probability).

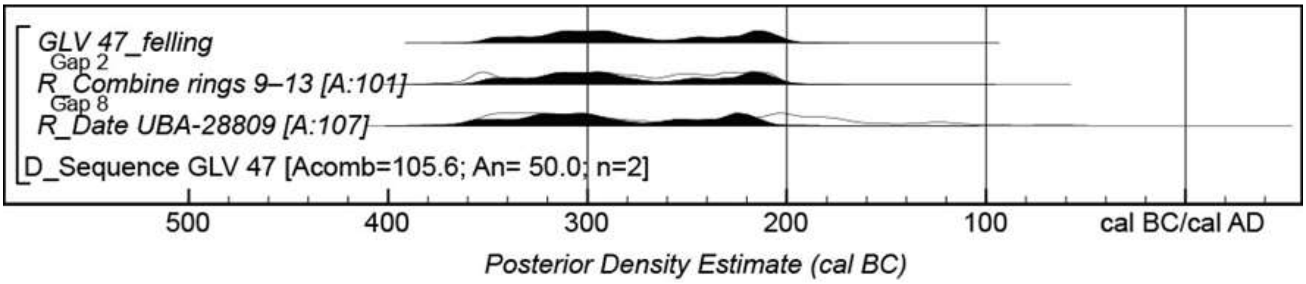

Figure 73 Probability distributions of dates from timber GLV 47. The format is identical to Figure 72

GLV 48(1) wiggle-match

The chronological model for the dating of timber GLV 48(1) is shown in Figure 74. This incorporates the information that the centre of block dated by SUERC59108 (ring 3) is 28 years earlier than the block dated by Combine rings 29-33 and there are then two years until the last ring of the sequence (ring 33). The radiocarbon dates and prior information derived from the tree-ring analysis (the relative number of years between the samples) have good agreement (Acomb = 112.5%, An=50.0%, n=2). The model provides an estimate for the formation of the last ring of the tree-ring sequence of the timber of 350–310 cal BC (26% probability; GLV 48(1)_outer_ring; Fig 6), or 230–165 cal BC (69% probability), probably 335–320 cal BC (9% probability) or 205–175 cal BC (59% probability).

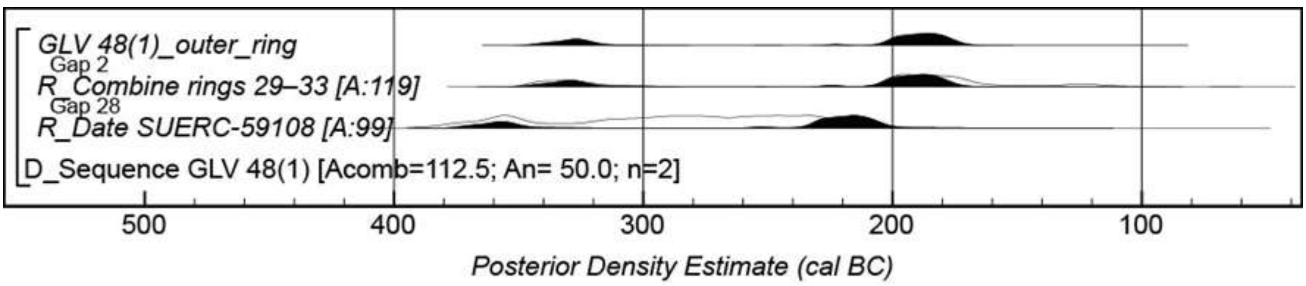

Figure 74 Probability distributions of dates from timber GLV 48(1). The format is identical to Figure 72

Estimating felling dates

In order to derive an estimate for the felling date of timbers GLV 206 and GLV 48 the probability distribution for the number of sapwood rings, for native English oak (Bayliss and Tyers 2004, table 1), truncated to allow for the extant sapwood rings in the case of timber GLV 48), has been applied to the estimated date for the final measured ring of both tree-ring sequences in order to produce an estimate for the felling date of the timbers. The final ring of timber GLV 206, ring 157, is the possible H/S boundary (GLV 206_HS), and the addition of a sapwood estimate (Bayliss and Tyers 2004, table 1) provides an estimate for its felling of 345–265 cal BC (95% probability; GLV 206_felling; Fig 7) probably 335–290 cal BC (68% probability).

For timber GLV 48(1) a sapwood distribution, that allows for the six surviving sapwood rings was calculated (Bayliss and Tyers 2004) and then added to the last dated ring (GLV 48(1)_ring_33; Fig 6). This suggests that timber 48 was felled in 340–280 cal BC (27% probability; GLV 48(1)_felling; Fig 75) or 205– 135 cal BC (68% probability) probably 320–305 cal BC (10% probability) or 195–150 cal BC (58% probability).

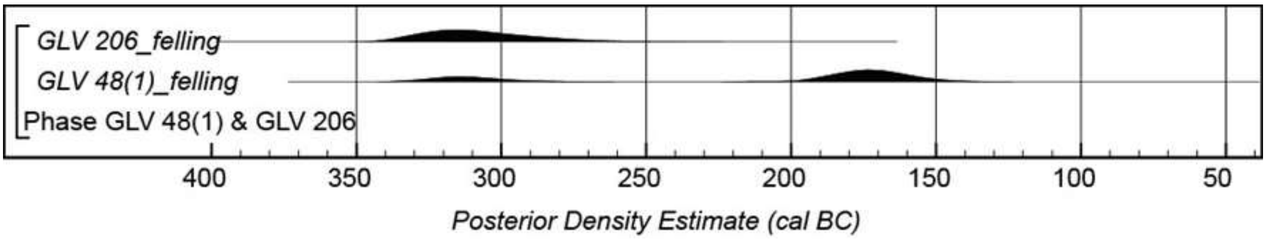

Figure 75 Probability distribution for the felling dates of the timbers GLV 48(1) and GLV 206. The distributions from Figs 73 (GLV 206_HS) and 74 (GLV 48(1)_outer_ring) have been shifted by the expected number of sapwood rings for ancient oak trees in England (Bayliss and Tyers 2004).

6.2.1 Interpretation

The lack of similarity of the tree-ring data from Glastonbury with chronologies from other parts of Britain suggests that either local conditions are masking the climatic signal on which the success of dendrochronological dating relies or that different climatic signals are being observed which would necessitate the construction of local chronologies. The radiocarbon wiggle-match results obtained on the three timbers dated have been included in chronological models discussed below.

6.3 Radiocarbon

The radiocarbon dating programme for Glastonbury Lake Village was conceived within the framework of Bayesian chronological modelling (Buck et al. 1996). This allows the combination of calibrated radiocarbon dates with archaeological prior information using a formal statistical methodology. At Glastonbury Lake Village stratigraphic relationships between wooden built structures and palisades were available to constrain the radiocarbon dates. Although the Iron Age has often been perceived as a period during which radiocarbon dating has little value, due to the existence of two distinct ‘plateaus’ in the radiocarbon calibration curve (Reimer et al. 2013) the impact of the Bayesian methodology (Bayliss 2009) is now beginning to become apparent on Iron Age chronologies (Hamilton et al. 2015).

6.3.1 Sampling

Given the large number of small timbers used to construct the structures and palisades of the settlement the number of potential samples without any inherent age-at-death offset was considerable. The sampling strategy was therefore designed to target structures where stratigraphic relationships between rebuilding episodes existed. Dates were obtained from 15 structural groups of waterlogged timbers (table 17). These included a series of collapsed palisades and associated horizontal timber at the southern edge of the settlement (Trench 5), nine sequential roundhouse walls from Mound 9 (Trench 4), a roundhouse wall from Mound 59 and adjoining palisade (Trench 1) and a roundhouse wall from Mound 74 (Trench 2).

Wiggle-matching (Galimberti et al. 2004) of three timbers (T47, T48(1) and GLV_T206; Nayling et al. 2017) was undertaken as discussed in the previous section. In addition, three of the samples dated at the Oxford Radiocarbon Accelerator Unit in the mid 1990s (Coles & Minnitt 1995, Bronk Ramsey et al. 2002) were resampled in 2015 to determine the accuracy of the original set of determinations given the improvement to bone pre-treatment in the last two decades (Bronk Ramsey et al. 2004). Two of the samples obtained in 2015 (B 357 and B 407) failed due to a low yield following pre-treatment (Table 16), and the one sample that was dated B 198 (OxA-32068), is statistically consistent (T'=0.2; T'(5%)=3.8; v=1; Ward and Wilson 1978) with the original measurement (OxA-4744). The fact that two samples that previously dated failed, might simply be due to the more rigorous suite of analytical parameters that is now routinely used to add additional screening to collagen used in radiocarbon dating (Bronk Ramsey et al. 2004).

Laboratory number	Material & context	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	Reference
OxA-4744	Animal bone (B 198), perforated horse/ox tibia (rom Mound 27, Floor 4	−21.1			2230±45	Coles & Minnitt (1995)
OxA-32068	Replicate of OxA-4744	−21.6±0.2	8.3±0.3	3.3	2206±28	
^{14}C: 2213±24 BP, T'=0.2;						
OxA-4749	Antler (B 357), sawn from Mound 74, floor 3	−21.2			2475±45	Coles & Minnitt (1995)
P38733	Replicate of OxA-4749	Failed due to low yield				
OxA-4747	Animal bone (B407), sawn bone from Mound 75, Floor 3	−23.2			2485±50	Coles & Minnitt (1995)
P38734	Replicate of OxA-4747	Failed due to low yield				
OxA-4745	Animal bone (B 217), perforated horse/ox tibia from Mound 18, floor 4	−20.8			2350±45	Coles & Minnitt (1995)
OxA-4746	Animal bone (B 406),	−21.1			2190±45	Coles &

Laboratory number	Material & context	$\delta^{13}C$ IRMS (‰)	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	Reference
	unidentified, perforated and polished, from under Mound 74					Minnitt (1995)
OxA-4748	Animal bone (B 326), ox tibia, sawn and longitudinally perforated from Mound 38, floor 3	−22.3			2345±45	Coles & Minnitt (1995)
OxA-4750	Animal bone (B 398), unidentified, ‘bobbin’ type D, from Mound 71, floor 2	−21.1			2180±45	Coles & Minnitt (1995)
OxA-4751	Antler (H 215), ?worked from Mound 5, floor 2	−23.6			2180±45	Coles & Minnitt (1995)
OxA-4752	Antler (H 244), shed from Mound 1	−23.4			2465±45	Coles & Minnitt (1995)
Q-2618	Fairly woody *Carex* and *Cladium* sedge fen peat directly under the clay structure of the causeway				1975±70	Housley (1988)
Q-2619	*Carex* and *Cladium* sedge fen peat directly under the grey clay with quartzite which abutted the causeway				1920±70	Housley (1988)

Table 16 Previous radiocarbon measurements and re-dated animal bone samples

6.3.2 Radiocarbon results

A total of 79 radiocarbon measurements are now available from Glastonbury (Tables 15, 16, and 17). All are conventional radiocarbon ages (Stuiver & Polach 1977). Methods used to produce these results and their technical details are specified in the Supplementary Information contained in an article reporting the scientific dating results (Marshall et al. 2020).

Seventeen pairs of replicate measurements on waterlogged wood are available on samples that were divided and submitted for dating to different laboratories. Eleven of these pairs of measurements are statistically consistent at 95% confidence (Table 17; Ward & Wilson, 1978) are have been combined by taking a weighted mean before calibration (Ward & Wilson 1978) and inclusion in modelling. Two are inconsistent at 95% confidence, but consistent at 99% confidence, and four are inconsistent at more than 99% confidence. This reproducibility is not within statistical expectation, and so the accuracy of these measurements has been assessed during the modelling process by their compatibility with related radiocarbon results.

Laboratory number	Sample reference & material dated	$\delta^{13}C_{IRMS}$ (‰)	Radiocarbon age (BP)
Structural Group 1: wall line of the 'floor 3' roundhouse from Mound 59			
SUERC-57878	T10. cf *Populus/Salix* (10 rings) outer 2 rings	−28.5±0.2	2194±29
OxA-33538	T10B. Replicate of SUERC-57878	−28.0±0.2	2148±26
^{14}C: 2169±20 BP, T'=1.4; δ^{13}C: −28.3±0.15‰, T'=1.3			
UBA-27984	T12. *Populus/Salix* (approximately 16 rings) outer 2 rings	−26.8±0.22	2086±22
OxA-31643	T41 (A). *Populus/Salix* (20 rings) outer 2 rings	−25.4±0.2	2126±27
SUERC-57880	T41 (B). Replicate of OxA-31643	−27.7±0.2	2109±29
^{14}C: 2118±20 BP, T'=0.2; δ^{13}C: −26.6±0.15‰, T'=66.1			
Structural Group 2: easternmost posts of the palisade line between Mounds 60 and 59			
GU36311	T15. cf *Populus/Salix* (16 rings) outer 2 rings		Failed on AMS
UBA-27985	T26. *Alnus* last two rings dated	−27.4±0.22	2213±25
OxA-33539	T26B. Replicate of UBA-27985	−27.3±0.2	2074±25
^{14}C: T'=16.7; δ^{13}C: −27.4±0.15‰, T'=0.1			
SUERC-65754	T81. *Quercus* sp (9 rings) last 2 rings	−27.5±0.2	2174±30
UBA-31253	T87. *Rhamnus* (16 rings) outer 2 rings	−29.3±0.22	2024±31
SUERC-57883	T88. cf *Populus/Salix* (12 rings) outer 2 rings	−29.2±0.2	2122±26
Structural Group 9: wall line of the 'floor 5' roundhouse from Mound 74. The earliest structure built on Mound 74			
SUERC-57881	T69. Indeterminate, outer two rings	−26.7±0.2	2122±29
SUERC-57882	T76. cf *Populus/Salix* (13 rings) outer 2 rings	−24.2±0.2	2138±29
UBA-27986	T73. Indeterminate, outer 2 rings	−24.2±0.22	2080±23
Structural Group 10: three oak posts that had been driven through the mortice holes of a substantial oak beam. These lie underneath the floors of Mound 75 and under the later floor of Mound 74			
UBA-28809	GLV 47, rings 1–5. *Quercus* sp. heartwood rings 1–5	−27.1±0.22	2177±39
UBA-28810	GLV 47, rings 9–13 – sample A. *Quercus* sp. heartwood (3) and sapwood (2) rings 9–13	−27.0±0.22	2172±31
OxA-31792	GLV 47, rings 9–13 – sample B. Replicate of UBA-28810	−25.1±0.2	2245±30
^{14}C: 2210±22 BP, T'=2.9; δ^{13}C: −26.0±0.15‰, T'=40.8			
SUERC-59108	GLV 48(1), rings 1–5. *Quercus* sp. heartwood rings 1–5	−24.6±0.2	2223±29
UBA-28811	GLV 48(1), rings 29–33 – sample A. *Quercus* sp. sapwood rings 29–33	−27.4±0.22	2140±25
OxA-31793	GLV 48(1), rings 29–33 – sample B. Replicate of UBA-28811	−25.2±0.2	2158±26
^{14}C: 2149±19 BP, T'=0.2; δ^{13}C: −26.2±0.15‰, T'=54.8			
Structural Group 13: westernmost wall line of the series of roundhouse walls from Mound 9. Probably the latest structure built on Mound 9, relating to floors 1 and 2 from the Bulleid & Gray excavations.			
UBA-27987	T116. *Populus/Salix* (10 rings) outer 2 rings	−26.5±0.22	2102±23
SUERC-57887	T117. *Populus/Salix* (approximately 8 rings) outer 2 rings	−27.9±0.2	2170±26
OxA-33540	T117B. Replicate of SUERC-57887	−26.3±0.2	2092±27
OxA-33541	T117B. Replicate of SUERC-57887	−27.4±0.2	2157±30
^{14}C: 2143±16 BP, T'=5.7; T'(5%)=6.0; ν=2; δ^{13}C: −27.2±0.12‰, T'=33.5; T'(5%)=6.0; ν=2			

Laboratory number	Sample reference & material dated	$\delta^{13}C_{IRMS}$ (‰)	Radiocarbon age (BP)
UBA-27990	T185 (A). *Populus/Salix* (6–7 rings) outer 2 rings	−26.1±0.22	2102±23
OxA-31605	T185 (B). Replicate of UBA-27990	−24.0±0.2	2117±28
^{14}C: 2108±18 BP, T'=0.2; δ^{13}C: −25.0±0.15‰, T'=49.9			
SUERC-65761	T186. Indeterminate, outer 2 rings	−26.7±0.2	2151±30
UBA-31252	T188. cf *Populus/Salix* (> 11 rings) outer 2 rings	−25.4±0.22	1993±31
Structural Group 14: easternmost wall line of the series of roundhouse walls from Mound 9. Probably relating to floors 7, 6, and 5 from the Bulleid & Gray excavations.			
UBA-27991	T192. *Alnus* (10 rings) outer 2 rings	−30.1±0.22	2067±25
SUERC-57890	T193. cf *Populus/Salix* (6 rings) outer 2 rings	−26.2±0.2	2143±29
SUERC-57891	T194. *Populus/Salix* (13 rings) outer 2 rings	−28.4±0.2	2175±29
OxA-33542	T194B. Replicate of SUERC-57891	−30.4±0.2	2080±26
^{14}C: 2123±20 BP, T'=6.0; δ^{13}C: −29.5±0.15‰, T'=45.2			
Structural Group 15: ?earliest wall line of a series of roundhouse walls from Mound 9. Probably relating to floors 8 and 9 from the Bulleid & Gray excavations			
UBA-27989	T157. Indeterminate outer two rings	−29.7±0.22	2101±35
Structural Group 16: ?earliest wall line of a series of roundhouse walls from Mound 9. Probably relating to floors 8 and 9 from the Bulleid & Gray excavations			
UBA-27988	T149. Indeterminate, outer 2 rings	−29.0±0.22	2103±33
SUERC-57888	T150. Indeterminate, outer 2 rings	−25.8±0.2	2157±25
SUERC-57889	T152. Indeterminate, outer 2 rings	−28.9±0.2	2151±29
Structural Group 23: east-west line of collapsed palisade timbers, that with SG 21 probably formed the contemporary walking surface on the inside of the palisade			
SUERC-65762	T242. cf. *Populus/Salix* (>32 rings) outer ring	−26.6±0.2	2113±30
UBA-31250	T244. *Alnus* sp. (> 15 rings) outer 2–3 rings	−29.2±0.22	2078±33
UBA-31249	T253. *Alnus* sp. (approximately 25 rings) outer 2 rings	−29.2±0.22	2044±32
Structural Group 25: east-west line of collapsed palisade timbers that appeared to be a retaining deposit of brushwood on its northern side. Other palisade lines (Structural Groups 26–29) appear to post-date this collapsed structure.			
UBA-27993	T272a. *Populus/Salix* sp. (13 rings) outer 2 rings	−28.4±0.22	2018±26
SUERC-57893	T272b. Replicate of UBA-27993	−28.6±0.2	2121±29
^{14}C: 2064±20 BP, T'=7.0; δ^{13}C: −28.5±0.15‰, T'=0.5			
SUERC-59113	T275. *Alnus* sp. (approximately 15 rings) outer 2 rings	−29.2±0.2	2141±25
UBA-28813	T277. *Alnus* sp. (approximately 10 rings) outer 2 rings	−29.9±0.22	2069±29
Structural Group 27: east-west line of collapsed roundwood palisade timbers that slumped southwards, i.e. into the surrounding wetland, and appears to be later than SG 29			
SUERC-65765	T305a. *Alnus* sp. (>16 rings) outer 2 rings	−29.1±0.2	2117±30
UBA-31246	T305b. Replicate of SUERC-65765	−29.2±0.22	1988±26
^{14}C: 2044±27 BP, T'=10.6; δ^{13}C: −29.2±0.15‰, T'=0.1			
UBA-31248	T292. *Populus/Salix* sp. (approximately 14 rings) outer 2 rings	−29.5±0.22	2021±27
Structural Group 28: east-west line of collapsed roundwood palisade timbers that slumped southwards, ie into the surrounding wetland. Timbers of SG 27 and 28 both appear to overlie the collapsed 'birch' palisade (SG29)			
UBA-27994	T297a. Indeterminate, outer 2 rings	−28.6±0.22	2116±29
SUERC-57897	T297b. Replicate of UBA-27994	−28.5±0.2	2085±29
^{14}C: 2101±21 BP, T'=0.6; δ^{13}C: −28.6±0.15‰, T'=0.1			
UBA-27995	T299. *Alnus* sp. (6 rings) outer 2 rings	−31.4±0.22	1963±30
OxA-33544	T299B. Replicate of UBA-27995	−30.3±0.2	2038±25

Laboratory number	Sample reference & material dated	$\delta^{13}C_{IRMS}$ (‰)	Radiocarbon age (BP)
^{14}C: 2008±20 BP, T'=3.7; δ^{13}C: −30.8±0.15‰, T'=13.7			
SUERC-57898	302a. *Alnus* sp. (6 rings) outer 2 rings	−29.9±0.2	2069±25
UBA-27996	302b. Replicate of SUERC-57898	−30.2±0.22	2123±26
^{14}C: 2095±19 BP, T'=2.2; δ^{13}C: −30.0±0.15‰, T'=1.0			
SUERC-65769	T306a. *Alnus* sp. (>16 rings) outer 2 rings	−29.3±0.2	2131±30
UBA-31245	T306b. Replicate of SUERC-65769	−30.1±0.22	1999±26
^{14}C: 2056±20 BP, T'=11.1; δ^{13}C: −29.7±0.15‰, T'=7.2			
Structural Group 29: east-west line of collapsed roundwood palisade timbers that slumped southwards, i.e. into the surrounding wetland. This palisade appears to be later than SG 25 and earlier than SG 27 and 28			
OxA-31644	T257. Indeterminate, outer 2–3 rings	−27.8±0.2	2162±26
UBA-27992	T258. Indeterminate, outer 2–3 rings	−29.0±0.22	1999±28
OxA-33543	T258B. Replicate of UBA-27992	−29.3±0.2	2026±26
^{14}C: 2014±20 BP, T'=0.5; δ^{13}C: −29.2±0.15‰, T'=1.0			
SUERC-57892	T259. Indeterminate, outer 2–3 rings	−27.9±0.2	2116±27
SUERC-65763	T262. cf *Alnus* sp. (>22 rings) outer 2 rings	−31.9±0.2	2102±30
SUERC-65764	T301a. *Alnus* sp. (13 rings) outer 2 rings	−30.5±0.2	2128±30
UBA-31247	T301b. Replicate of SUERC-65764	−30.2±0.22	2062±39
^{14}C: 2104±24 BP, T'=1.8; δ^{13}C: −30.4±0.15‰, T'=1.0			
Structural Group 30: east-west orientated line of roundwood logs laid horizontally that overlies the collapsed woven palisade (SG29)			
SUERC-65759	T138. *Populus/Salix* sp. (>8 rings) outer 2 rings	−27.2±0.2	2117±30
SUERC-65755	T141a. cf *Alnus* sp. (16 rings) outer 2 rings	−28.4±0.2	2103±30
UBA-31251	T141b. Replicate of SUERC-65755	−25.4±0.22	2030±27
^{14}C: 2063±21 BP, T'=3.3; δ^{13}C: −27.0±0.15‰, T'=101.8			
Structural Group 31: roughly east-west orientated group of horizontally timbers which overlies the palisade SG 29			
SUERC-65760	T165. *Populus/Salix* sp. (>18 rings) outer 2 rings	−29.3±0.2	2103±30
UBA-31254	T167. *Populus/Salix* sp. (23 rings) outer 2 rings	−26.6±0.22	2067±33
Reburied: ?timber from the east side of Mound VI, excavated by Bulleid and Grey and reburied on-site			
SUERC-59112	GLV 206, rings 1–5. *Quercus* sp. heartwood rings 1–5 of a 157 rings sequence	−24.9±0.2	2425±29
UBA-28812	GLV 206, rings 153–157. *Quercus* sp. heartwood rings 153–157 of a 157 rings sequence	−26.8±0.22	2154±24

Table 17 New radiocarbon and δ13C measurements from Glastonbury Lake Village (all samples were waterlogged wood). Replicate measurements have been tested for statistical consistency and combined by taking a weighted mean before calibration as described by Ward & Wilson (1978; T'(5%)=3.8, v=1; except where stated).

6.3.3 Bayesian modelling

The chronological modelling described in this section has been undertaken using OxCal 4.2 (Bronk Ramsey 1995; 2009), and the internationally agreed calibration curve for the northern hemisphere (IntCal13: Reimer et al. 2013). The models are defined by the OxCal CQL2 keywords and by the brackets on the left-hand side of Figs S2–S3, 3–4, 6, and 8. In the diagrams, calibrated radiocarbon dates are shown in outline and the posterior density estimates produced by the chronological modelling are shown in solid black. The Highest Posterior Density intervals which describe the posterior distributions are given in italics.

6.3.4 The chronological models

Radiocarbon dates obtained from below (Q-2618) and abutting the causeway (Q-2619; Housley 1988, 80–1) and from animal bone and antler (Table 16) have been excluded from the models described which only include dated structural timbers. Determinations on the peat from below and abutting the causeway are statistically consistent (T'=0.3; T'(5%)=3.8; v=1) suggesting that the interpretation that these deposits were in situ might not be correct and the animal bone/antler could all be older than the use of the site, given its unknown taphonomy.

Model 1a (Fig. 76) includes all the structural elements in a single, continuous phase of activity (Buck et al. 1992). This model has poor overall agreement (Amodel: 1), with nine dates having individual agreement values A:<30, of which two UBA-27985 [A:1] and UBA-27993 [A:3] are extremely low. UBA-27985 is statistically significantly earlier than a replicate measurement OxA-33539 on the same timber (T26) (T′=16.7; T′(5%)=3.8; v=1; Ward & Wilson 1978), and UBA-27993 is statistically significantly later than a replicate measurement SUERC-57893 on the same timber (T272) (T′=16.7; T′(5%)=3.8; v=1). UBA-27985 and UBA-27993 are likely to be laboratory outliers.

Model 1b (Fig. 77) therefore implements outlier analysis (Christen 1994; Bronk Ramsey 2009b) to identify and proportionally weight any statistical outliers in the data. Each radiocarbon measurement has been given a prior outlier probability of 5%. Nine radiocarbon dates have posterior outlier probabilities of more than 10%, which is more than would be expected in a dataset of this size where all the data are compatible with the model. Hence, in order to interpret the results from the chronological model for settlement activity we need to scrutinise each radiocarbon date that has been identified as an outlier in an attempt to evaluate why it may be so (i.e. whether it is a misfit, an outlier, or has an offset (Bronk Ramsey 2009b)).

Five structural timbers have posterior outlier probabilities between 25% and 54% (UBA-31252, O: 25/5; UBA-27993, O: 26/5; T299, O: 45/5; UBA-31245, O: 35/5; and UBA-31246, O: 54/5). These probably represent statistical outliers that accurately date activity that falls into the relatively concentrated horizon of building on the site suggested by the modelling. The three timbers with a posterior outlier probability of >60% (UBA-27985, O: 98/5; timber_47_felling, O: 61/5 and T258, O: 76/5) clearly represent misfits.

Given that ‘every scrap of clay, stone and gravel, and doubtless a large proportion of the timber, was imported by the inhabitants to the site (Bullied & Grey 1911, 60) and with some of that timber clearly being reused (eg Structural Group 10), residual material is clearly going to form a component of the material on the site. The timbers that Bulleid and Gray reburied on site were mainly worked oak planks that were originally used in the foundations, often having redundant mortice holes. These are very likely to be have been brought to the site from demolished structures from elsewhere. This is supported by the dating of T206. The large oak timbers of structural group 10 could also have been reused, although the survival of sapwood suggests that this was not be the case. The small diameter roundwood used in the other structures is extremely unlikely to be reused because it would lose structural integrity over a very short time.

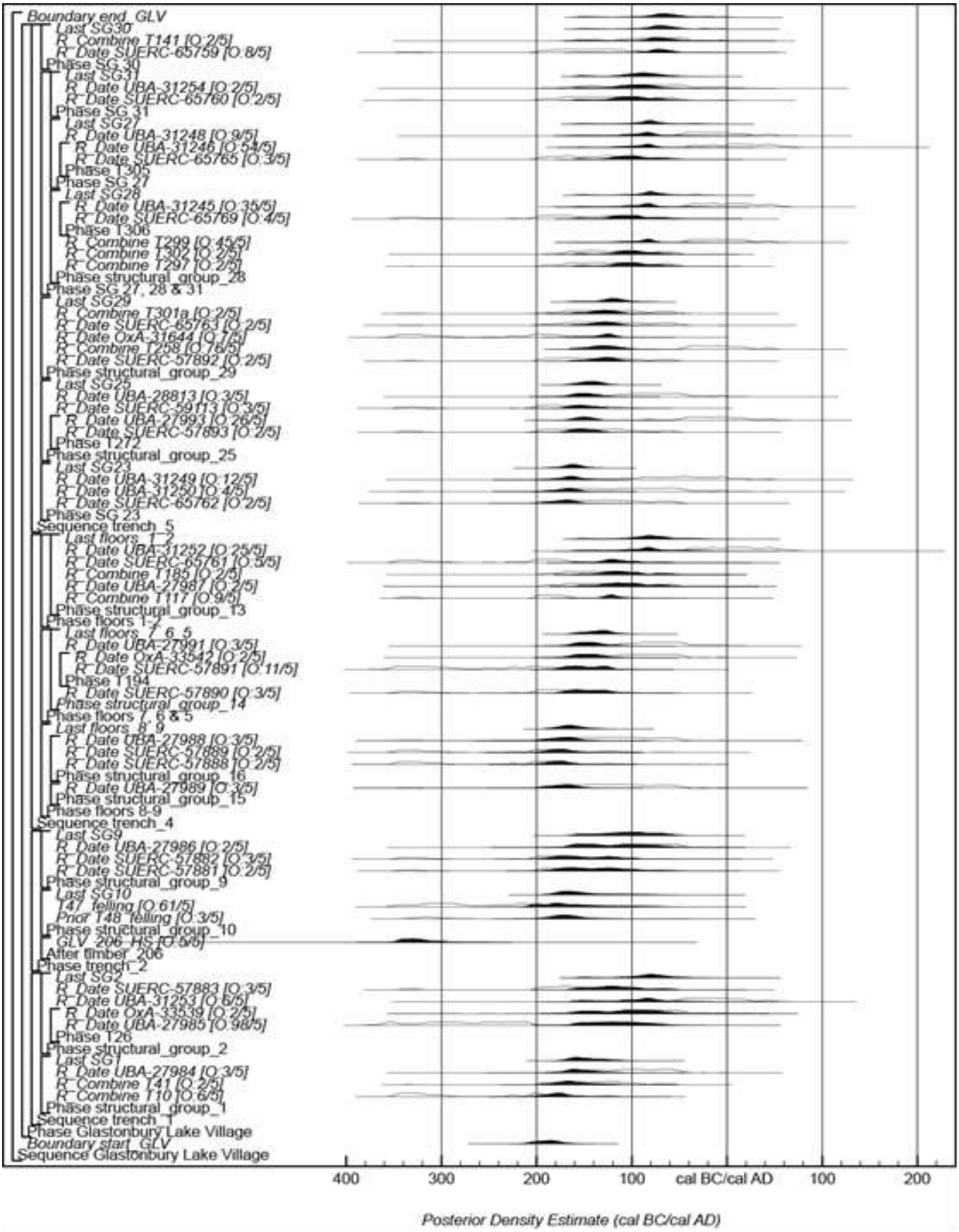

Figure 76 Probability distributions of dates from the Glastonbury Lake Village; each distribution represents the relative probability than an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. Distributions other than those relating to particular samples correspond to aspects of the model. For example, the distribution 'SG1' is the estimated date when the wall line of the 'floor 3' roundhouse from Mound 9 was constructed. Posterior/prior outlier probabilities are shown square brackets. The large brackets down the left-hand side along with the OxCal keywords define the model exactly.

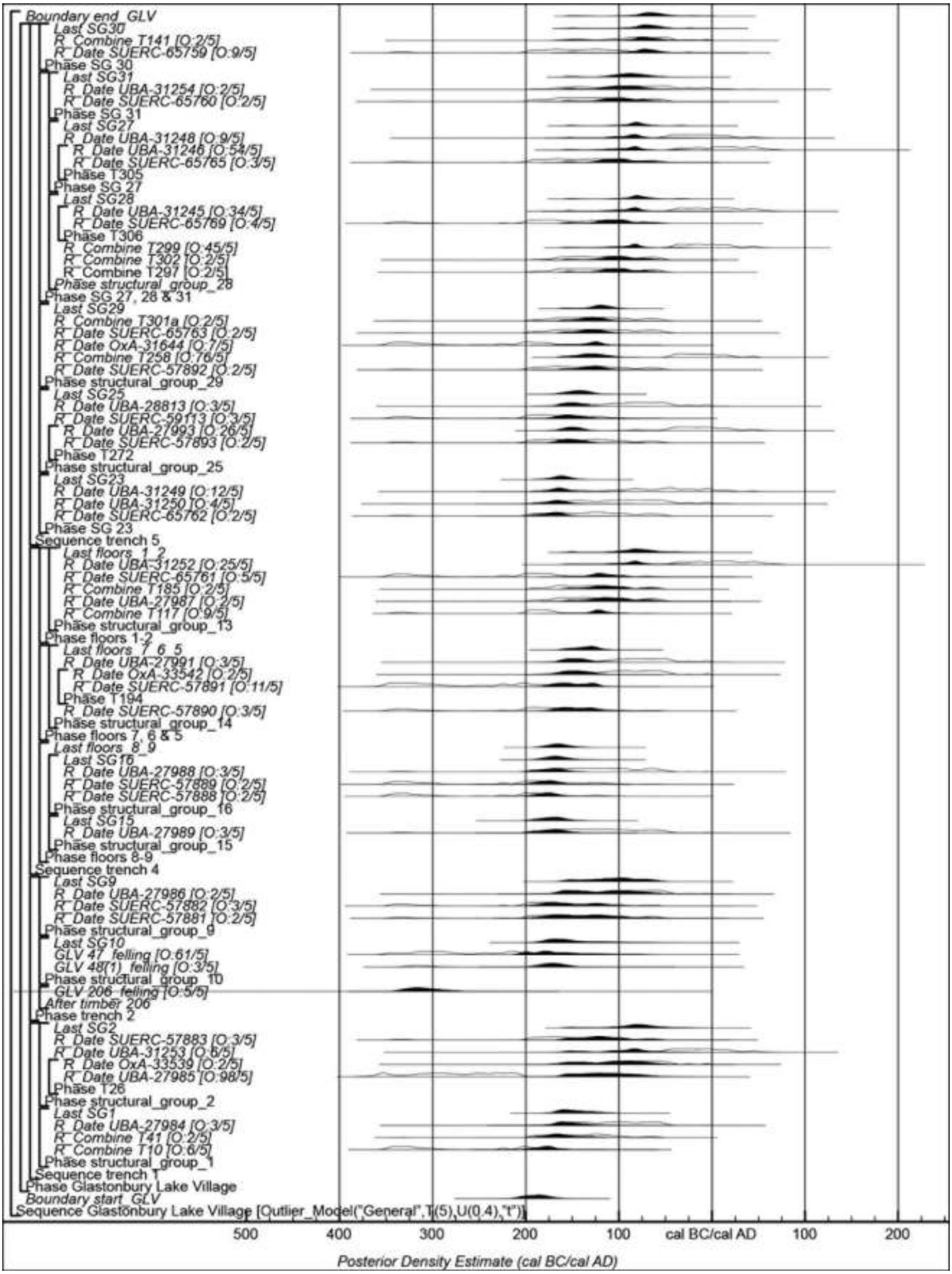

Figure 77 Probability distributions of dates from the Glastonbury Lake Village; each distribution represents the relative probability than an event occurs at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. The large brackets down the left-hand side along with the OxCal keywords define the model exactly.

Such an interpretation of the outliers is important as it indicates that (94%) of dated timbers in our sample, 47 of the 50, probably fall in the concentrated period of building suggested by the modelling, with only one outlier that that clearly represent earlier material.
Given that we wish to determine the date of construction of the Structural Groups, the last dated event has been calculated as providing the best estimate for when they were completed (eg SG1; Fig 76). These calculated parameters have then been used in Model 2 as providing independent estimates for constructional events during the occupation of the settlement.

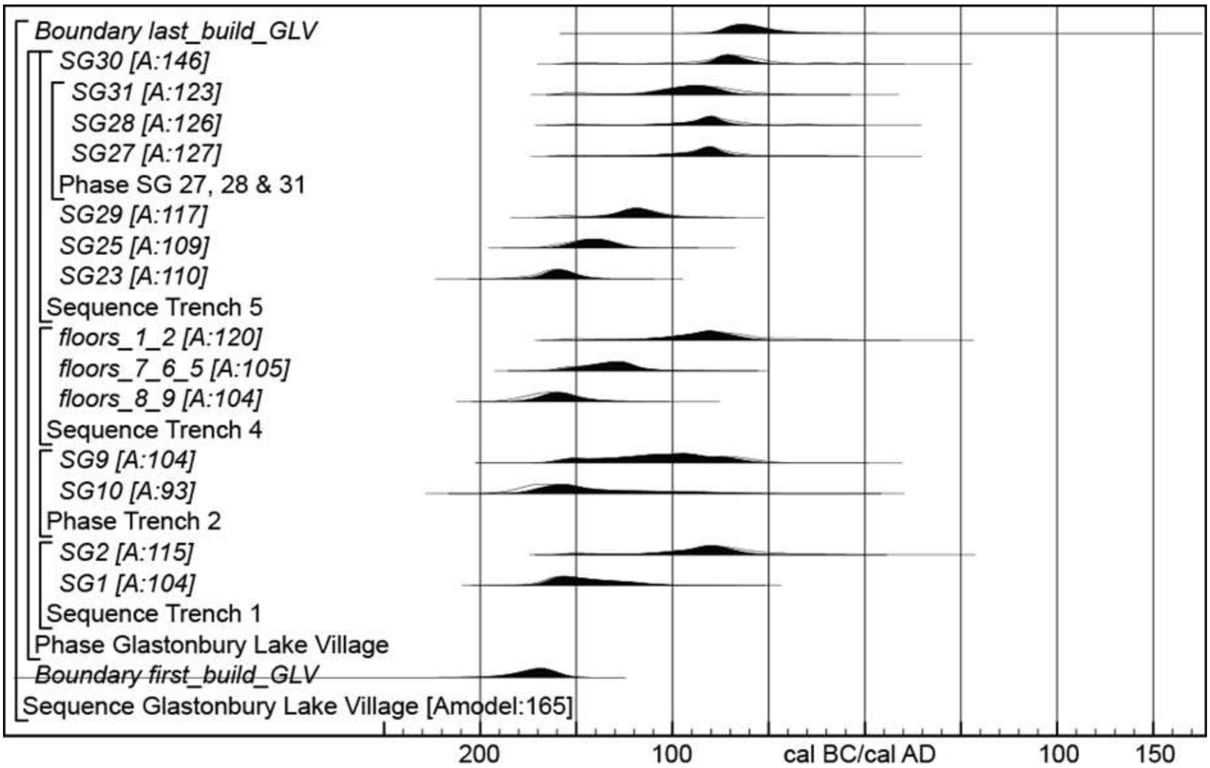

Figure 78 Probability distributions of estimates for the building of structures. The overall format is as for Fig.76. The large brackets down the left-hand side along with the OxCal keywords define the model exactly.

The model shown in Figure 78,that has good overall agreement [A:model=165], suggests that Glastonbury Lake Village was established in 210–150 cal BC (95% probability; first_build_GLV; Fig 78), probably in 190–160 cal BC (68% probability) and the last constructional event took place in 80–20 cal BC (95% probability; last_build_GLV; Fig 78), probably in 75–45 cal BC (68% probability). It was therefore in use for a minimum of 75–135 years (95% probability; use_GLV; Fig 79), probably for 85–120 years (68% probability).

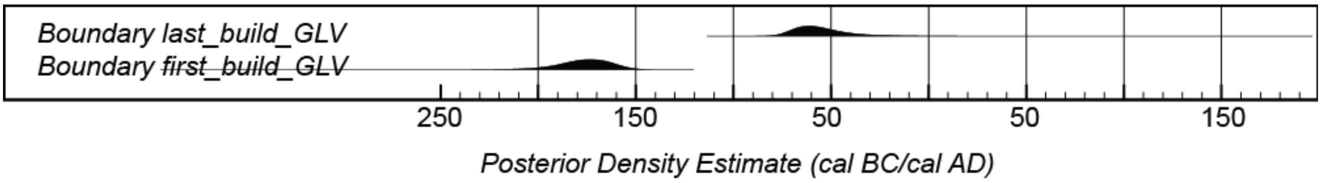

Figure 79 Probability distributions for the first and last structures to be constructed (derived from the model shown in Figure 78)

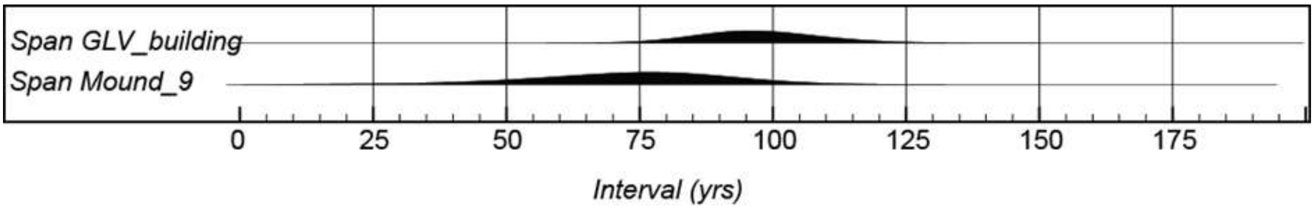

Figure 80 Probability distributions of the duration of dated activity on Mound 9 and building activity at Glastonbury Lake Village, derived from the model defined in Figure 78

The initial construction (walls and floors 8–9), subsequent rebuilding (walls and floors 7-6-5), and final builds (walls and floors 1-2) of structures on Mound 9 took place over a period of 35–120 years (95% probability; use_Mound_9; Fig 80) and probably only 60–100 years (68% probability). Given the short overall duration of the settlement most structures were probably in use for no more than a decade or two (if the use life of floors on Mound 9 is representative).

Coles & Minnitt phasing model (model 2)
An alternative model for activity at Glastonbury Lake Village was constructed to examine the reliability of Model 1b for the chronology of the site. This model incorporates the archaeological phasing (see Coles & Minnitt 2000, 99–120) that suggested four phases of occupation: 'early', 'middle', 'late', and 'final' and the stratigraphic relationships between structures (cf Sidell et al. 2007). The model, that treats the four occupation periods as representing contiguous phases of activity, has poor overall agreement (Amodel=58; Fig S81), with three parameters having poor individual agreement (SG9, A:10; SG2, A:27 and SG23, A:33).

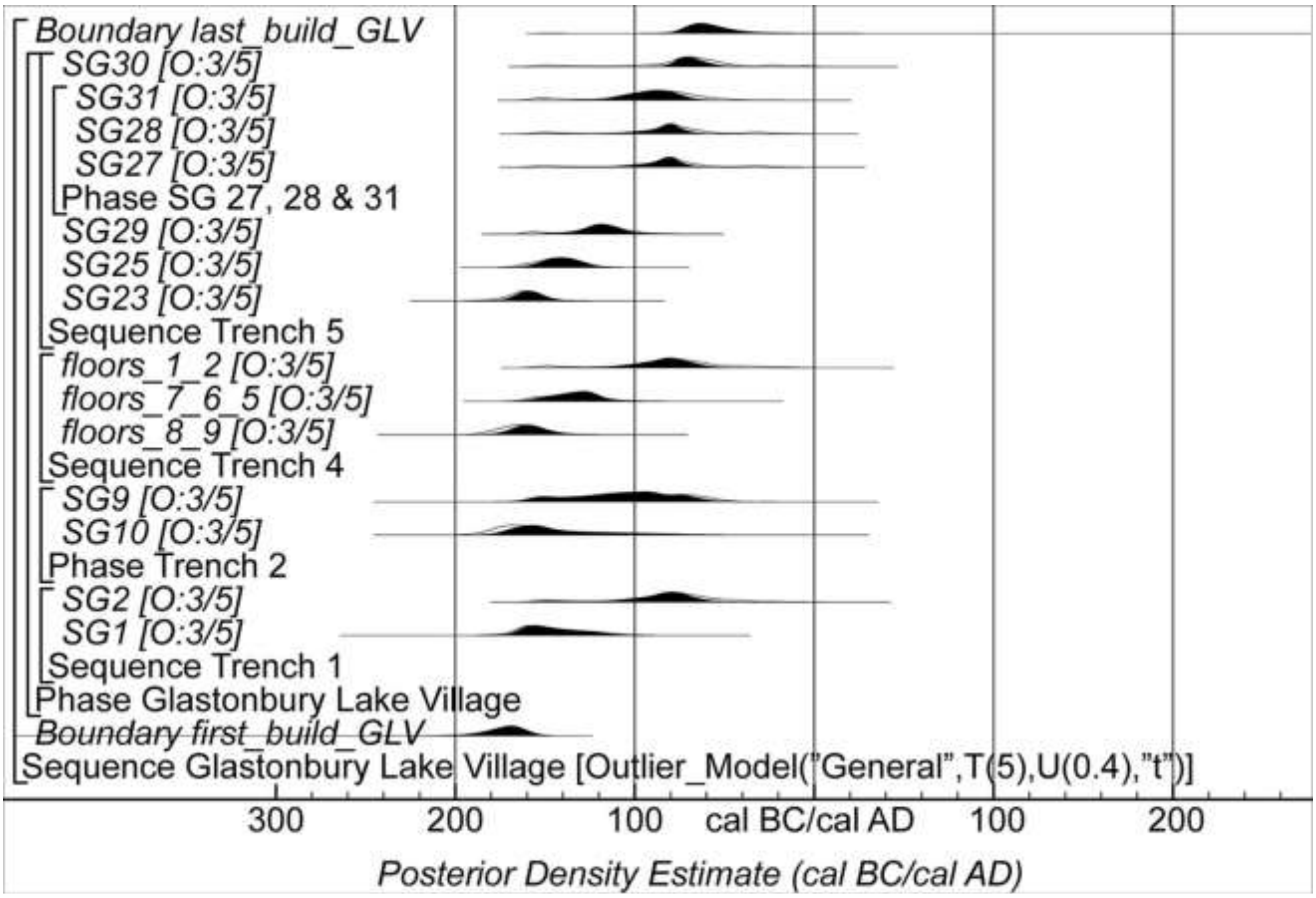

Figure 81 Probability distributions of estimates for the building of structures (the parameters have been derived from the model shown in Figure 78). The overall format is as for Figure 78. The large brackets down the left-hand side, along with the OxCal keywords, define the model exactly

Model 2 (Fig 81) again implements outlier analysis (see above), with each radiocarbon measurement being given a prior outlier probability of 5%, identifies only one parameter (SG9, O9/5) as representing a statistical outlier.

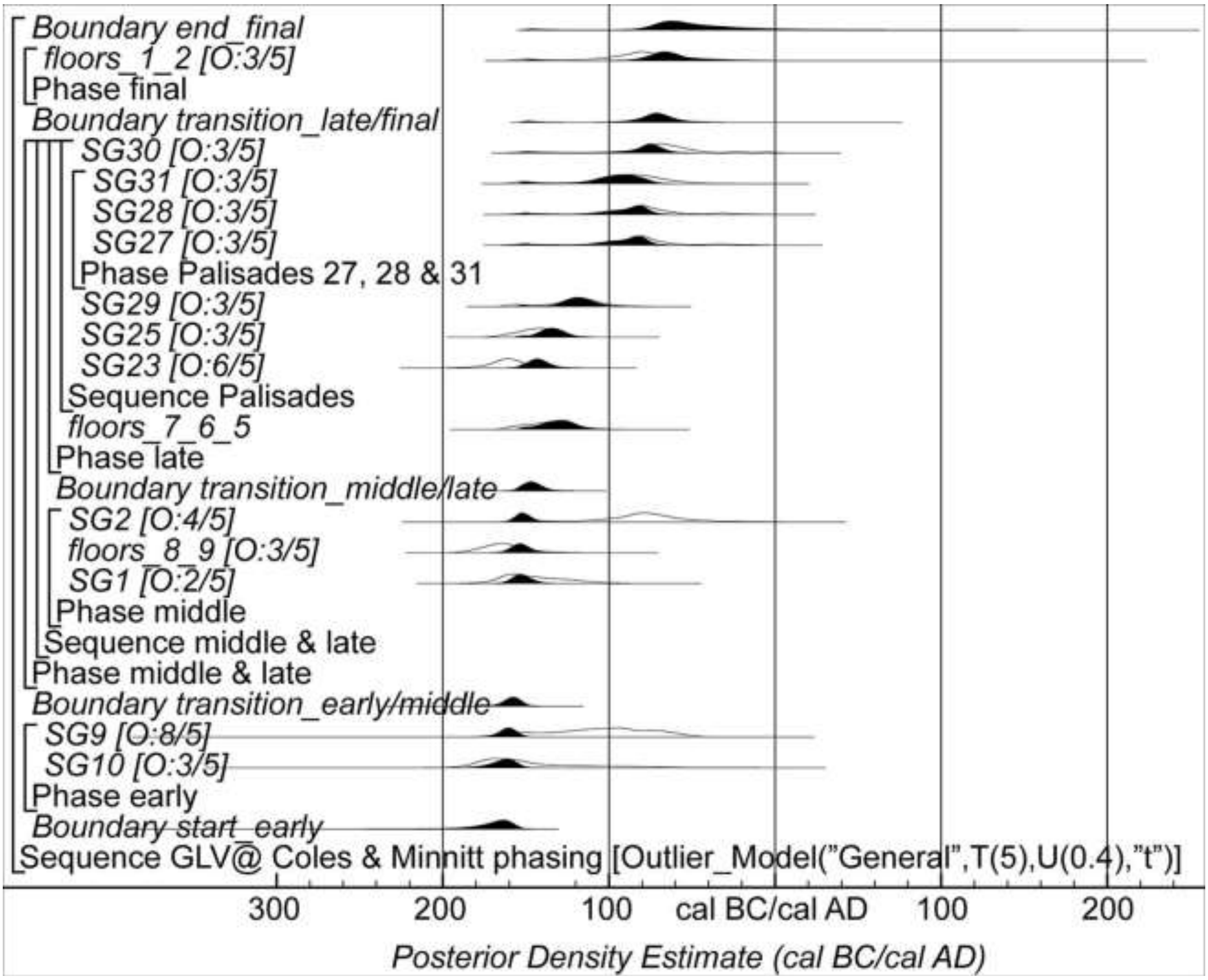

Figure 82 Probability distributions of dates from Glastonbury Lake Village (Coles&Minnitt (2000) phasing; model 3);the parameters have been derived from the model shown in Figure 78. The overall format is as for Figure 78. The large brackets down the left-hand side, along with the OxCal keywords, define the model exactly

Coles and Minnitt (model 3)

An alternative model (3) for activity at Glastonbury Lake Village was constructed to examine its reliability. This general outlier model (Bronk Ramsey 2009b; see model 1b, above, for details of the approach to outlier analysis implemented) incorporates Coles and Minnitt's (2000: 99–120) archaeological phasing ('early', 'middle', 'late' and 'final'), plus the stratigraphic relationships between structures and calculated parameters from model 1b. Two parameters from model 3 have posterior outlier probabilities of more than 5 per cent (SG9; O: 8/5 and SG23; O: 6/5)—no more than would be anticipated in a dataset of this size, where all the data are compatible with the presented model. Highest posterior density intervals for key parameters from the model are given in Table S4 of Marshall et al 2020. Model 3 (Figure 82) gives results that are generally similar to those presented in Figure 5, with the medians of the parameters for the start and end of construction activity varying by three and nine years, respectively.

6.4 *Implications*

Chronological modelling of radiocarbon dated timbers used for the construction of structures and palisades during activity at Glastonbury Lake Village has provided robust timings for its occupation. Models 1b and 2 both indicate that the settlement was probably first established in the first half of the second century cal BC; Model 1b: 190–160 cal BC (68% probability; first_build_GLV; Fig 78) and Model 2: 205–160 cal BC (68% probability; start_early; Fig 81), with the final construction of structures taking place in the decades around the middle of the first century cal BC; Model 1: 75–45 cal BC (68% probability; last_build_GLV; Fig 77) and Model 2: 75–15 cal BC (68% probability; final; Fig 81). Derived from a formal statistically methodology these timings are remarkably similar to those suggested from analysis of the sites brooches (Haslegrove 1997) and suggest that chrono-typologies may in some cases have an efficacy (contra Hamilton et al. 2015, 10).

Timings derived from Model 2 combined with estimates of the number of houses in use during the 'early', 'middle', 'late', and 'final' phases (Coles & Minnitt 2000; table 4.5) allow us to comprehend the tempo and intensity of settlement activity (Fig 82; see Bayliss et al. in press, fig 6). The rise of settlement appears to have been swift with the main phases of occupation lasting for perhaps 70–80 years (eg three generations), before a gradual decline prior to abandonment.

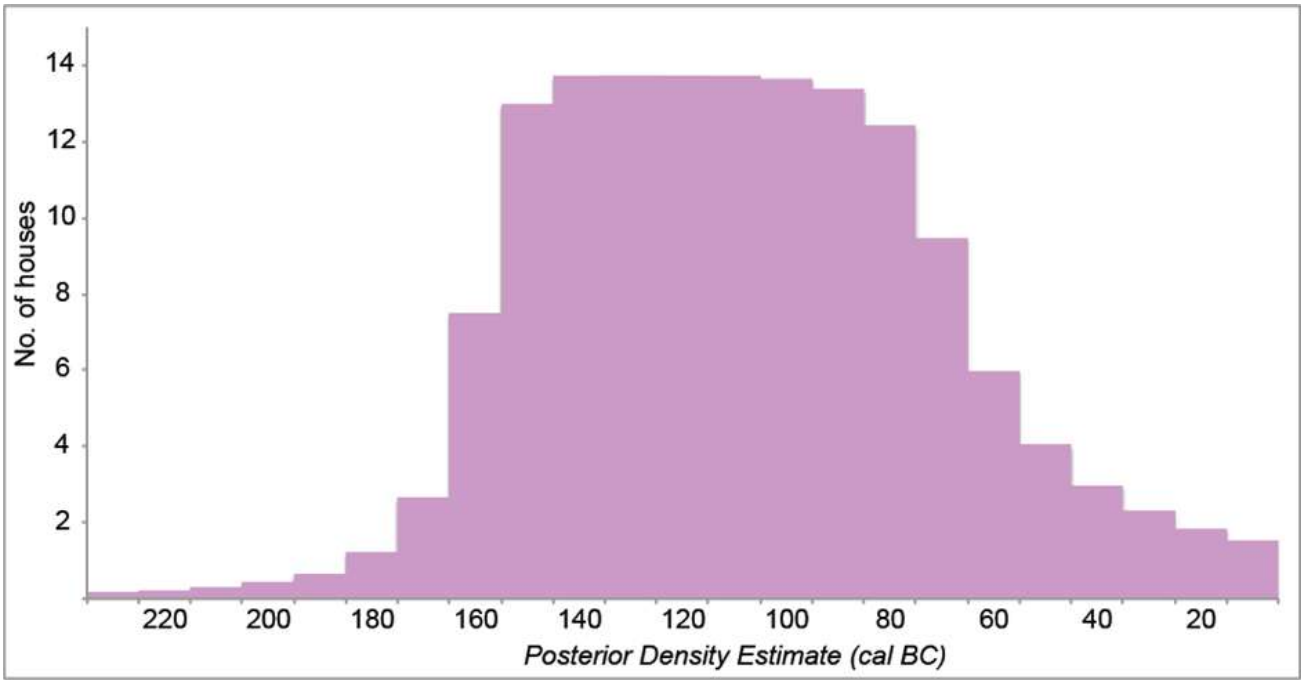

Figure 83 Estimate of the number of houses in use at Glastonbury Lake Village during its occupation

That a substantial village had such a restricted lifespan may not necessarily have been uncharacteristic, for early Mesa Verde villages, termed 'social tinderboxes' rarely endured beyond 30–70 years or one–three generations (established with precision through dendrochronology). In that context the abandonment of villages were primarily carried out in a variety of ways from simply walking away to burning (Wilshusen & Potter 2010, 178–9). Although environmental factors have been advocated, eg flooding (Tratman 1970, 166) or a possible volcanic event occurring about 44–40 BC (Coles & Minnitt 2000, 206; Baillie 1991) for people leaving the site, these have been rejected in the most recent analysis (Brunning 2013, 201) and it seems unlikely that social and political factors did not have some part to play.

The construction and subsequent rebuilding of a structure/house has only been examined in detail on one mound (Mound 9). Taking the median duration for construction, 80 years (walls and floors 8–9 to walls and floors 1–2) for the nine phases of wall building would give an average duration of approximately 13-10 years for a structure. The impermanent architecture of structures at Glastonbury was primarily determined by the environment, as substantial buildings would be too heavy for the soft peat substrate. The wall posts from Mound 74 varied from 15m-54mm in diameter (average 38mm) and the posts from the Mound 9 houses ranged from 22mm-59mm (average 40mm). Such small roundwood would lose its structural integrity very quickly so the decadal estimate for house longevity may be over generous. Clay floors also required renewal or replacement as they were likely to be constantly sinking into the underlying peat deposits.

It is striking therefore that the estimate for house 'life' is so close to that derived for Alpine foreland houses by dendrochronology, 10–15 years (eg Leuzigner 2000, 61–87) belonging to villages on lake shores and peat bogs and built with impermanent materials (Hoffman et al. 2016, 607). The Iron Age to early Medieval packwerk crannogs of Scotland provide a better structural comparison for Glastonbury, the best dated example at Buiston displaying a similar rapid evolution of wooden structures (Crone 2000, 48-66). Reconstructions of the Glastonbury roundhouses, using wall posts of significantly larger dimensions than the originals, have only lasted 11-12 years before collapse (Brunning 2016).

The dating of one of the jointed oak timbers (T206) that had been dumped among the foundations at Glastonbury Lake Village has shown that they derived from structures erected many generations before the settlement was created. The dating of one of the rectangular structures made of oak beams held in place by piles (ie. T47 and 48) has confirmed the stratigraphic evidence that they occurred at the beginning, but not significantly before the creation of the mounds. This suggests that they might have performed a function during the initial construction of the settlement, perhaps before material was brought onto the site to create a dry habitation area. The inability of dendrochronology to establish a site chronology linking those two groups of oak timbers, to the ones sampled from the causeway, may therefore be because they occupy separate time spans, with little or no overlap.

The new dating analysis for Glastonbury Lake Village has provided a robust chronological framework for the rich material culture assemblage from the site. Although only 64% of artefacts from the original excavations had their location recorded (Coles and Minnitt 2000, 30) the stratified objects include most of the significant artefacts. The robust site chronology can therefore be used to establish the dates of use for a wide range of objects, complementing the Bayesian chronologies established on other Iron Age sites (Hamilton et. al. 2016) and the 'Dating Celtic Art' project (Garrow et al. 2009).

7 Condition assessment

The OD height of the ground surface and of the *in situ* remains varies significantly across the site (Table 18).

Table 18 OD height of in situ wooden features across the site

Trench	Ground surface mOD	Top of feature mOD	Feature mOD of top of feature
1	4.40-4.47	3.71-3.78	palisade posts
		3.62-3.63	in situ peat on East side
2	4.30–4.49	3.68-3.83	Mound 74 floor and wall posts
		3.84-3.90	Oak posts
		4.04	Hearth
		3.83-3.88	In situ peat

Trench	Ground surface mOD	Top of feature mOD	Feature mOD of top of feature
3	4.17-4.34	3.82-3.83	In situ peat
		3.67-3.79	Reburied wood
4	4.50-4.71	3.75-3.89	Tops of vertical stakes
4		3.70-3.77	Tops of horizontal timbers
5	4.29	3.85-3.91	Tops of horizontal wood
5		3.82-3.89	Tops of palisade stakes at S end

7.1 Visual condition

7.1.1 Trench 1

The horizontal roundwood and the pushed over tops of the palisade stakes all showed signs of significant compression by the overlying deposits. The wood exposed by Bulleid also showed definite signs of decay and desiccation. Stake 41, which was 300mm long, was removed whole and had desiccation cracks over its entire length. The toolmark preservation was still good on the worked tip however.

The lower parts of the palisade timbers that had not previously been exposed by Bulleid were generally in a very good visual condition. As these were not significantly deeper than the other elements, it is possible that the poor surface condition of the upper elements may be due to their exposure during Bulleid's excavation.

7.1.2 Trench 2

The horizontal flooring of Mound 74 showed signs of very significant decay and had been compressed. The lower brushwood and the wall posts retained more of their original shape but also showed signs of decay.

Several of the wall posts of Mound 74 were totally excavated. The toolmarks and surface condition of the cut ends were in general quite well preserved (figures 60 and 61). Unfortunately, they had obviously suffered from sever desiccation at some point as they exhibited severe vertical cracking resulting from shrinkage stress around the circumference of the roundwood (fig. 84). It is uncertain when this happened, but the otherwise good surface condition strongly suggests that it did not occur in prehistory. The level of the structural remains in this area would probably not have required pumping by Bulleid and Gray. As the posts were from the earliest floor of Mound 74, they were probably not exposed for a long period during the original excavations. The desiccation and cracking could have occurred during one particularly dry summer, such as 1976. The short length of the posts meant that they could not draw up water from lower levels like more deeply set vertical timbers, such as the oak posts in the same trench.

Figure 84 Poor preservation of post 72 from trench 2

7.1.3 Trench 3

The reburied wood did not appear to be in very good condition. The surface condition of the wood was not very good and the wood appeared to have suffered from significant vertical compression. Roots were observed to be growing through several of the pieces. No good toolmarks were preserved on the material. Sapwood survived on some of the oak pieces, but significant lateral shrinkage and decay of the sapwood had occurred (fig. 85).

Figure 85 shrinkage of sapwood -lighter colour at top

7.1.4 Trench 4

The horizontal flooring material appeared poorly preserved and had suffered from significant vertical compression. The vertical wall posts were more variable. Some had vertical cracking resulting from desiccation, while many of the small number that were totally excavated had moderately well preserved toolmarks at the cut ends (fig. 64). The roundwood in the foundations was better preserved than the flooring and had suffered less from vertical compression. The woodchips in the house floor, which had not been exposed by Bulleid's excavation, were in a relatively good condition.

7.1.5 Trench 5

The visual condition of the material varied significantly. The horizontal roundwood had a poor surface condition and had suffered from significant vertical compression. The tops of the palisade posts also had a poor surface condition, but just below the surface the surface condition appeared to be very good, with complete bark often surviving and no evidence of cracking from shrinkage. This suggests that the deeply set cut ends of the posts would be in excellent condition (Fig 65).

Figure 86 Fine root growth through Iron Age roundwood from the site from Trench 5

7.2 **Detailed condition assessment** *David Pearson and Eleanor Schofield*

7.2.1 Sample overview

Samples were in two layers of plastic zip lock bags. Initial observations regarding the number of pieces the sample comprised of, size and weight were recorded and can be seen in Table 19. Where samples had more than one piece these were recorded as A or B, and this nomenclature was used in subsequent analysis.

Sample	Notes	Trench	Dimensions (mm)	Weight (g)	Wood ID
18		1	106 x 53 x 33	147.5	Poplar / willow
41		1	45 x 46 x 48	117.4	No ID possible
46 A	110 mm	1	93 x 47 x 75	329.5	No ID possible
46 B	475 – 585 mm	1	102 x 70 x 74	314.3	No ID possible
77		2	119 x 71 x 49	317.5	Birch or Alder
47A	0 – 210 mm	2	71 x 30 x 52	214.4	Oak
47B	460 – 580 mm	2	77 x 52 x 106	247.0	Oak
48A	110 mm	2	106 x 88 x 51	305.0	Oak
48B	800 – 900 mm	2	113 x 82 x 87	536.6	Oak
59		2	98 x 57 x 33	110.3	Birch
76		2	61 x 33 x 24	45.8	Poplar / Willow
206		3	83 x 93 x 28	408.1	Oak
130		4	106 x 32 x 31	82.5	Poplar / Willow
133		4	116 x 112 x 80	664.0	Alder
239A	0 – 160 mm	5	151 x 60 x 58	307.7	Alder
239B	500 - 600 mm	5	82 x 72 x 68	342.3	Alder
236A	0 – 150 mm	5	108 x 42 x 30	124.1	Alder
236B	500 – 800 mm	5	257 x 43 x 47	387.4	Alder
237A	0 – 200 mm	5	203 x 28 x 26	125.9	Alder
237B	540 – 690 mm	5	89 x 39 x 26	130.5	Alder

Table 19 Number of pieces in each sample, dimensions and weights

7.2.2 Visual assessment

For each sample the initial wood was inspected in terms of colour, saturation, firmness, mould, smell and a pin test was conducted. The pin test involves the insertion of a 30 mm metal pin into the material and measuring how far it can progress without hindrance. Where the different grain orientations can be distinguished, the pin is tested in each to see if there is any variation. The information is recorded in Table 20.

All of the samples appeared saturated, and were a dark/medium brown colour, with no evidence of mould. One sample had an orange streak on it (46B), and two samples had an obvious smell of sulphur (47B and 239B). All the samples had a spongey texture, except 48A, 48B, 206 and 133. All of the samples were soft to some extent, except 47B, 48B and 206. When the pin test was carried out, no resistance was observed for all samples except 77, 47A, 48A, 48B, 59, 206, 133. Samples 48B and 206 appear from these to be the samples in the best condition.

Sample ID	Spongey?	Saturated?	Soft?	Colour?	Smell?	Mould?	Pin Test
18	Yes	Yes	Slightly	Dark Brown	No	No	Goes in fully at some points but not in others
41	Yes	Yes	Yes	Dark Brown	No	No	Whole way – little resistance
46A	Yes	Yes	Slightly	Dark Brown	No	No	Whole way – resistance
46B	Yes	Yes	Slightly	Dark Brown w/ Orange Streak	No	No	Whole way – little resistance
77	Slightly	Yes	Slightly	Dark Brown	No	No	Resistance - not in much ($^1/_5$)
47A	Yes	Yes	Yes	Dark Brown	No	No	Half – resistance
47B	Slightly	Yes	No	Dark Brown	Sulphur	No	In full – resistance
48A	No	Yes	Yes	Dark Brown	No	No	Resistance from 2mm in
48B	No	Yes	No	Medium Brown	No	No	Resistance half way
59	Slightly	Yes	Slightly	Dark Brown	No	No	Resistance half way
76	Yes	Yes	Yes	Dark Brown	No	No	Whole way – no resistance
206	No	Yes	No	Dark Brown	No	No	Resistance from 2mm in
130	Yes	Yes	Yes	Dark Brown	No	No	Whole way – no resistance
133	No	Yes	Slightly	Dark Brown	No	No	Resistance half way
239A	Slightly	Yes	Slightly	Dark Brown	No	No	Whole way – no resistance
239B	Yes	Yes	Slightly	Dark Brown	Sulphur	No	Whole way – no resistance
236A	Yes	Yes	Yes	Dark Brown	No	No	Whole way – little resistance
236B	Slightly	Yes	Slightly	Dark Brown	No	No	Whole way – little resistance
237A	Slightly	Yes	Slightly	Dark Brown	No	No	Whole way – little resistance
237B	Yes	Yes	Slightly	Dark Brown	No	No	Whole way – no resistance

Table 20 Visual observations on colour, texture and pin test

7.2.3 Physical properties

Sections of wood were taken from the sample and used for analysis. Once sectioned, the weight of each sample was recorded. They were then dried for 24 hours at a temperature of 100°C to ensure all moisture is removed. Following drying, the weight of the section is again recorded. The Moisture Content (%) is then determined using the following equation:
Moisture Content (%) = 100 x (M s – Mo)/Mo
Where, Ms is the mass of waterlogged wood and Mo is the mass of oven dried wood.

To measure the basic density of the samples, cube sections were cut and the volume was calculated. The sections were then dried following the same procedure used to determine the Moisture Content. The basic density was then calculated using the following equation: Basic Density, Db (g/cm3) = Mo / Vs, where, Vs is the volume of the sample when wet.

The Residual basic density compares the basic density of the archaeological sample to that of nondegraded (fresh) wood from the literature. It is calculated using the following equation: Residual Basic Density = 100 x (Db / Dbf), where, Dbf is the basic density of fresh wood. A value of 0.7 g/cm3 as this is representative of oak; 0.35 g/cm3 of poplar; 0.67 g/cm3 of birch; and 0.4 g/cm3 of alder. The Loss of Wood Substance can then be calculated using the following equation: Loss of Wood Substance (%) = 100 x (Dbf – Db)/Dbf. The results from this testing can be seen in Table 21.

Sample ID	Wet weight (g)	Volume (cm^3)	Dry weight (g)	Moisture Content (%)	Basic Density of Sample (g/cm^3)	Residual Basic Density (%)	Loss of Wood Substance (%)
18	1.653	1.44	0.242	583.06	0.168	48.016	51.984
41	2.712	1.8354	0.276	882.61	0.150	21.482	78.518
46A	1.156	0.63	0.203	469.46	0.322	46.032	53.968
46B	2.731	2.744	0.433	530.72	0.158	22.543	77.457
77	1.194	0.864	0.412	189.81	0.477	71.172	28.828
47A	1.478	1.32	0.295	401.02	0.223	31.926	68.074
47B	3.094	2.704	0.492	528.86	0.182	25.993	74.007
48A	0.94	0.63	0.255	268.63	0.405	57.823	42.177
48B	1.165	1.215	0.245	375.51	0.202	28.807	71.193
59	0.609	0.528	0.213	185.92	0.403	60.210	39.790
76	1.073	0.972	0.199	439.20	0.205	58.495	41.505
206	1.108	1.04	0.257	331.13	0.247	35.302	64.698
130	0.599	0.512	0.08	648.75	0.156	44.643	55.357
133	0.837	0.7776	0.226	270.35	0.291	72.659	27.341
239A	1.294	1.521	0.115	1025.22	0.076	18.902	81.098
239B	1.456	1.56	0.125	1064.80	0.080	20.032	79.968
236A	1.283	1.521	0.147	772.79	0.097	24.162	75.838
236B	1.618	1.3824	0.297	444.78	0.215	53.711	46.289
237A	1.426	1.683	0.21	579.05	0.125	31.194	68.806
237B	1.643	1.56	0.127	1193.70	0.081	20.353	79.647

Table 21 Moisture Content, (Residual) Basic Density and Lack of Wood Substance

The De Jong classification indicates the degree of degradation of archaeological wood, as indicated by the Moisture Content. There are three classes which are defined as follows:

- Class III is wood containing < 185 % water = sound core beneath a thin degraded layer
- Class II is wood containing 185 – 400 %water = Comparatively small core present
- Class I is > 400 % water = highly degraded wood predominates

Figure 87 shows the moisture content of the Glastonbury Lake samples, compared with the De Jong classification system. 14 of the samples are in the Class I, which indicates highly degraded wood, and 6 samples are in Class II, indicating more wood integrity has been retained in these samples. The 6 samples in Class II were 77, 48A, 48B, 59, 206 and 133, which correlates exactly with the samples that showed some resistance in the pin test.

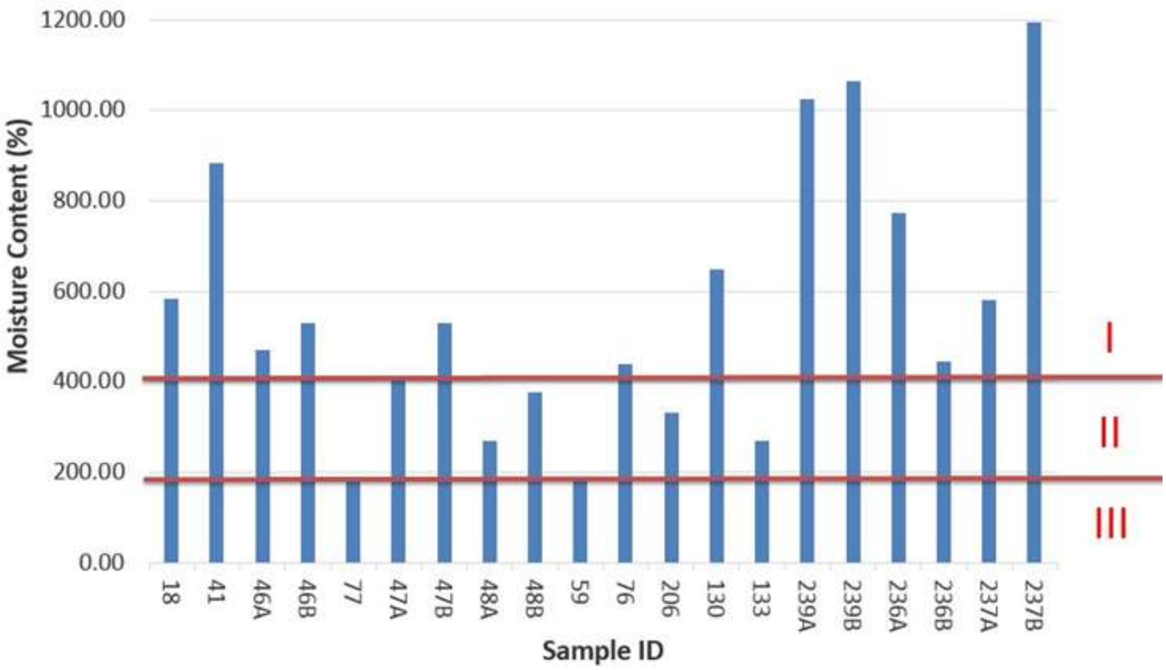

Figure 87 Moisture Content of samples, compared with De Jong wood degradation classification

The residual basic density and loss of wood substance can be seen in Figure 88. The loss of wood substance varies for 30 – 80%. The samples which showed some resistance to the pin test and that were in the Class II of the De Jong classification system also show the lowest loss of wood substance.

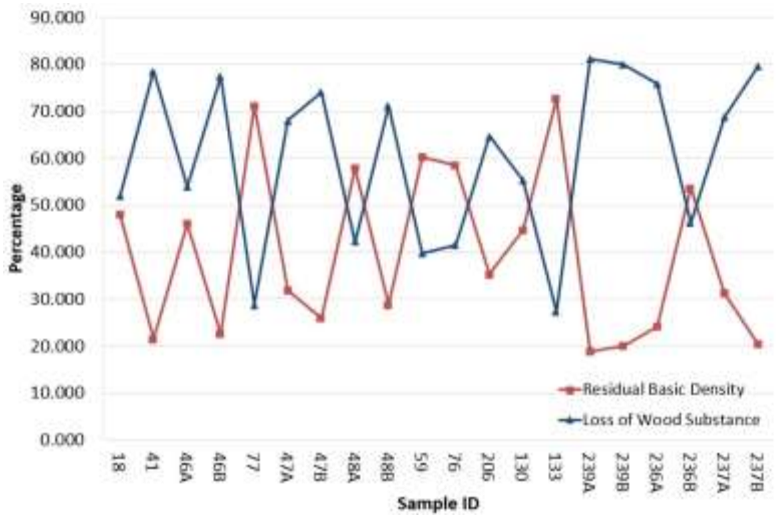

Figure 88 Residual Basic Density and Lack of Wood Substance

The shrinkage was measured by sectioning samples (approximately 1 cm^3) and inserting pins to define the longitudinal, radial and tangential directions. Distances were measured between the points when the wood was saturated. After drying for 24 hours at 100 ºC the distance was re-measured and percentage shrinkage was determined for each direction. The recorded measurements and the associated percentage shrinkage in the radial, tangential and longitudinal direction can be seen in Table 22 and Figure 89.

Sample ID	Saturated			Dry (100 ºC for 24 hrs)			% Shrinkage		
	R (mm)	*T (mm)*	*L (mm)*	*R (mm)*	*T (mm)*	*L (mm)*	*R (mm)*	*T (mm)*	*L (mm)*
18	7.23	8.22	12.88	4.6	3.93	11.6	36.38	52.19	9.94
41	6.33	8.82	17.55	4.13	5.42	15.97	34.76	38.55	9
46A	7.14	7.47	14.85	4.35	6.27	12.64	39.08	16.06	14.88
46B	8.41	7.81	12.62	5.34	5.7	10.52	36.5	27.02	16.64
77	6.97	6.75	13.51	4.41	4.86	12.06	36.73	28	10.73
47A	6.26	5.92	14.42	4.17	4.73	13.16	33.39	20.1	8.74
47B	7.42	6.53	11.38	5.93	3.97	10.14	20.08	39.2	10.9
48A	7.09	5.94	15.87	6.12	4.55	15.13	13.68	23.4	4.66
48B	5.83	7.07	15.24	3.19	4.14	12.44	45.28	41.44	18.37
59	4.04	5.26	11.12	3.28	4.44	9.42	18.81	15.59	15.29
76	4.24	5.31	10.11	3.01	3.07	8.61	29.01	42.18	14.84
206	7.08	6.7	10.99	6.38	5.44	10.99	9.89	18.81	0
130	5.79	5.19	7.36	3.94	2.33	6.48	31.95	55.11	11.96
133	5.67	7.07	14.23	5.22	4.52	11.76	7.94	36.07	17.36
239A	6.33	7.51	13.09	3.88	3.72	12.82	38.7	50.47	2.06
239B	8.57	7.98	16.22	6.22	1.94	14.23	27.42	75.69	12.27
236A	-	-	-	-	-	-	-	-	-
236B	6.57	7.45	15.35	4.3	3.82	13.17	34.55	48.72	14.2
237A	5.66	6.81	12.42	3.69	3.54	10.32	34.81	48.02	16.91
237B	6.47	5.52	16.66	4.39	1.82	14.27	32.15	67.03	14.35

Table 22 Shrinkage values and percent changed in radial, tangential and longitudinal directions

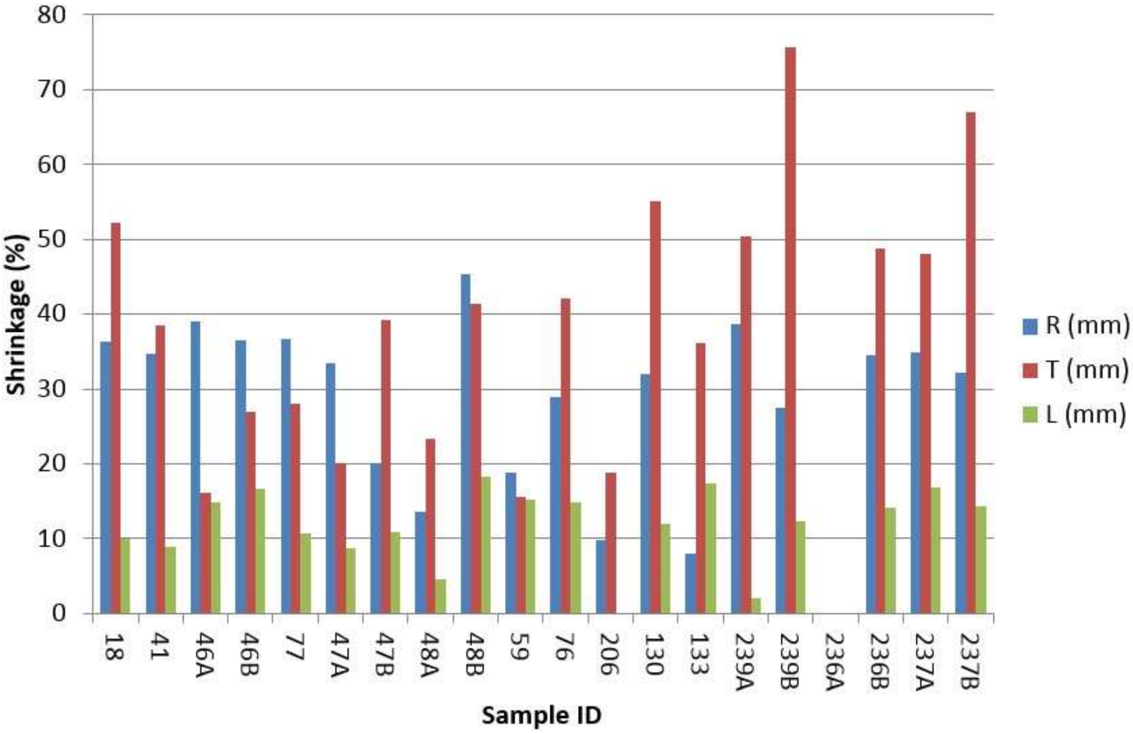

Figure 89 Shrinkage as percentage of original length in the radial, tangential and longitudinal directions

For 13 of samples, the largest shrinkage is in the tangential direction and for the other 6 samples measured the largest shrinkage was in the radial direction. In all but one sample the smallest shrinkage was in the longitudinal direction, which is to be expected. In one sample the degradation of the wood made identifying the directions challenging, and therefore this was not measured. The samples with the highest shrinkage correlate with those considered most degraded by the Moisture Content measurement.

7.2.4 X-ray Fluorescence analysis

X-ray Fluorescence (XRF) analysis was completed using an Oxford Instruments XMET8000. Sections of the sample, approximately 0.5cm^3 in size were analysed. Three sections from each sample were analysed for a total of 180 seconds. The XRF was calibrated to analyse the elements listed below by measuring known quantities of iron and sulphur in pellets of cellulose. The results, compared with that of fresh oak, alder, birch and polar are given as bar chart format in Figure 90 and actual numbers in Table 23.

In the fresh wood samples, no sulphur is detected, apart from in birch, but still at relatively low levels. Small amounts of iron and some calcium is also detected as expected from nutrients that travel through the wood. In the Glastonbury Lake samples, there are significant levels of calcium, iron and sulphur, which will have been incorporated from the groundwater in which they were buried for extended periods of time. Samples 47B and 239B had a sulphur odour when unwrapped and these both have high levels of sulphur identified from the XRF. Those that contain sulphur but did not emit a smell most probably have sulphur present in a different oxidation state. This cannot be determined via this technique. Sample 46B had an orange streak along it which is most likely a concentration of iron, which is corroborated by the high iron content in this analysis.

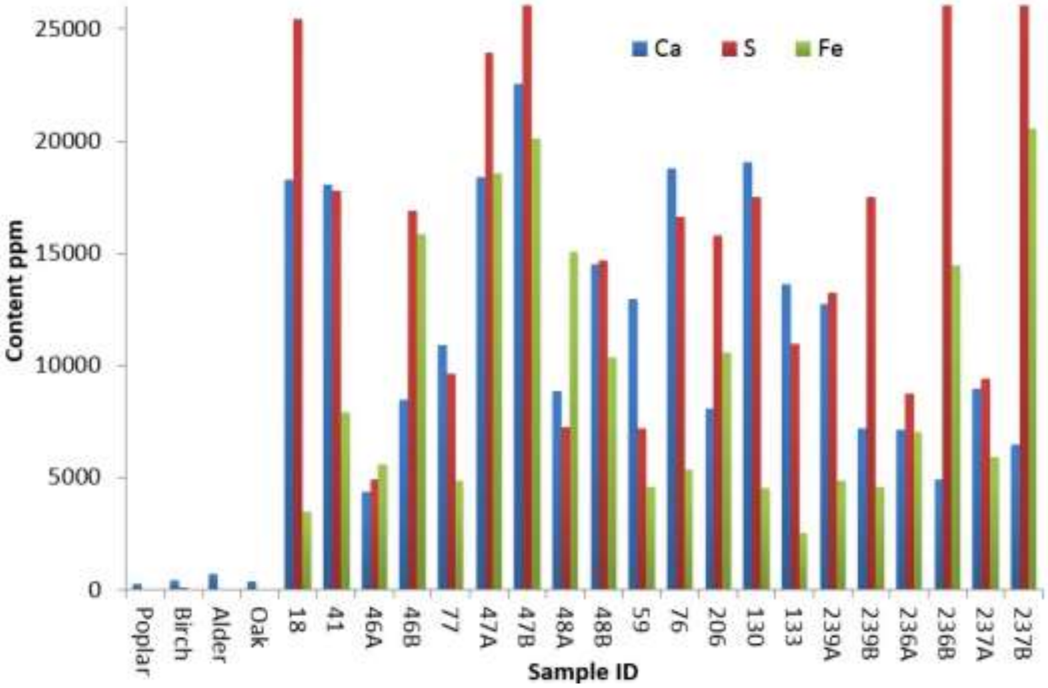

Figure 90 **Contents in ppm of Ca, S and Fe of samples compared with fresh oak and ash**

Sample ID	Ca (ppm)	S (ppm)	Fe (ppm)
Poplar	289	0	10
Birch	455	117	26
Alder	701	0	24
Oak	402	0	9
18	18268	25414	3459
41	18081	17781	7903
46A	4353	4930	5614
46B	8469	16895	15844
77	10930	9610	4889
47A	18382	23936	18548
47B	22534	28564	20128
48A	8854	7241	15059
48B	14528	14669	10338
59	12978	7207	4587
76	18803	16599	5394
206	8104	15769	10577
130	19082	17533	4524
133	13638	10945	2558
239A	12740	13247	4849
239B	7177	17509	4595
236A	7168	8761	7029

236B	4911	28753	14470
237A	8969	9401	5945
237B	6479	36819	20562

Table 23 Contents in ppm of Ca, S and Fe of samples compared with fresh oak and ash

7.2.5 Fourier Transform Infrared Spectroscopy (FT-IR) analysis

Thin sections of wood were taken from each sample using a double-edged razor blade. Spectra were collected using a Perkin-Elmer Spectrum One Fourier Transform Infrared Spectrometer. 32 scans were collected on each sample with a resolution of 4 cm^{-1}. Fresh oak was measured for direct comparison in the analysis.

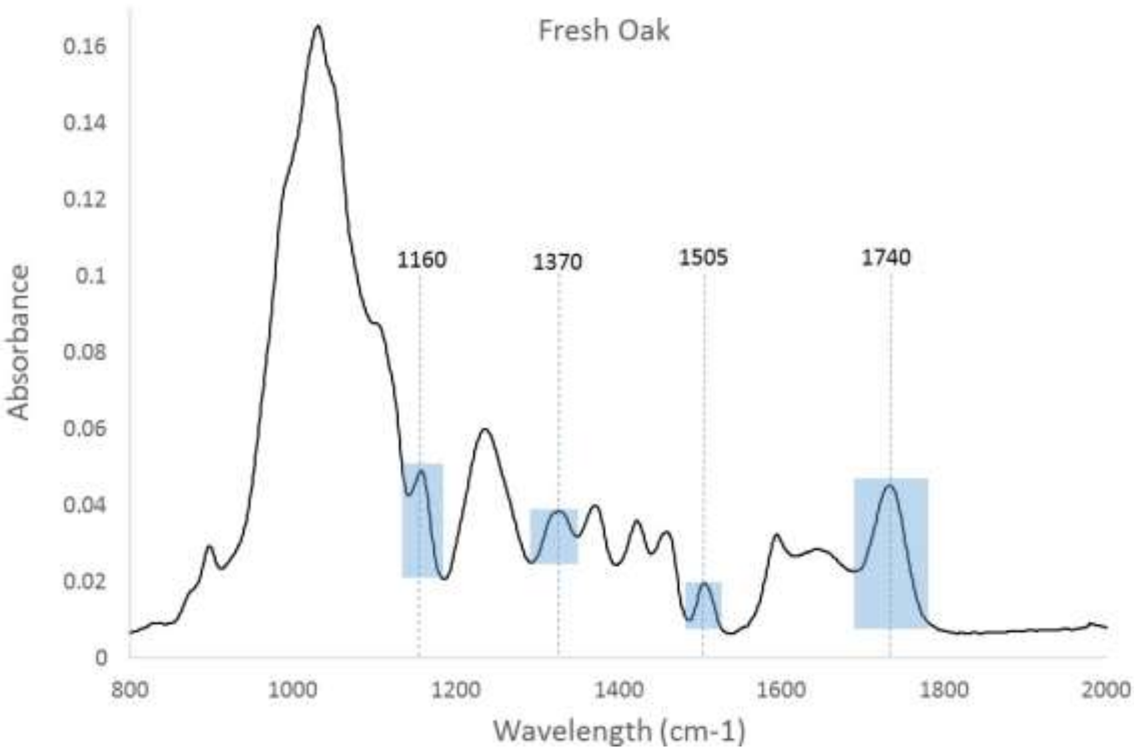

Figure 91 FT-IR spectra of fresh oak indicating key peaks used in analysis

Data was analysed by looking at key peaks in the data that can be associated with specific bonds within the wood, namely 1160 cm-1 (C-O-C vibration in hemicellulose and cellulose), 1370 cm-1 (CH deformation in hemicellulose and cellulose), 1505 cm-1 (Aromatic skeletal in lignin), and 1740 cm-1 (C=O in hemicellulose), as seen in Figure 91. Traditionally in wood, the holocelluose components (hemicellulose/cellulose) are lost before the lignin. Therefore, by measuring the ratio of the lignin peaks to that of the holocellulose components for fresh wood and then comparing with the archaeological samples, gives us an indication of how degraded the material is. This data can be seen in Figure 92. Where no ratio is given, this is due to there being insufficient peak available to measure, indicating a complete lack of that material component from the wood.

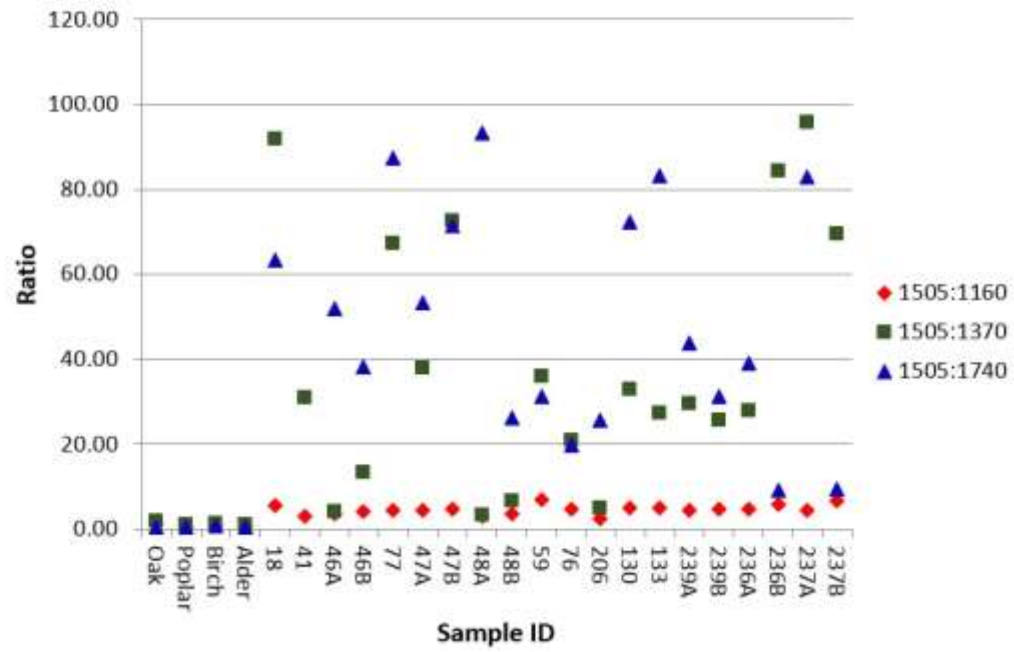

Figure 92 Ratios of Lignin to holocellulose components

The ratios of lignin to holocellulose components for the fresh wood range from 0.5 - 2, which is as expected for undegraded wood. This ratio increases for all the Glastonbury Lake samples. The smallest increase is for the 1160 cm-1 peak, with an average value of 5. For the other peak analysis, the ratio can be as high as 95, with averages of 39 and 49, indicating significant degradation of the wood. There is no clear correlation between this data and the other sets of measurements taken.

7.2.6 Conclusions and recommendations

The samples provided consist of heavily degraded wood, which should remain wet, unless conservation is planned. If not kept wet, shrinkage, distortion, cracking and ultimately complete breakdown of the wood will occur. There was no significant difference in the condition of the wood between the five trenches, or by species or by the depth of the sample below ground.

If conserved, it is recommended that they be impregnated with PEG 400 and 4000, as indicated in Table 24, followed by freeze drying. If freeze drying is not an option, then they could be air dried in a control environment of approximately 55% RH and 19^{o}C, and the PEG concentration would need to be adjusted to compensate for that. Following conservation, it is recommended the items are stored at the 50 – 60 % RH, 18 – 20^{o}C and less than 100 lux light level, to preserve their integrity for the maximum time.

Sample	Wood ID	Moisture Content	Class	Density of fresh wood	PEG 400	PEG 4000
18	Poplar / willow	**(%)** 583.06	I	0.35	7%	17%
41	No ID possible	882.61	I			
46 A	No ID possible	469.46	I			
46 B	No ID possible	530.72	I			

77	Birch or Alder	189.81	II	0.67	18%	26%
47A	Oak	401.02	I	0.7	9%	36%
47B	Oak	528.86	I	0.7	7%	38%
48A	Oak	268.63	II	0.7	13%	32%
48B	Oak	375.51	II	0.7	9%	36%
59	Birch	185.92	II	0.67	19%	25%
76	Poplar / Willow	439.2	I	0.35	10%	14%
206	Oak	331.13	II	0.7	10%	34%
130	Poplar / Willow	648.75	I	0.35	7%	18%
133	Alder	270.35	II	0.4	15%	11%
239A	Alder	1025.22	I	0.4	4%	25%
239B	Alder	1064.8	I	0.4	4%	25%
236A	Alder	772.79	I	0.4	5%	23%
236B	Alder	444.78	I	0.4	9%	19%
237A	Alder	579.05	I	0.4	7%	21%
237B	Alder	1193.7	I	0.4	3%	25%

Table 24 Recommended consolidation treatments

8 **Hydrological monitoring and water control infrastructure** *Phil Brewin and Richard Brunning*

The field containing the monument is bounded on three sides by watercourses. Great Withy Rhyne, representing the fossilised course of the former River Brue in the medieval period, runs along the eastern side of the monument. This is a main channel watercourse and, as such, its level cannot be precisely controlled where it runs beside the site. The northern ditch is small and poorly maintained and probably contributes little to the drainage or irrigation of the site.

Figure 93 The new inlet to ditch on the western side of the site. Great Withy Rhyne in the foreground

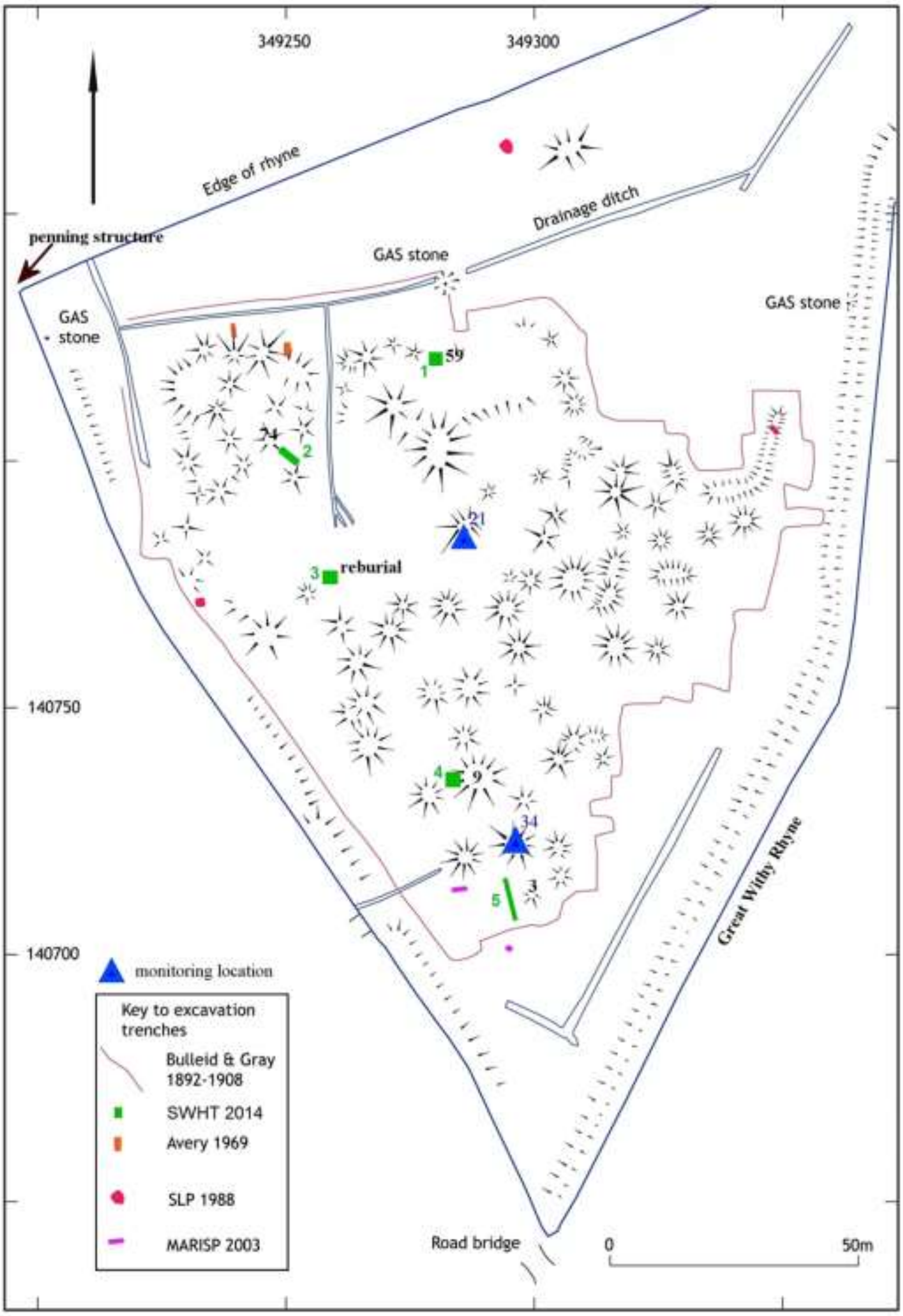

Figure 94 Location of monitoring points and new penning structure. The new water inlet allowed water from Great Withy Rhyne into the rhyne on the western side of the site

The western rhyne was therefore the most suitable for enhancement works, previously to which there was no method to retain water in it during summer as it formed the 'top' closed end of the drainage system. The enhancement works had three parts. At the southern end a new inlet and associated retaining wall was installed so that water could be brought in directly for Great Withy Rhyne. Loss of water back to the rhyne was prevented by a one-way flap. A new culvert allowed this water to pass under the entry to the field gate. At the northern end of the rhyne a new water control structure was created. This consisted of sheet pile cut off dam penning structure with a 200mm inlet flap and telemetry board.

Figure 95 The new water control structure and gauge board at the northern end of the ditch on the west side of the site

The hydrological monitoring equipment consisted of dipwells installed in two locations (figure 93 ST49283 40780 and ST49304 40730) which had been carefully chosen to represent key parts of the hydrological model developed by Jones (2013). Water levels in the dipwells were monitored using a pressure sensor (Druck PDCR/PTX 1830). The data was continuously collected using a Frog RX GPRS data logger, which could be accessed remotely by the Drainage Board.

Figure 96 Installation of the new monitoring equipment

Figure 97 Monitoring site being installed

Flooding of the ground surface over the winter months caused significant problems for the equipment so it was decided that every winter the equipment would be removed for a few months, depending on the weather. As the crucial drawdown of the water table occurred in the summer and autumn periods it was felt that the gaps in the data would not be significant.

Monitoring has been carried out since installation, except for the winter gaps noted above. The water levels in the western ditch have been significantly higher than they would otherwise have been before the installation of the new inlet and water retention structure. However, the supply of water is governed by the availability of water in the Great Withy Rhyne. In dry periods there is insufficient supply to maintain a high water level (figure

98). The drier conditions of the years 2018-2020, compared to 2016 and 2017 are reflected in the lower minimum levels of water in the ditch and the length of time that the water is low. Although water levels are maintained at c. 4.2m OD for most of the year, it drops to between 3.8 and 4.1m OD in the drier months (top of *in situ* wood at c.3.9mOD).

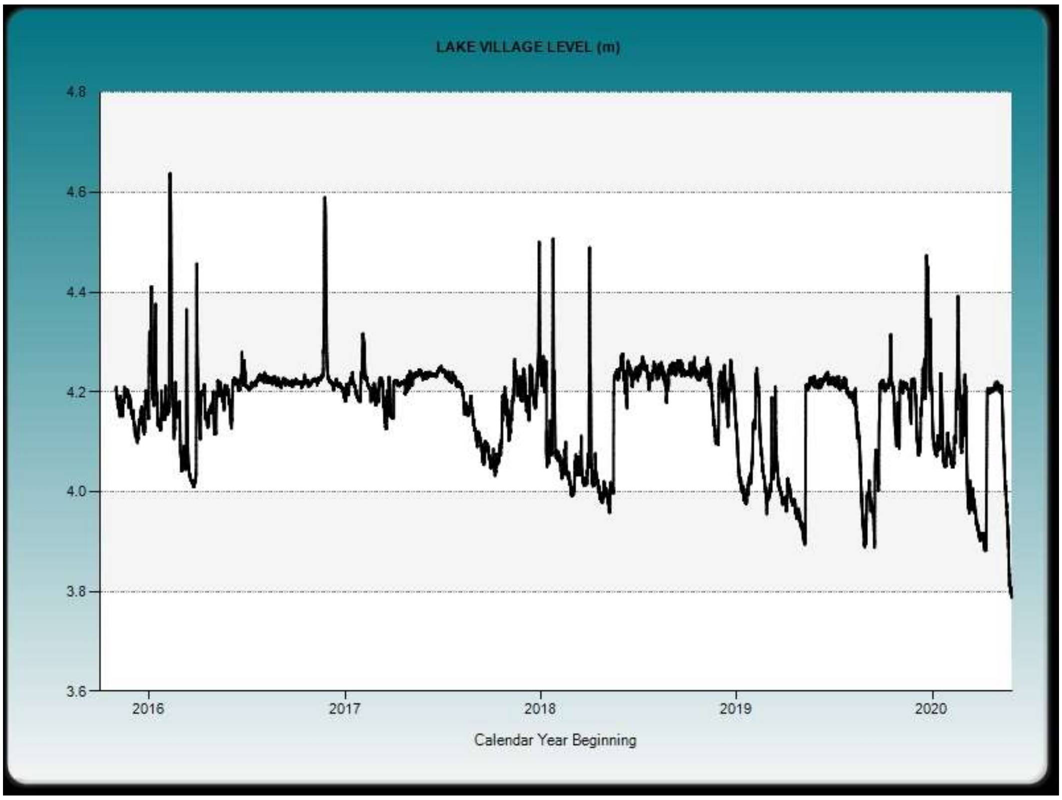

Figure 98 water levels in the western ditch

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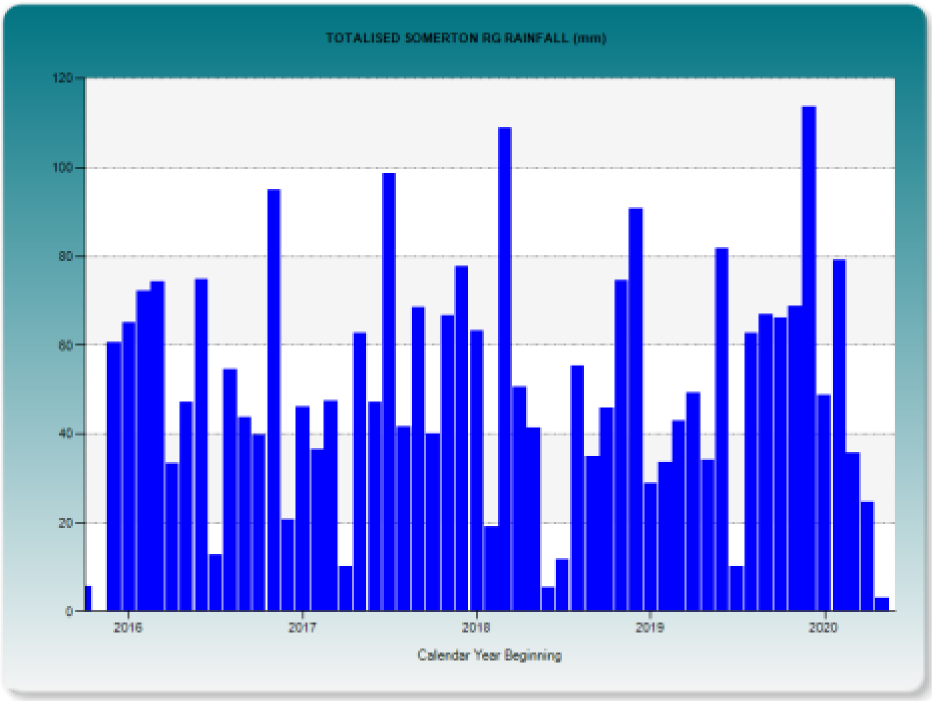

Figure 99 rainfall data from Somerton

The ditch water levels can be contrasted to the rainfall data from Somerton (figure 99). There is generally a good correspondence between the two, which demonstrated how rainfall dependent the irrigation system is.

For the monitoring points within the field, three years data is available (2016-18) including the dry summer of 2018. The results can be seen in figures 100 and 101. There is a very noticeable difference between the three years in both locations that can be directly related to the weather patterns over those years. In 2016 the driest period of the year was from July to the end of October, although an unusually dry May had previously reduced the water table. That corresponds well with the previous monitoring results from the site. In 2017 a more unusual pattern occurred with an early summer draw down in June followed by significant rainfall in July and August bringing the water table back up for the rest of the summer and autumn. In 2018 there was a significant dry summer event across the whole of the UK. The effect of this dry summer can be clearly seen in the graphs where the water table steadily decreases over June, July and August, until recharge begins again at the end of August.

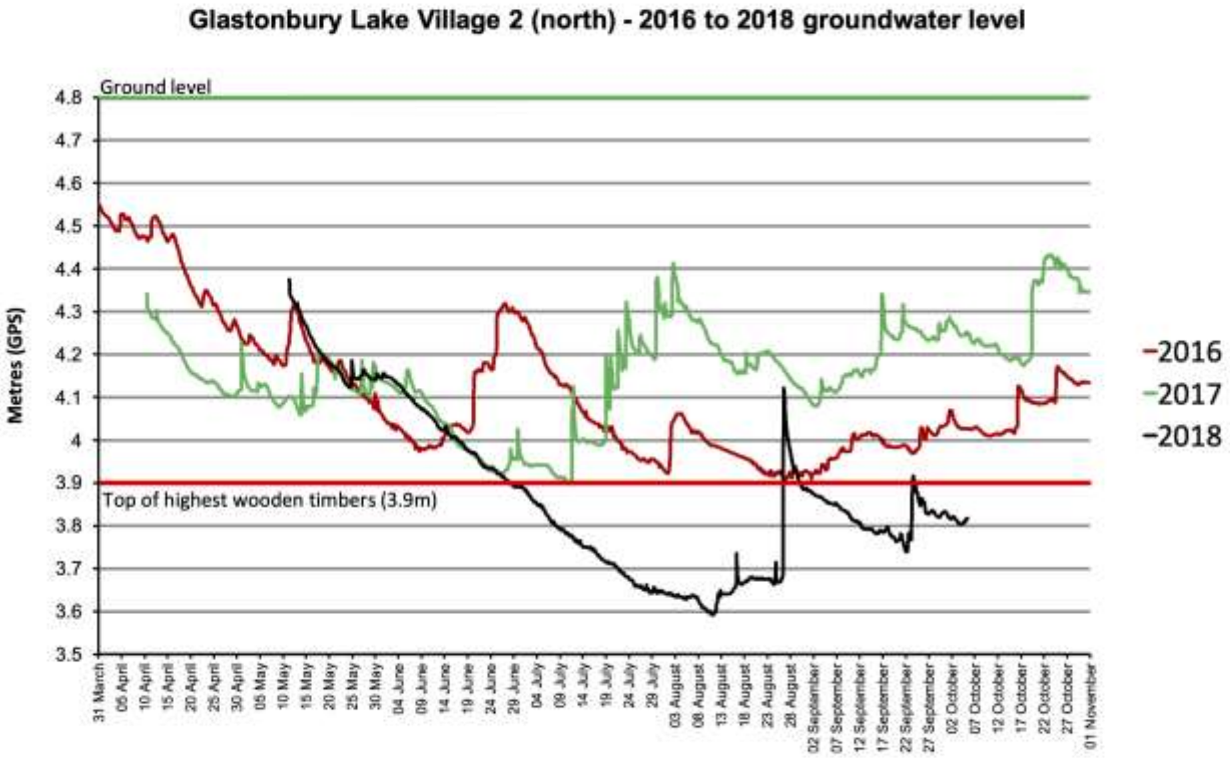

Figure 100 Groundwater monitoring at the northern monitoring location over three years

As the climate change models for the UK predict that such extreme events and extreme dry summers will become more frequent over the coming decades, the results have significant implications for the medium-term preservation of the waterlogged archaeology on the site. It appears likely that the waterlogged archaeological remains which are known to survive closest to the ground surface will be at significant risk of gradual destruction by desiccation and decay.

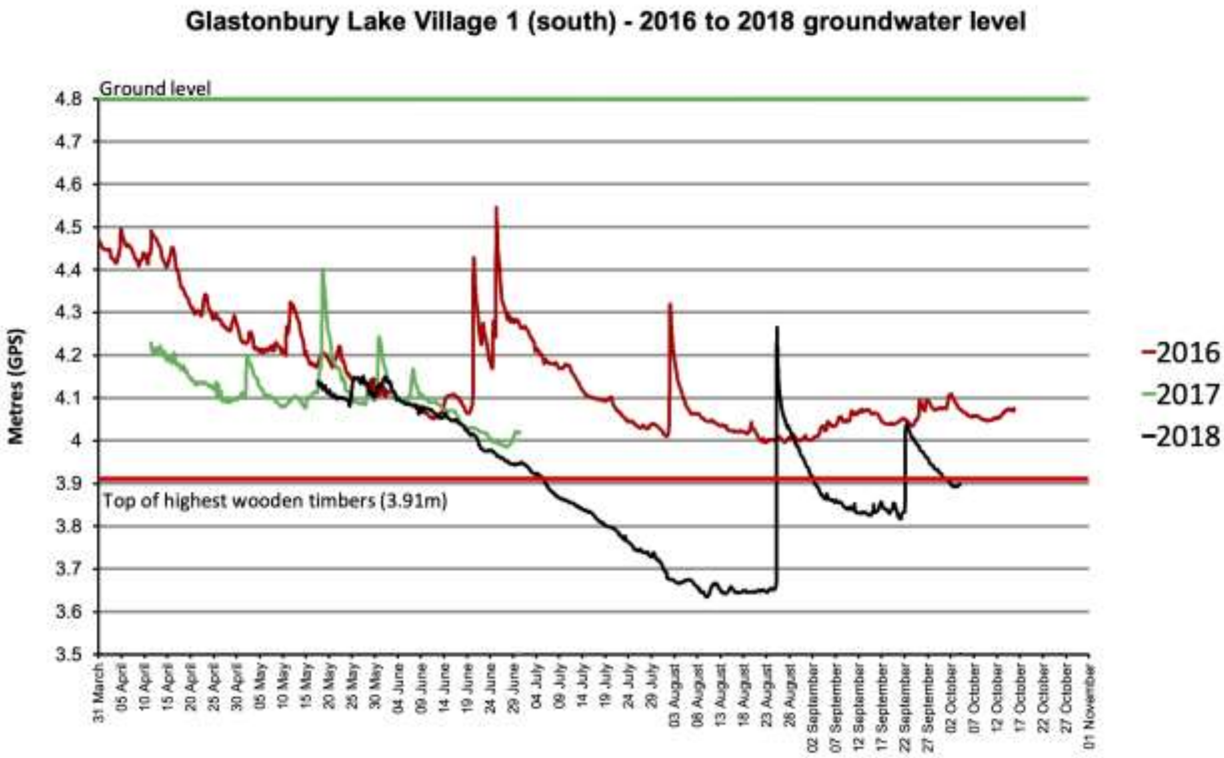

Figure 101 groundwater monitoring at the southern monitoring location over three years

9 Conclusions

9.1 Bulleid and Gray excavation techniques

The excavation techniques employed on the site have been examined at greater length in other works (Coles and Minnitt 1995: Coles, Goodall and Minnitt 1992; Minnitt and Coles 1996 and 2006), so the brief discussion below will concentrate on new evidence from the recent excavation.

Bulleid and Gray were excavating at the end of the 19th and the beginning of the 20th century when archaeological fieldwork was still in its infancy in Britain. Bearing this in mind, the detail and accuracy of the plans and sections produced by Bulleid are exceptionally good. It is testament to his skill that the project was successful in being able to target specific components of the site with small keyhole trenches.

The incredible rapidity of the excavation must have meant that many things were missed during the excavation. This can be seen in the large numbers of pottery and bone fragments recovered from the backfill. Based on the evidence of the recently excavated trenches, over 6,884 pieces of pottery (50.80 kg), 3,478 pieces of daub (46.45 kg) and 16,304 pieces of animal bone are probably present in the backfill. In the 2014 excavation the backfill material was also being rapidly removed with spades so a much larger quantity of material must be present. Those totals are therefore likely to underestimate the quantities present.

Not only artefacts were missed by the original excavation, as in one place in trench 4 some of the lower flooring survived in situ along with wall posts, whose bent over tops were concealed by *in situ* floor deposits. This raises a question over the recorded gaps in the wall lines on many of the mounds. As we now know that the posts were often set to a shallow depth it is possible that some were removed during the original excavation without being recorded. Others, like those in trench 4, might never have been exposed during the excavation. It is likely that the remains of finer material such as textile, rope and string may have been present on the site. Such material is unlikely to have been recognised when the settlement mounds were being spaded away and would have been hard to spot in the peat deposits in such circumstances.

As the 2014 excavations were the first once since 1907 to investigate the centre of the settlement, as opposed to its periphery, they have provided the first reliable evidence for the extent of the original excavations. This will be explored in the discussion of future archaeological potential (below). Suffice to say at this stage, that the habitation mounds were excavated to their lowest levels, after which further smaller investigations were made into the foundations and around individual timbers. The collapsed palisades, and everything under them, were generally left *in situ*.

The 2014 fieldwork has also clarified what material Bulleid and Gray included in their reburial area. The assemblage comprised not just oak timbers but also small offcuts and even woodchips. As only part of the reburial area was examined it is not known how representative this is of the whole reburied assemblage. The oak timbers were probably from the foundations of the settlement, to judge from Bulleid's records and plans. Some of the more finely worked and jointed timbers may be present elsewhere in the reburial area.

9.2 Character of the settlement

The evidence from the excavations have illustrated the dynamic character of the settlement. Every year there is likely to have been building taking place, either in the creation of a new roundhouse or a repair to a collapsed palisade. The water table was clearly very high, and the inhabitants must have been fighting a constant battle to keep the interior of their buildings dry. The interior spaces were having constant additions of small layers of material in addition to the floor relaying episodes that Bulleid recorded in his sections. The presence of thin layers of silt or woodchips in mound 9 are a reminder that the gradual accumulation of material on the site was a product of a myriad number of brief actions, only a few minutes or even seconds in duration.

Outside the buildings, rubbish accumulated in the remainder of the settled space, including grain, animal bone, broken pottery and daub. Most of the rubbish seems to have been dumped outside the settled area, in some cases to be buried underneath the later expansion of the settlement or the collapse of a palisade.

Although the settled area was very confined and surrounded by a wetland, the dung evidence suggests that domesticated animals were present on the site. These were probably small animals such as chickens or pigs, but cattle could have grazed in the shallow reedbeds. The Highland cattle on Shapwick Heath National Nature Reserve, seem to enjoy grazing among the reedbeds, especially in hot summers. The presence of herbivore dung in the floor make up of the mound 9 roundhouse suggests that some of the animals were present inside the buildings, either by design or by stealth.

The grain analysis provides the first suggestion that spelt wheat, barley and oats were being brought to the site as spikelets, and probably stored in the same form until ready to be ground for flour. The charcoal evidence suggests that fuel was predominantly alder wood, no doubt collected from the local wetland.

Diatom analysis of the silt within the roundhouse floor in mound 9 suggest that the material had been gathered from a stagnant or slow-moving freshwater environment, similar to that where peat had also been gleaned to help create the foundations of the mound. This suggest that both materials were probably gathered from locations quite close to the settlement.

9.3 Date and duration of the settlement

The project has successfully obtained reliable scientific evidence for the date and duration of the settlement as outlined in the dating chapter above. This has proved the short duration of the lifespan of the wooden structures on the site, most notably from the evidence from mound 9. It has also shown how short the lifespan the settlement was as a whole, although the wiggle match dating one of the reburied timbers raises the possibility that there may have been earlier activity on the site.

The reburied timbers have shown that there is some surviving potential for dendrochronology from the site, with the option of wiggle-match dating if the site chronology cannot be tied into a master chronology for the period. The reburied wood (trench 3) is one of the more likely sources of dendrochronology samples.

A similar dating exercise for the Meare Lake Villages could also prove productive, although the survival of wooden remains on those sites is known to be significantly poorer than at Glastonbury (Brunning 2013). The existing dating data has been compared for the Meare and Glastonbury Lake Villages as part of the publication on the dating of Glastonbury (Marshall et al. 2020).

9.4 Future archaeological potential and priorities for research

The project results have proved that significant Iron Age deposits remain *in situ* on the site but that the excavations of Bulleid and Gray have removed most of the occupation layers in the habitation area. In the three mounds excavated, one (mound 59) had been completely excavated below the level of the foundations with wall elements only surviving where they intermingled with an earlier palisade line, one (mound 74) had been excavated down to its earliest floor and wall phase and one (mound 9) had been excavated to below its earliest floor and in places into the foundations but with traces of flooring and wall posts from several phases surviving. The survival in mound 9 was highly variable however, even within the small area of the 2014 excavation. In some isolated patches the earlier floors survived, and the sequential rebuilding of the walls was represented by arcs of the lowest portions of the wall posts, although their associated floors had been totally excavated. Even a small patch of surviving floor from a roundhouse interior yielded useful information to help characterise its occupation.

In the palisaded areas the general policy of Bulleid and Gray appears to have been to leave the collapsed posts and the associated horizontal timbers *in situ*. This was evident in trenches 1 and 5 on the northern and southern sides and had previously been seen on the western side in trench 1 of the 2003 project (Brunning 2013). Bulleid appears to have excavated in between the collapsed palisades and their associated horizontal structural timbers, wherever there was a gap. This was probably done to provide further information on the relationship between the different structural elements and to look for artefacts.

The combined results of the 2003 and 2014 projects suggest that the original records, sections, plans and photographs from the Bulleid and Gray fieldwork provide a very good basis for suggesting what is likely to survive on the settlement site. In every area this basic pattern varies significantly, both from mound to mound and within small areas within each mound. The following principles of preservation can be established in relation to the Bulleid and Gray fieldwork;

- In the area of the mounds only the lowest floors are likely to exist *in situ*
- In some mounds the lowest floor and the underlying foundations will have been completely removed
- Within each mound there could be considerable variation in survival over a short distance
- The wall posts associated with later floor levels can sometimes survive even though the floors have been totally excavated
- The palisade timbers and the associated horizontal timbers were invariably left *in situ*, although the gaps between them were usually excavated as deep as the space permitted
- Nice looking features such as the mound 9 decorated hearth, or the mound 74 earliest wooden floor, were usually left *in situ*. This probably also applies to the complete wattle panels.
- Some isolated patches of flooring still survive and can provide useful information to characterise the occupation
- Not all the roundhouse wall posts were excavated or recorded (eg. unrecorded ones from mound 9)

The 2014 excavation has shown that significant results can be obtained from the excavation of small areas of the settlement, elucidating the chronology of the settlement, its construction and its environmental setting. The site clearly holds great potential for further research. Four areas of particular interest deserve to be highlighted;

1. Mound 9 hearth. The sequence of superimposed hearths and 'fire ash' layers below the decorated hearth clearly represent a valuable opportunity for scientific dating. They were not analysed in the 2014 project because analysis would entail the removal of the entire column. As methods of analysis improve it will probably prove possible to obtain results from smaller samples. It is not known how far this unexcavated column is suffering from annual periods of wetting and desiccation. The continuing integrity of the unexcavated block cannot be assumed.
2. Palisades. The sequentially collapsed palisades hold great potential for enhancing the chronology of the site. The material below the collapsed posts is highly likely to include 'midden' deposits, well preserved artefacts and potentially 'ritual' deposits. Analysis could potentially significantly improve our understanding of the character of the settlement
3. Reburial area. The reburied timbers represent a significant resource for dendrochronology and for woodworking studies.
4. The wider area beyond the excavation. Bulleid appears to have trenched around the palisades but cultural material exists over a much wider area beyond the limits of the Bulleid and Gray fieldwork. This was shown by Bulleid's exploratory coring and by the evidence of the excavations by the Somerset Levels Project and the 2003 fieldwork. These areas could include particular locations of human activity set slightly away from the settlement which could further elucidate the character of the occupation of the site. The 'Faxon Mound' to the north of the settlement could represent one particular point of activity as imported clay appears to exist there.

The other significant point is that although no textiles, leather or rope were recorded from the original excavation, the remaining *in situ* waterlogged layers clearly hold the potential to retain such material. For the Iron Age this is very important because of the general lack of evidence for such materials from the UK's archaeological record. The recent excavation of the Bronze Age settlement at Must Farm in Cambridge and the Whitehorse cist on Dartmoor (Jones 2016), show the potential of such sites.

Glastonbury Lake Village still has great potential to answer research questions. As archaeological science continues to improve the potential of the waterlogged deposits is likely to keep increasing. Against this must be set the impossibility of being able to protect the site against all degradation in the face of extreme weather scenarios. The condition of artefacts and ecofacts can only get worse over time, never better. This suggests that small scale further fieldwork to answer research questions is a justifiable priority, especially where the resource is significantly threatened by degradation (eg. the reburial area) or where there is a very extensive resource (eg. the border palisading and the wider landscape beyond it).

9.5 Condition of the settlement

The excavation and subsequent analysis of wooden remains have demonstrated that the waterlogged deposits are in a highly vulnerable condition, where a prolonged period of desiccation could lead to their destruction. It was not possible to identify many of the wooden remains to species. This demonstrates the gradual denudation of scientific information in the organic remains. The poor surface condition of the material previously uncovered by Bulleid and Gray may be a product of deterioration during that period or could be due to previous or subsequent damage. This also applies to the shrinkage and cracking observed in the small wall stakes in trenches 2 and 4. The original excavation must have caused some damage to the exposed and reburied remains, but those lowest levels that were left *in situ* may only have been exposed for a short period.

The wooden remains reburied by Bulleid and Gray still survive, despite their proximity to the surface, but are in a highly vulnerable condition. On the split oak timbers, the potential loss of the more vulnerable sapwood, could have a significant detrimental effect on the potential for future dendrochronological analysis, as would warping and cracking of the heartwood.

9.6 Future preservation

This project has accurately established what waterlogged archaeological remains still exist in the core of the site and their OD height. This has enabled water monitoring results to be more directly applied to those remains across the site.

The initial two years of water table monitoring appeared to predict a relatively hopeful future for the future preservation of the site. The penning of the ditch on the western edge of the field also helped to maintain much more favourable summer water levels in that feature. However, the very dry summer of 2018 has shown how false all these hopes were, as the water table went below the top of the waterlogged archaeological remains for several months.

The climate change predictions for the UK (UKCIP18 https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index) suggest that the SW region of England will experience increasingly hot and dry summers and that extreme events such as the summer drought of 2018 will increase both in intensity and in frequency. Where does this leave the future of Glastonbury Lake Village? The current hydrological regime will clearly not be sufficient to maintain the preservation of the uppermost surviving elements of the *in situ* waterlogged remains over the next decades. This suggests that either improved hydrological protection is required, or mitigation measures for the parts of the site most at risk.

Improving the hydrological regime of the site will be extremely problematic for the following reasons:

- In dry summers there may well be a general shortage of water that will prevent improving the local hydrological regime. This is already a problem in dry summers (Phil Brewin pers. comm.)
- The site water table is not isolated and is affected by conditions over a wider area. Isolating the water table within the field, even if this was possible, could be dangerous as it could prevent local recharge after a period of desiccation.
- Bringing water into the top of the ground surface within the field is unlikely to help as it is known from the previous studies (Jones 2013) that a perched water table can sit on the surface while the real water table underneath is still lowered. This suggest that only an intrusive irrigation system installed underneath the mixed clay and peat backfill of Bulleid and Gray would be effective. The installation of such a system could damage the site and there may be the additional danger that in a very dry year with no additional water supply such a system could also cause additional harm if not kept waterlogged.

Because of these significant barriers to improving the hydrological regime, a mitigation strategy must also be considered. The elements of the archaeological record must vulnerable are those highest in terms of OD. These include:

- The wooden material reburied by Bulleid and Gray
- The earliest floors and wall stakes on each mound that may have been missed or just left *in situ*
- The tops of the collapsed palisade stakes (which help to demonstrate their stratigraphic relationship)
- Any surviving occupation layers between the habitation/activity mounds

The waterlogged remains that would be at lesser risk would be;

- The foundation material underneath the habitation/activity mounds
- The lower levels of the palisade stakes
- The potential midden material and ritually deposited material underneath the collapsed palisades
- The potential midden material and ritually deposited material outside the palisades
- The palaeoenvironmental evidence contemporary with the occupation outside of the settlement
- Any activity earlier than the known occupation

Any mitigation strategy would have to focus on the category of material most at risk. However, some materials such as fabric may only survive in the lower deposits and may be less robust than wood in the face of occasional desiccation. There would therefore also be an argument in attempting to determine if different categories of evidence existed in the deeper parts of the site, such as below the collapsed palisades.

Field work on a large scale would inevitably be very destructive and could enhance the risk to the surviving deposits. Therefore, the mitigation strategy should build on the success of the current project by answering key research questions through small scale ‘keyhole’ archaeological investigations. The target for such investigations could be as follows:

- The wooden material reburied by Bulleid and Gray. Research priority - the recovery of samples for dendrochronology before sapwood is lost and wood cracks and deteriorates.
- Sample areas within the settlement between the occupation mounds. Research priority – assessment of what survives in such areas and the character of the occupied area between the buildings.
- Floors and walls in 2 sample areas. Research priority – enhancing our knowledge about the character of the buildings across the site and determining if there are consistent changes in the original excavation technique over time.
- Sample excavation of palisade lines in 2 places. Research priority – to enhance understanding of the character and development of the border palisade over time and to assess if significant deposits exist in situ beneath the collapsed palisades and if other more fragile categories of artefacts are present in such areas (eg. textile, rope).

Glastonbury Lake Village retains a significant quantity of *in situ* archaeological remains despite its ‘total excavation’. The future preservation of elements of this key Iron Age site looks bleak over the coming decades. Further small-scale research excavation will enable preservation by record of a small proportion of this at risk archaeology and could help to answer significant research questions about the site.

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Figure 102 Bulleid leading a site visit c.1897


Figure 103 modern excavation techniques 2014