Excavation of a Medieval Bridge at Waltham Abbey, Essex, in 1968

By P. J. HUGGINS

THE single-arch bridge over the lower mill stream at Waltham Abbey was excavated in advance of roadworks. The bridge had three double-chamfered ribs set skew to the abutments. The springers were of Caen stone; the ribs and ashlar facing of the abutments were of Kentish ragstone. The abutments were set on oak sill-plates and staggered rows of elm piles. Bank revetting and coffer-dam timbers were also found. The bridge is compared with the near-by single-arch Stony Bridge. A mid 14th-century date is established by dendrochronology. Documentary study has enabled phases in the development of the watercourse system to be postulated.

THE SITE

WALTHAM ABBEY and the town that grew up around it lie on a gravel terrace beside the River Lea (or Lee), 14 miles due north of Greenwich, London (FIG. 51). Excavations were conducted on the site of the bridge, TL 381009, by the Waltham Abbey Historical Society, before the building of a relief road, the embankment of which would encroach on the bridge.

The meadows north of the precinct are known locally as the abbey fields. Foundations in one of the fields called Veresmead[1] were first recorded[2] in the dry summer of 1933. These included the E. abutment of a stone bridge in the side of the present ditch on the W. side of Veresmead (FIG. 51). A causeway links this bridge with the existing, but incomplete, medieval Stony Bridge[3] which spans the Cornmill stream; this stream forms the E. and S. sides of Veresmead. Beyond the bridges the line of the road is uncertain, but it is assumed to link the monastic grange[4] with the mill site south of the excavated bridge. Most of Veresmead and Redholm to the west is an alluvial flood-plain deposit. The depressions in the north of Veresmead are generally identified as monastic fish-ponds. A foundation, *c.* 170 by 35 ft., south of the causeway, is assumed to be the hospital[5] founded *c.* 1218.

[1] The name is established as a result of the work here reported.

[2] By S. F. and R. E. Puddephatt, their plan retraced as drawing PL/570/001 of the Lee Valley Regional Park Authority. Foundations II to IV have been seen as crop-marks only. Foundations I, VII, VIII and IX were excavated in 1970 before and during road building.

[3] In the guardianship of the Department of Environment; also called Harold's bridge.

[4] The grange is taken to be a complex of buildings between Stony Bridge and Crooked Mile indicated on the Hatfield House map of *c.* 1600 (Hatfield House, maps and charts, II, fol. 23; copy in British Museum, maps, 186.h.2 (fol. 23). Foundations X (an aisled tithe barn), XI, XII and XIII were excavated in 1970.

[5] D. D. Knowles and R. N. Hadcock, *Medieval Religious Houses of England and Wales* (1953), p. 315.

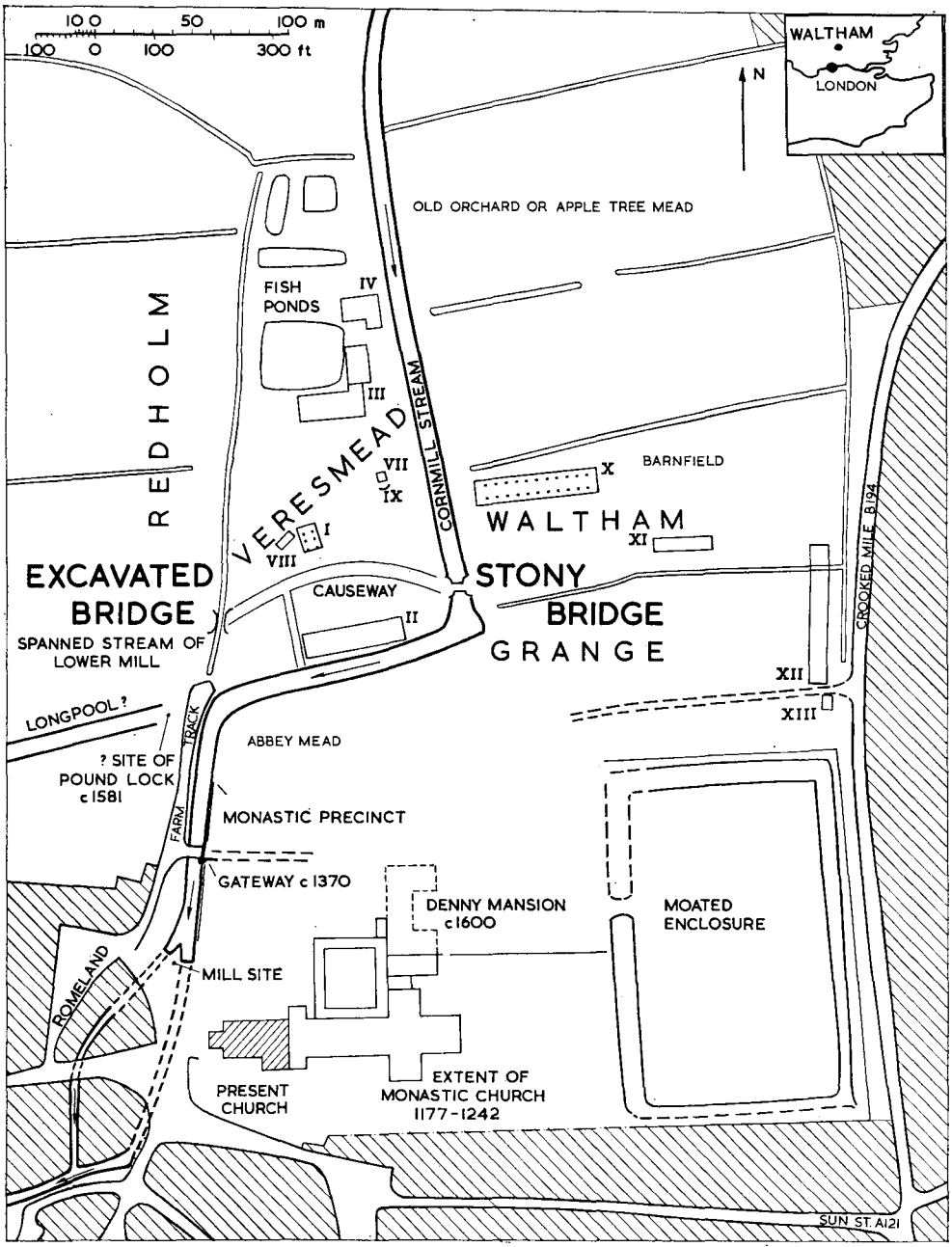

FIG. 51

WALTHAM ABBEY, ESSEX

Plan showing location of sites; inset, sketch-map showing position of Waltham in relation to London (pp. 126, 128, 137)

DOCUMENTARY EVIDENCE

As a result of documentary study by Dr. K. N. Bascombe it is possible to postulate stages in the development of the watercourse system at Waltham Abbey.

From the account of the construction of a conduit[6] from Wormley to Waltham in 1220–22 the stream spanned by the excavated bridge is identified as *the stream of the lower mill* and the Cornmill stream as *the stream of the second mill.* The lower stream, running due south to the mill site, would fit the Domesday record of one mill at Waltham in 1066. Possibly by 1086, when Domesday records three mills in the vill of Waltham, a second and more elevated supply along the Cornmill stream had been provided;[7] this would have meant that both streams ran parallel from the SW. corner of Veresmead to the site where, in later times, two mills were recorded under one roof. The Cornmill stream, with a possible extension[8] south near Stony Bridge, would have provided a head of water to flush the monastic sewers[9] and have enabled barges to approach the conventual buildings.[10]

The two mill streams could have operated together for many years until the Cornmill stream was used to supply power to both mill wheels, as it continued to do until the mill was demolished in 1906. But by *c.* 1581, probably in response to an act[11] of 1571, to be put into effect in ten years, the through route for navigation was diverted from the old River Lea or King's stream, some 220 yd. west of the excavated bridge. The new route is likely to have been down the Cornmill stream to the SW. corner of Veresmead, through a pound lock,[12] into the *long pool*[13] (FIG. 51), and back into the old river. This new route, which only lasted until *c.* 1590,[14] would have necessitated blocking the lower mill stream if it had not already been filled in. Leland,[15] writing between 1535 and 1543, mentions 'but one principall arme' on the E. side which 'goeth to the corne mill in Waltham'. Thus the other arm may have been filled in when the two mills were combined under one roof; the earliest reference to this is in 1528.[16] Earlier still in 1482 the abbot was taking too much water for his mill;[17] it is conceivable that at this date

[6] B. M. Harl. MS. 391, fols. 1–5.

[7] The actual difference in level between the water in the two streams, estimated from comparable features on the two bridges, is *c.* 5 ft.

[8] Suggested by excavations in 1969 near the N. claustral range.

[9] As had been 'done since the foundation of the Abbey': B. M. Add. MS. 37665, fol. 269 (an agreement of 1281).

[10] Following the refoundation in 1177 by Henry II.

[11] An act (13 Elizabeth) for bringing the River Lea to the N. side of the city of London.

[12] Described as 'newly made but sore decayed': W. Vallans, *A Tale of Two Swannes* (*c.* 1589). Probably the second such lock in England: T. S. Willan, *River Navigation in England 1600–1750* (London, 1964), p. 89.

[13] Northamptonshire Record Office, WC/244/2 (sessions of justices of sewers, 1682).

[14] When Sir Edward Denny made 'a new cut and passage', meaning he recut the old River Lea: *ibid.* The pound lock, the *long pool* and the lower mill stream are not indicated on the map of Waltham of *c.* 1600 (see above, note 4).

[15] *The Itinerary of John Leland* (ed. L. Toulmin Smith, London, 1910), pt. VIII, 112. Leland describes four arms of the Lea: the small river and the fulling mill (later powder-mill) stream on the west, then the old river and the Cornmill stream on its E. side.

[16] Public Record Office (henceforth P.R.O.), E. 303/3/Essex no. 209 (conventual leases).

[17] Sir William Dugdale, *Monasticon Anglicanum* (1830 ed.), VI, pt. 1, 57 (verdict of jury): '. . . the head at the entry of the said Abbott's Myll, where water goeth out of the kinges ryver, is of xvj fote brode where it should be but foure foote, by the which the kings streame is sore hurte.'

the Cornmill stream was supplying both mills. From the documentary evidence therefore the lower stream must have gone out of use, and possibly been completely filled in, by *c.* 1581 at latest, but possibly before 1528.

The first record[18] of stone bridges at Waltham is *c.* 1542 when 'the grange,[19] next to the stony bridge' is mentioned. Two wooden bridges,[20] for which the abbot was responsible in 1278, may possibly be predecessors of that excavated and Stony Bridge. One was 30 ft. long and the other 20 ft.; both were 8 ft. broad.

THE EXCAVATIONS

Trench A (FIG. 52), excavated to produce a section across the bridge, was realigned to follow the unexpected skew angle of the central rib (PL. XI, A); an extension of the trench up to the boundary hedge established the existence of the W. abutment. Trench B was dug to show the end of the E. abutment and the original form of the bank (PL. XI, C). Trench C cut across the causeway to Stony Bridge. Trench D established the relationship of the causeway to the back of the E. abutment. Much of the work was below the present water-table. The wooden piles are not in danger of drying out.

All the excavated features have been given numbers, F1 to F48. These numbers are used on the plans and sections and reference can be made to the list below (Table I) for a description of the features and for the record of associated finds. Clay pipes are classified and dated according to Oswald[21] and Harrington.[22]

TABLE I. LIST OF EXCAVATED FEATURES

FEATURE NUMBER	DESCRIPTION	SIGNIFICANT ASSOCIATED FINDS
F1	Caen stone springers for double chamfered ribs (PL. XI, A–B)	
F2	Kentish ragstone ashlar facing to bridge abutments (PL. XI, A–C)	
F3	Oak sill as pile capping, planks 1½–2 in. thick, 16 in. and 8 in. wide (PL. XI, B–D)	
F4	Tapered elm piles, set staggered in two rows, more than 4 ft. long (PL. XI, B–D)	
F5	Mortared flints, laid in courses, forming upper backing to abutment (PL. XI, A)	*coins:* 1863, 1863, 1885, on surface
F6	Loose flints forming lower backing to abutment	
F7	Topsoil	*clay pipes:* 19th-cent. *coin:* 1862 *pottery:* 19th-cent. and derived
F8	Bed of ditch, black, silty. Probably formed from F9. Essentially 19th-cent. material, possibly not cut until then	*white-glazed bead or spindle-whorl*, 24 mm. diam., 18 mm. thick *clay pipes:* 3 19th-cent. *pottery:* 19th-cent.

[18] P.R.O., S.C. 6/Hen. VIII/964 no. 105r (lands of dissolved religious houses).
[19] See above, note 4.
[20] B.M. Add. MS. 37665, fol. 279 (proceedings of an inquisition held at Hertford).
[21] A. Oswald, 'The evolution and chronology of English clay tobacco pipes', *Archaeological Newsletter*, v, no. 12 (Dec. 1955), 243–50.
[22] See I. C. Walker, 'Statistical methods for dating clay pipe fragments', *Post.-Med. Archaeol.*, 1 (1967), fig. 27.

TABLE I—*continued*

FEATURE NUMBER	DESCRIPTION	SIGNIFICANT ASSOCIATED FINDS
F9	Clayey soil, in places covering bridge abutments and filling space between. Late 16th-cent., probably same deposit as F42	*pottery:* 1 shelly ware; 2 sandy red ware, 14th- to 15th-cent.; 7 red ware, 16th-cent. (FIG. 55, nos. 9–10); 18th-cent. intrusions
F10	Sandy mortary rubble, destruction-debris	*pottery:* 15 red ware, late 15th- to early 16th-cent. (FIG. 55, nos. 4–6); 1 buff ware like FIG. 55, no. 1
F11	Black stony river-bed silt	*pottery*, all 14th- to early 15th-cent.: 5 large sherds of 2 red ware jugs, green-glazed on white slip (FIG. 55, nos. 2–3); 2 large sherds of pink ware jug; 2 sherds of white-painted jug; 1 buff rim (FIG. 55, no. 1) *leather sole* (FIG. 56, no. 1) *iron* (FIG. 56, nos. 2–3)
F12	Post, quartered tree trunk, possibly support for coffer-dam planks, but none found on this W. side of bridge	
F13	Black river-bed silt, not consolidated as in F11, possibly dug out behind coffer dam and replaced after pile driving	*pottery:* 2 red sandy, 14th-cent.
F14	Black river-bed silt as F13, separated by vertical line from F11, interpreted as indicating position of coffer-dam plank or sheathing set on beam F15	
F15	Oak beam or sole-plate, 17 in. by 7 in., interpreted as base to coffer dam and support for wooden centring during construction of ribs	
F16	Grey silt, possibly natural marsh deposit	
F17	Loose stony soil covering causeway, interpreted as after 1770 but with derived finds	*clay pipes:* Oswald 6*c* (1670–90); *ibid.*, 9 or 10 (1680–1780); 18th-cent. stems *pottery:* 19th-cent.
F18	Gravel in clay matrix, causeway surface probably open until *c.* 1770	*clay pipes:* 18th-cent. stems *pottery:* 3 18th-cent.
F19	Clay with patches of stone, causeway make-up deposit	*pottery:* 3 red ware, 1 green-glazed, 14th- to 15th-cent.; 1 pink ware, green-glazed, 15th-cent.
F20	Dirty gravel, intermediate causeway make-up deposit	*pottery:* 1 large sandy red ware, 14th-cent.
F21	Clay with mortar, stone, chalk, slate and tile fragments. Lower causeway make-up deposit from time of building of bridge	*bronze* (FIG. 56, no. 4) *pottery:* 2 worn coarse sandy ware, 12th- to 13th-cent.; 1 fine sandy, 14th-cent.
F22	Clean clay, possibly recent natural deposit. Ground surface at time of construction of bridge, debris as in F21 trodden into surface	
F23	Grey silt, probably same as F16, possibly natural marsh deposit	
F25	Clayey loam, ditch filling on N. side of causeway	*pottery:* 1 grey ware, late 12th- to early 13th-cent.; 7 17th-cent.; 5 cream ware 18th-cent.
F26	Buried humus level formed over ditch F25	
F27	Wall and foundation of orange-red hand-made bricks (*c.* 9.4 in. by 4.3 in. by 2.2 in.) Part of sub-rectangular enclosure shown on late 19th-cent. maps. Built into side of ditch F28. Probably 18th-cent.	

TABLE I—*continued*

FEATURE NUMBER	DESCRIPTION	SIGNIFICANT ASSOCIATED FINDS
F28	Sandy loam ditch filling. Possibly same date as F27	*clay pipes:* Oswald 10*b* (1690–1740); 18th-cent. stems *pottery:* 1 red ware 14th- to 16th-cent.; 1 white stoneware base, 18th-cent.
F29	Buried humus formed over top of ditch F28	
F30	Compact layer of stones in loam. Probably connected with 19th-cent. farm enclosure	
F31	Post, 5 in. diam., bark remaining, set in F10 and F11 in middle of stream. Purpose not clear	
F32	Square post, tapered, set in F10 and F14, 1 ft. 5 in. long, top was 9 in. above top of sill F3. Possibly to protect abutment from river traffic	
F33	Fragments of oak plank interpreted as sheathing of coffer dam to divert water from E. abutment	
F34	Sawn timber slice, 1½ in. thick, used to buttress plank F33 against pile F4A	
F35	Remains of timber plank originally set on edge against posts F36, interpreted as sheathing of bank-revetting scheme, secondary to F39	
F36	Two vertical posts, supporting plank F35 (PL. XI, C)	
F37	Oak ground beam or sole-plate, 12 in. by 9 in., with two mortises, length not established. Interpreted as base to bank-revetting timbers (PL. XI, C)	
F38	Oak post, *c.* 9 in. sq. with tenon, set vertically in beam F37, fixed with dowel F47. Other mortise in F37 did not have post fitted	
F39	Two butting oak planks, 2 in. thick, remained to height of 11 in. Interpreted as primary sheathing of bank-revetting scheme (PL. XI, C, one plank removed)	
F40	Chalk lumps set on F37 and against F38 and F39. Chalk debris found in F21	
F41	Squared flints set in end of abutment flush with masonry	
F42	Clayey soil with patches of gravel. Probably 16th-cent. deposit as F9 to fill course of stream	*pottery:* 3 worn, 13th- to 14th-cent.; 2 worn, 14th- to 15th-cent.; 3 16th-cent. (FIG. 55, nos. 7–8)
F43	Clay with pebbles. Interpreted as bank-revetting deposit	
F44	Gravelly mud. Interpreted as deposited before revetting of bank	
F45	Silty layer above F44. Probably formed under water after primary bank-revetting timber F39 in position, but before F35 and F36 fitted	
F46	Clean silt lens formed against conjectural sheathing of coffer dam	
F47	Oak dowel, octagonal form 1 in. across flats. Fixed post F38 in beam F37	
F48	Dowel used to fix one of planks, F3, into pile F4A	

DESCRIPTION OF BRIDGE AND CAUSEWAY

The excavated bridge (plan, FIG. 52; section, FIG. 53, MM) is of single-arch construction with evidence of three double-chamfered ribs. The principal dimensions of the bridge are given in Table II (p. 137). The bridge was set obliquely to the stream.

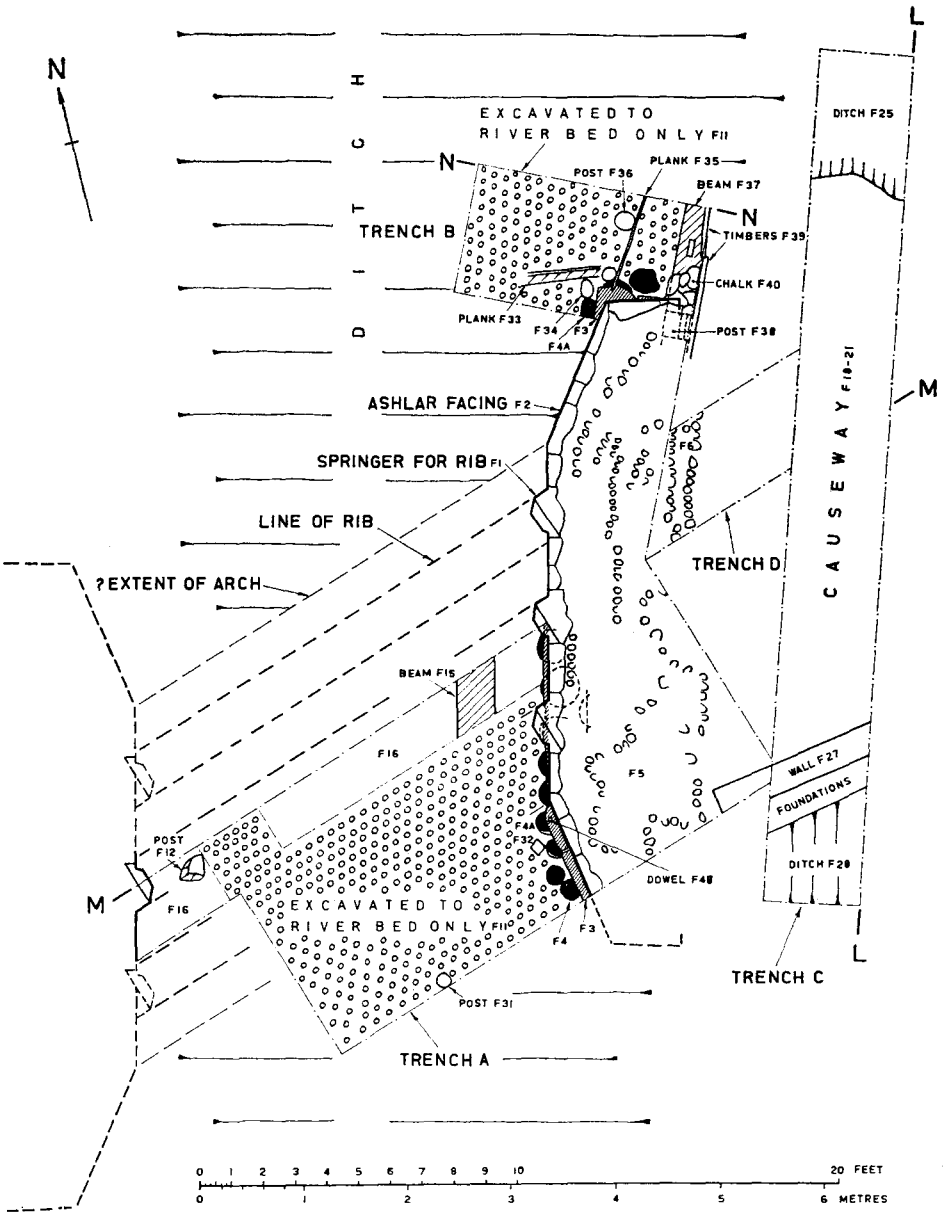

FIG. 52
WALTHAM ABBEY, ESSEX
Plan of excavations of bridge over lower mill stream (pp. 129 ff., 133, 135 f.)

THE COFFER DAM

The building operation was seemingly begun by constructing a coffer dam at each side to keep the water out while the ground was being piled and the abutments built. Evidence for the coffer dam remained in the form of the ground beam or sole-plate F15 set in the underlying silt. Immediately above this beam was a clear vertical line seen in the section which is taken to represent the position of planking or sheathing forming the side of the coffer dam. The formation of the clean silt lens F46 against this sheathing is seen in FIG. 53, MM. On the E. side of the stream no supporting post was found; on the W. side, however, post F12 was found but no sole-plate. It may remain unexcavated or it may have been removed. Further evidence of coffer-dam construction was seen at the N. end of the E. abutment (FIG. 52, trench B), where a fragmentary oak plank F33 remained; the timber slice F34 was placed to support this plank against the pile F4A.

The beam F15 could have acted as the sole-piece of the wooden centring for the construction of the ribs and arch,[23] as well as of the coffer dam.

PILING AND PLANKING (PL. XI, B–D)

After the construction of the coffer dam and any necessary cutting back of the bank and causeway, the operation of piling and planking[24] could proceed. The piles F4 follow the shape of the abutment (FIG. 52) and seem to be set in two staggered rows. They were of elm and range in diam. from 7 to 15 in. Owing to the amount of water encountered the full length of the piles was not determined, but they were over 4 ft. long. They were tapered to a squarish section from *c.* 2 ft. from the top (FIG. 53, MM), the bark was left over the untapered length, and branches were lopped. At the top, most of the piles were chamfered all round in order to centralize the blow during driving; those which did not show this chamfering may have been sawn off to height *in situ.*

The driving of the piles by blows from a falling weight or tup would have been accomplished by ropes and pulleys in conjunction with a tripod structure. The beams F15 and F37 may have served to support the legs of such a tripod. Before driving the piles the surrounding silt seems to have been dug away; this is suggested by the replaced material F13 and F14 (FIG. 53, MM). F13, in particular, with roof-tile debris, was not consolidated like the central river-bed F11.

A capping or sill of oak planks, F3, was laid over the piles to give a flat surface for the building of the stone-faced abutments. These planks, *c.* 2 in. thick, were simply butted up to each other as necessary to cover the area required. In following the angle of the abutment the planks were cut to shape. Two of the piles, F4A, were rebated to receive the planks and to give them horizontal stability. One plank was fixed to a rebated pile by means of the dowel F48.

THE ABUTMENTS (PL. XI, A–B)

The abutments, built on the oak sill F3, were faced with well-coursed Kentish ragstone ashlar, the bottom four courses measuring 2 ft. 6½ in. The faces of the

[23] In the construction of Catterick Bridge (Yorks.) in 1420–1 timber was to be provided for coffer dams, piles and centrings: L. F. Salzman, *Building in England down to 1540* (Oxford, 1967), p. 497.

[24] For the construction of a wharf at Norwich in 1432 the mason was 'to take the ground, pile it and plank it': *ibid.*, p. 85.

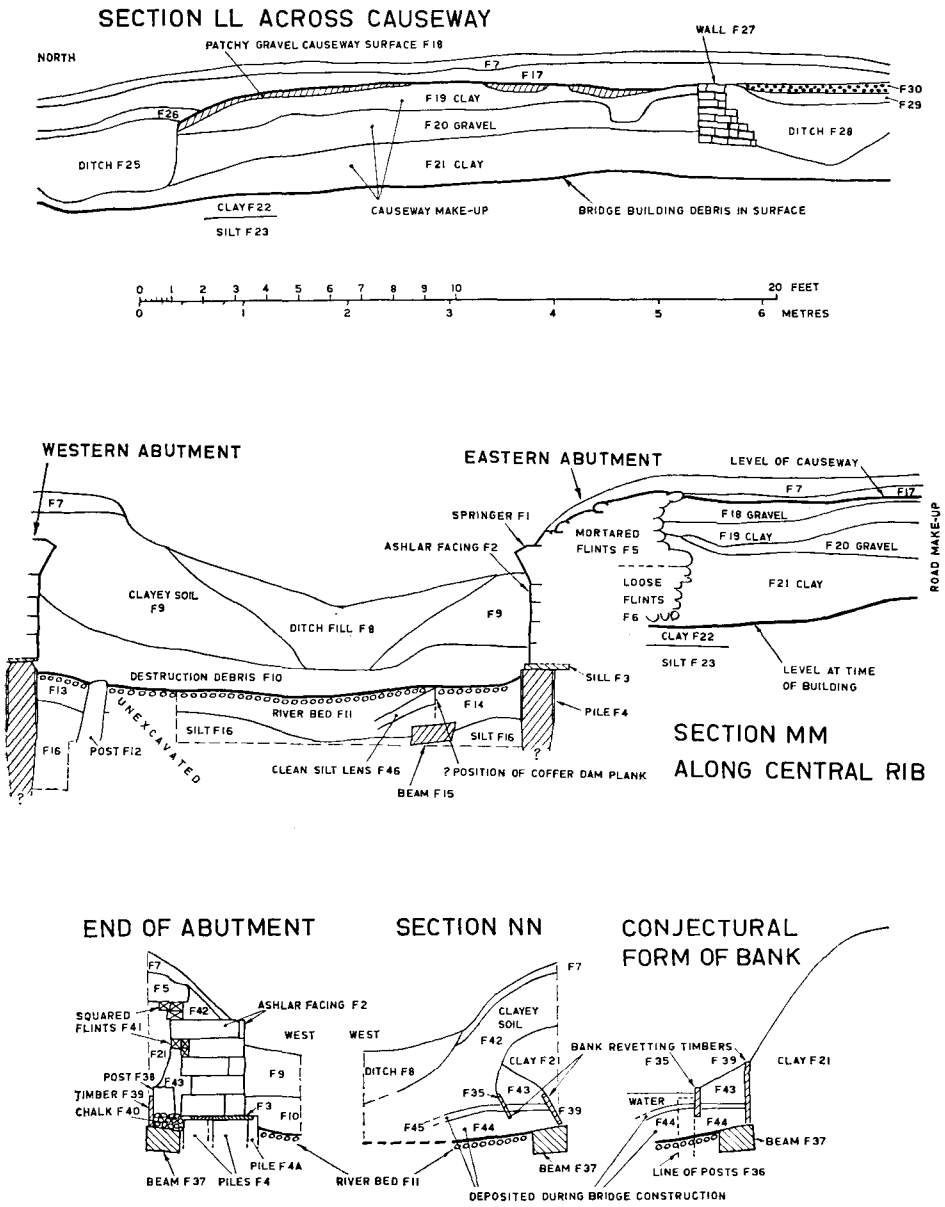

FIG. 53

WALTHAM ABBEY, ESSEX

Sections LL, MM, and NN, across bridge over lower mill stream; view of end of abutment and conjectural reconstruction of bank of stream (pp. 131, 133, 135 ff.)

blocks were only rough-tooled; the sides were tapered to accommodate mortar, the backs left rough-hewn. The filling consisted of loose flints F6 and, above these, well-coursed flint rubble F5.

The three springers for the ribs on the E. abutment were exposed. Only the central rib on the W. side was seen. The springers were of Caen stone,[25] and all rested on the fourth course of ragstone but they varied in width from 1 ft. 2½ in. to 1 ft. 8 in. and in depth from 11 in. to 1 ft. 2 in. Two courses of ragstone were laid between the springers and a last, seventh, course was represented by one remaining block with a thin block on one of the springers bringing it to the same level. The arch would have sprung from this level. Nothing of the arch remained *in situ*. One rib stone was recovered from the destruction-debris F10. It was of fairly smoothly tooled Kentish ragstone, 18½ in. long, 15 in. wide, and 8½ in. deep; the exposed under-face was 6 in. wide with faces chamfered to angles of 45°. The curvature suggests a radius of from 12 to 16 ft.

After the masonry had been finished and the centring removed, leaving the timbers F15 and F12, the deposits F13 and F14 could have been replaced to form the river-bed once more. Two sherds of sandy red ware from F13 are similar in fabric to a large part of a jug (FIG. 55, no. 2) found in the river-bed F11, and are consistent with a date of *c.* 1350. No earlier pottery was found stratified in these levels.

REVETTING OF THE BANK OF THE STREAM (PL. XI, C)

The remains of the revetting of the bank were detected in trench B (plan, FIG. 52; section, FIG. 53, NN). FIG. 53 also includes a conjectural reconstruction of the form of the bank.

First, the oak ground beam F37 was laid in the river-bed F11. In this beam were two mortise holes. One of these was behind the bridge abutment and held the tenon of post F38; this post remained to a height of 15 in. and was fixed by means of an oak dowel F47. The other mortise in the beam was empty and had not been bored for a dowel. The vertical post supported a sheathing of substantial oak planks F39 set on edge behind it; a butt joint in this planking coincided with the empty mortise in the beam F37, and, being unsupported there, the planks had been pushed forward (FIG. 53, NN).

On the beam F37 and after the post F38 and sheathing planks F39 had been fitted, lumps of chalk F40 were deposited and piled up to the post F38. On the other side of the post were mortared flints forming the backing to the abutment. Some of the lumps of chalk actually lay under one of the oak sill planks so that the beam F37, the post F38 and the sheathing F39 were set up to hold back the bank before the sill for the abutments was finished.

After the primary sheathing planks F39 had been set up a deposit F44 (FIG. 53, NN) was laid down covered by a layer of silt F45 before a secondary sheathing timber F35 was erected. This secondary member was supported by two vertical posts F36. The space between the timbers was packed with clay with pebbles F43.

[25] Caen stone was particularly suitable for intricate work: *ibid.*, pp. 135–7, etc.

THE CAUSEWAY AND ITS DITCHES

The causeway across Veresmead between the two bridges is visible on the ground as a raised area and shows clearly as a crop-mark in dry weather. The causeway and its flanking ditches are seen in plan on FIG. 52 and in section on FIG. 53, LL.

The causeway consists of deposits F21, F20, F19, and F18. The level at the time of the bridge building is taken to be below the clay layer F21 because building debris was trodden into the surface of the underlying clay F22, and F21 meets the back of the abutment in a way suggesting it was laid down after the building of the abutment. Two worn sherds in F21 are of 12th- to 13th-century type and one may be 14th-century. This deposit peeled off clearly from F22; it may be a restoration of the original causeway.[26] Above F21, gravel F20 contained one 14th-century sherd and above that a layer of clay F19 yielded sherds which suggested it might be a 15th-century surface. Finally patches of gravel in clay F18 are interpreted as the road surface in use in the 18th century. No medieval road surface was definitely evident but it must always have been maintained at about the same level if it was to meet the bridge at a practical height.

North and south of the causeway are ditches F25 and F28. The stratification suggests they were cut after the causeway had been raised when the 14th-century bridge was built. Since each ditch contained only one medieval sherd and much 18th-century material, it is clear that they remained open as long as the causeway was in use. A ditch on the N. side of a causeway is mentioned[26] as 'the outer ditch which encloses our demesne'. The S. ditch F28 had been utilized to build a brick wall F27 following the line of the road. This wall is probably part of a farm enclosure shown on 19th-century maps. Layers of humus F26 and F29 had formed over the ditches and a layer of stones F30 had been deposited near the brick wall inside the enclosure. The layers F17 and F7 contained 19th-century material.

After 1739 the Wake family, who then owned the mansion built by Sir Edward Denny, were seldom in residence and the mansion was pulled down[27] in 1770. The main entry to it had been through the abbey gateway and, after 1770, this passage probably superseded the causeway as an approach to the area of the supposed grange.

DESTRUCTION OF THE BRIDGE

The stony top of the black silt F11 is clearly the bed of the stream. The sandy mortary rubble F10, over the bed, is equally clearly associated with the destruction or collapse of the bridge. Only one sizable piece of masonry remained in F10, namely the ragstone rib stone (see above, p. 135).

The pottery in the river-bed F11 is 14th- or early 15th-century and the horseshoe and turnshoe sole are consistent with this date. The pottery in the destruction-level F10 is apparently of the late 15th or early 16th century but there is no closely datable piece. On documentary grounds (see above, p. 129) *c.* 1581

[26] B. M. Harl. MS. 391, fols. 1–5, dated 1220–2.

[27] K. N. Bascombe in P. J. Huggins, 'Waltham Abbey: the monastic site and prehistoric evidence 1953–67', *Trans. Essex Archaeol. Soc.*, II, 3 ser., pt. 3 (1969), 219.

is suggested as the latest possible date for the disuse of the lower mill stream, although an earlier date than this—before 1528—is quite admissible. The pottery would not support a date much earlier than 1528. The bridge might have been a casualty of the dissolution in 1540, but as both mill and causeway survived this is perhaps less likely.

The causeway was evidently in use into the 18th century, with the route presumably across the destroyed bridge and filled-in stream. The filling is represented by the deposits F9 (FIG. 53, MM) and F42 (FIG. 53, NN). Material in F9 and F42 is consistent with a 16th-century filling; F9 contained some 18th-century material but this is taken to be intrusive. In any case the stream is not shown on the map of *c.* 1600 which shows Stony Bridge and the Cornmill stream on its present line, as well as Sir Edward Denny's house (FIG. 51).[28] As long as the causeway remained in use the Veresmead W. boundary-ditch could not have been dug. This is supported by the fact that only 19th- and 20th-century material was found in the ditch filling F8.

Details of the bones of horses found in the destruction-level are given in Appendix 4 (p. 145 f.). It is still a common occurrence for horses grazing in these meadows to become trapped in the muddy ditches and streams.

COMPARISON WITH STONY BRIDGE

The excavated bridge and Stony Bridge lie on opposite sides of Veresmead *c.* 400 ft. apart (FIG. 51). Both are single-arch stone bridges with the carriage-way set skew to the abutments. Both have double-chamfered ribs. Stony Bridge was described in 1921[29] as retaining three chamfered ribs forming three-centred arches and as being probably of the 14th century; it was in a poor state of repair in 1860,[30] when the ends of the abutments seem to have been remodelled with the use of brick.

TABLE II. DETAILS OF EXCAVATED BRIDGE AND STONY BRIDGE (FIG. 54)

	EXCAVATED BRIDGE	STONY BRIDGE
True span	13 ft. 1 in.	18 ft. 5 in.
Angle of skew	32°	11½°
Span along length of rib	15 ft. 6 in.	18 ft. 10 in.
Length of parallel part of abutment	11 ft. 2 in.	18 ft. 3 in.
Number of ribs	3	5
Pitch of ribs	2 ft. 10 in.	3 ft. 10 in.
Estimated width of carriage-way	8 ft. 6 in.	17 ft.
Angle of cut-water	23°	27°
Stone used	Caen stone springers Kentish ragstone ashlar	Kentish ragstone throughout[31]
Depth of ashlar courses	7½ in.	9 in.

[28] *Op. cit.* in note 4.

[29] Royal Comm. Hist. Mon. (England), *Essex*, II (1921), 244. There were said to be traces of three other ribs making a total of six, but in fact only five can be fitted on the plan.

[30] J. Maynard, *The Parish of Waltham Abbey* (Waltham Abbey, 1865), p. 101.

[31] From examination of weathered surfaces on the site.

The angle of skew of both bridges must have been dictated by an existing roadway. As in 1220–23[32] the ditch north of the causeway was the boundary to 'our demesne' and the whole of Veresmead was part of the abbey lands, it seems evident that both bridges would have been the responsibility of the abbot.[33]

The plans and profiles of the two bridges are shown together on FIG. 54. The measured profile of Stony Bridge indicates a three-centred form with radii of 16 ft. and 4 ft. for the major and minor curves. The three-centred form was probably dictated by the desire to limit the rise of the bridge. One rib stone from the excavated bridge suggests a radius of between 12 ft. and 16 ft. The plan of Stony Bridge is unreliable at all four extremities where its shape is probably that of the renovation; only at the SE. corner is the angle of the cut-water likely to be original (FIG. 54). Skin divers, who obtained the measurements of Stony Bridge,

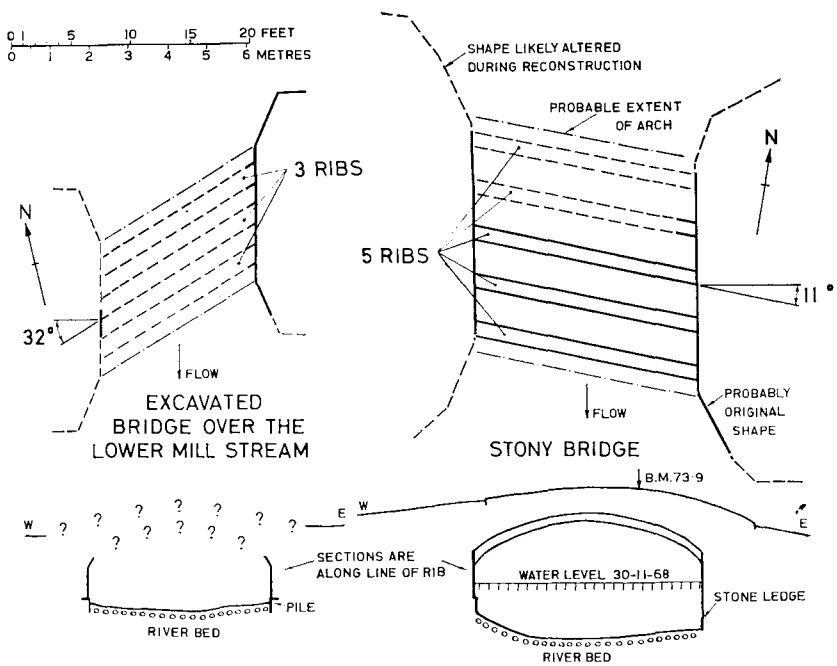

FIG. 54
WALTHAM ABBEY, ESSEX
Comparison of excavated bridge over lower mill stream and Stony Bridge (p. 137 f.)

reported under-water ledges of varying width round the abutments. Two of these ledges appear on the profile in FIG. 54; these ledges may represent the shape of an earlier bridge or be the result of repairs to the foundations carried out in 1901.[34]

The width of the carriage-way is not dependent upon the siting of the bridge, and allowing for a 6-in.-wide parapet on each side, that of Stony Bridge, 17 ft.,

[32] *Op. cit.* in note 6.
[33] As at Bury St. Edmunds (Suffolk) where a river bridge is just inside the monastic boundary.
[34] *Waltham Abbey Church Monthly* (Aug. 1901).

is double that of the excavated bridge. The width of other sizable medieval bridges, from nineteen examples[35] in E. and S. England, varies from 8 to 15 ft. with an average of just over 12 ft.

The stone predecessor of the existing three-arched brick bridge at the abbey gateway was also skew.[36] The angle of skew was 16°, as estimated from a single parapet coping stone which projects at this angle from the gateway wall. Its obliqueness was to accommodate traffic curving round from the direction of the excavated bridge. The width of this bridge is estimated at *c.* 22 ft.; this covers the vehicular gate which is 10 ft. wide and the pedestrian gate which is $4\frac{3}{4}$ ft. wide. It would have been a bridge of low rise, of a span *c.* 27 ft., and would presumably be contemporary with the gateway, i.e. in or soon after 1369.[37]

STRUCTURAL ANALOGIES OF THE TIMBERS

The possibility of a wooden predecessor to the excavated bridge has been raised (see above, p. 129). The basal members of a number of timber bridges have been recorded in Britain, usually in castle moats. These may be divided into two groups: those carried on rigid tower-like piers, structurally analogous to timber belfreys and presumably to the towers that surmounted mottes, and based on four sole-plates halved and lapped near their extremities; and those carried on independent parallel sole-plates, the rigidity being provided by the longitudinal upper plates and braces of the bridge. In the former category are West Derby, Liverpool;[38] Leckhampton (Glos.);[39] and Camlet, Enfield (Mddx.).[40] In the latter are Hen Domen (Montgomerys.) (early);[41] Eynsford (Kent) (three successive bridges, 12th- to 13th-century);[42] Caerlaverock (Dumfries.);[43] Bodiam (Sussex) (late, i.e. after 1380);[44] and Bushwood Hall, Lapworth (Warws.).[45] These plates commonly have mortises for two or three upright posts, flanked by two for braces or shores. The intervals between the parallel plates vary much—at Lapworth they are as little as 4 ft. The abutments of such bridges may be revetted or sheathed in timber, carried on a similar sole-plate, and such would seem a probable way of constructing a coffer dam, which could be sunk already framed-up.

Only short lengths of the beams at Waltham have been uncovered, but they are evidently sole-plates of this general type. One contains two mortises, of which

[35] E. Jervoise, *Ancient Bridges of England*, 4 vols. (1930–36).

[36] There seem to be very few skew bridges in the literature to compare with the three at Waltham. Old Brentford bridge was built 'obliquely to the road': C. W. Radcliff, *Middlesex, The Jubilee of the County Council* (London, 1939), p. 30. The first arch of the bridge at East Farleigh over the R. Medway is set at 45°: *op. cit.* in note 35, S. England volume.

[37] The abbot received licence to crenellate in April 1369: *Cal. Pat. Rolls*, XIV (1367–70), 245.

[38] J. P. Droop and F. C. Larkin, 'Excavations at West Derby Castle, Liverpool', *Annals Archaeol. and Anth. Univ. Liverpool Inst. Archaeol.*, XV (1928), 47–55.

[39] J. G. N. Clift, 'Leckhampton moat', *Trans. Bristol Glos. Archaeol. Soc.*, LV (1933), 235–48.

[40] D. F. Renn, 'Bridge framework from Camlet moat, Trent park, Enfield', *Trans. London Mddx. Archaeol. Soc.*, XXI, pt. 3 (1967), 224–5.

[41] Note by P. A. Barker, *Med. Archaeol.*, VIII (1964), 262.

[42] Note by S. E. Rigold, *ibid.*, XI (1967), 285.

[43] Note by I. MacIvor, *ibid.*, IV (1960), 147.

[44] Lord Curzon, *Bodiam Castle* (London, 1926).

[45] Note by A. Oswald, *Med. Archaeol.*, VI–VII (1962–3), 336–7.

one is empty, if indeed it had ever been used. The beams are not parallel, nor at the same level, and their situation suggests that F15 is part of a coffer dam and F37 part of a bank-revetting scheme more extensive than that of a mere abutment. The vertical division in the silt above F15 (FIG. 53, MM) does not coincide with a mortise and post, but could have been caused by the planking of a coffer dam. The dendrochronological evidence (Appendix I, p. 141) suggests that the beams are little earlier than, and structurally contemporaneous with, the stone bridge and not, therefore, part of an earlier timber one.

Medieval references to the use of piles for the foundations of buildings, wharves and bridges are numerous.[46] The Waltham combination of elm piles with an oak capping is paralleled at the Jewel Tower, Westminster, where the precinct wall and a quay wall built between *c.* 1280–1300 and 1365–66 are so supported.[47]

CONCLUSIONS

The date of *c.* 1342 for the majority of the oak specimens (Appendix I, p. 141) must be considered in relation to the one 'rogue' reading of 1360; the actual range covered by the tree rings was 1299–1360. The 1360 date is unlikely to represent replacement timber and, since the final years of growth of the oak could have been trimmed off, the 1360 date from one specimen may be nearest to the date of the construction of the bridge. The timber was adjudged to have been freshly cut so that its storage is discounted. Since the elm piles, which retain the final year of growth of the trees, are dated 1345–50 with less certainty, the date of *c.* 1360 is not impossible. The causeway, at the point where it was excavated quite close to the back of the abutment, seems to have been made or probably remade at the time the bridge was built. Near-by Stony Bridge is usually judged to be 14th-century from its double-chamfered ribs. The stone bridge at the abbey gateway is thought to belong to *c.* 1370.

The excavation has revealed the form and probable extent of the bridge and has shown evidence of constructional methods known from medieval documents. The associated documentary study has led to the identification of medieval fields and mill streams. As far as is known the problems here discussed have not been considered in print before.

If the bridge is to be laid out as a feature in the Lee Valley Regional Park Authority's museum complex at Waltham,[48] its complete excavation could be considered.

[46] *Op. cit.* in note 23, pp. 84–6.
[47] *Med. Archaeol.*, IX (1965), 198–201, pl. 23.
[48] This would now be possible since the line of the relief road has been moved slightly to the north.

APPENDIX 1

DENDROCHRONOLOGICAL EVIDENCE

By J. S. Appleby

Cuts of oak (*quercus*) and elm (*ulmus*) which had been in stagnant water for some time were submitted for examination. These specimens were well and carefully wrapped in polythene sheeting and bags and are now preserved in the Waltham Abbey Historical Society collection.

This report may have to be amended, as additions are made to the Essex oak trace based on WA/4 and WA/5[49] throughout the county. There is not yet enough evidence to compile and use an accurate Essex elm trace, although elm supplies good dating evidence as is known from the piles of the Venetian canals.[50]

The wood was well preserved, as is usual when it has stood in water or well irrigated soils. It was of first quality and freshly cut; this is common practice when a monument (e.g. a church) or a utility structure (e.g. a bridge) of public importance is to be built. The bridge at Waltham Abbey was of elm piles with an oak sill and was of importance.

To find the most accurate measurements of the annual rings the specimens were slowly air-dried for eight months. Oak shrinkage was as much as 5 per cent. in most examples. Using the Essex/Ashdon/Appleby, J. S., scripsit/oak trace,[51] (*c.* 1280–1370) I ascribe the oak of the sill to *c.* 1342, but one 'rogue' was of 1360. This dating was readily assessable over some sixty annual rings. By the Essex/Tendring Hundred/Appleby, J. S., scripsit/elm trace[51] I fix the date 1345–50 for the elm piles. This dating may be amended in the future if and when more elms are available for examination and plotting.

Evidence of the gall mite,[52] *eriophyes ulmicola*, suggests that the elm belongs to the *ulmus procera* (Wanstead) grouping. There is every reason to believe that both oak and elm came from Waltham Forest which was still supplying oak for the Royal Navy in the 18th century.[53]

APPENDIX 2

THE POTTERY

By Rhona M. Huggins

The small amount of pottery found during the excavation consists mainly of local red wares which are common in the Waltham area and in Essex from the 2nd half of the 13th century to the end of the 15th century. Although documentary evidence shows the river to have been in use early in the 13th century and probably in the 11th century, there is no stratified pottery of this early period. It seems probable therefore that the large baluster jug (FIG. 55, no. 2) and the squat jug with thumbed base (FIG. 55, no. 3) were deposited in the river-bed during the building of the bridge or soon after. Both jugs are of typical 14th-century fabric with green or blackish glaze over white slip applied by brushing. A date after 1350 is likely. Two sherds with white-painted lines found with the jugs illustrate the alternative method of decoration on local 14th-century jugs.[54] The dripping-pan (FIG. 55, no. 1), also from the river-bed, is of particular interest as it is closely paralleled by an almost complete pan in the Guildhall Museum, London.

[49] From the work of A. W. G. Lowther and J. H. Harvey on the oak chest in the Pyx chapel, Westminster Abbey: D. J. Schove and A. W. G. Lowther, *Med. Archaeol.*, I (1957), 83.

[50] L. Leboutet, 'Techniques et methodes, dendrochonologie et archéologie', *Annales de Normandie* (Dec. 1966), pp. 405–36.

[51] My unpublished research and records.

[52] R. H. Richens, 'Studies on *ulmus*. VII, Essex elms', *Forestry*, XI, no. 2 (1967), 185–206.

[53] A. L. Clarke, 'The forest of Waltham under the Tudors and Stuarts', *Essex Review*, XXXV (1926), 140.

[54] Evidence from excavations at Waltham Abbey in 1969, near the N. claustral range.

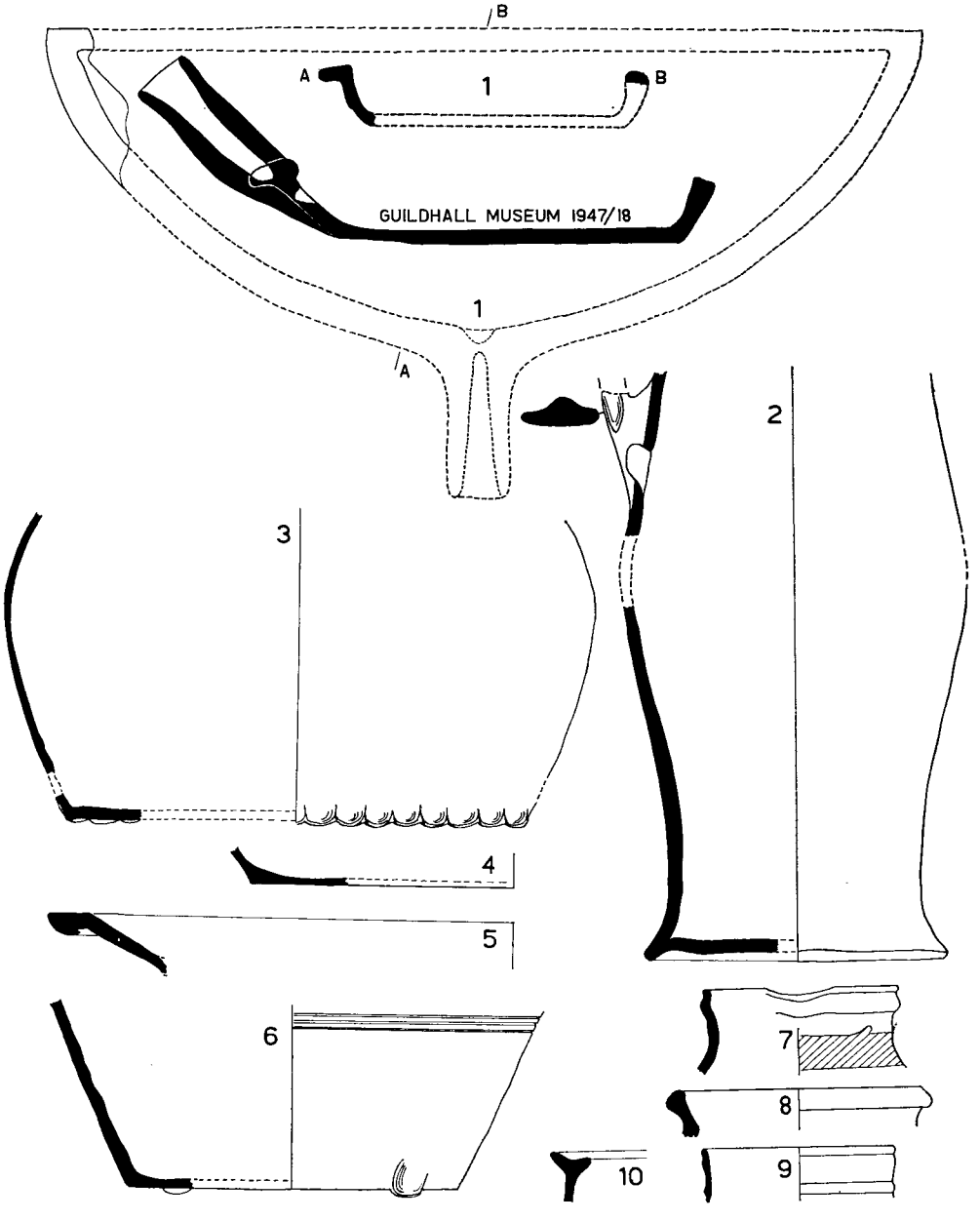

FIG. 55
WALTHAM ABBEY, ESSEX
Pottery, *c.* 1350–1600, from bridge over lower mill stream, and pan in Guildhall Museum, London (pp. 141, 143). Sc. $\frac{1}{4}$

Both combine flanged and plain rim forms on the same vessel. Flanged rims are common on 14th-century Surrey ware,[55] and the Guildhall dripping-pan was found in the 'lowest level of a 15th-century cellar' in Post Office Court, London.[56]

The pottery in the destruction-layer (FIG. 55, nos. 4–6) is unglazed and seems to be early 16th-century. The pottery from the river filling, however, includes brown- and black-glazed sherds (FIG. 55, nos. 7–10) and a sherd of pinkish ware with smooth green glaze outside, all of which seem to belong to the end of the 16th century; documentary evidence shows it is unlikely to be later.

DETAILED DESCRIPTION OF POTTERY

From river-bed F11. After 1350 (FIG. 55, nos. 1–3)

1. Corner of semicircular dripping-pan. Fine sand-tempered buff ware with black deposit inside (remains of green glaze?). Reconstructed from slightly larger pan found in London and now in Guildhall Museum (FIG. 55). Both of similar buff fabric, probably made in Surrey, the Guildhall one having green glaze inside and hand-moulded handle. Both have flanged rim on curved side and plain rim on straight side. Wheel marks on the Waltham flanged rim suggest it was wheel-made. The Guildhall pan is complete semicircle with radius of 10 in.; the Waltham sherd although fitting same radius appears in plan to be sector of circle *c.* 7 in. deep only. If correct, straight edge was bent up while Guildhall pan may have straight edge added. It seems probable therefore that two pans were made from one large circle.

2. Base of large baluster jug with double thumbing on handle base. Reddish brown surface with grey core disappearing towards top. Shoulder with blackish glaze apparently brushed round pot and thicker near top. Traces of white slip under glaze on handle. Unglazed lower part has vertical brush or tool marks. Base and body apparently thrown separately and inadequately joined in 'green' state. Considerable glaze splashing under base.

3. Base of squat jug with neat thumbing; finger-nail marks visible on inside of base. Speckled green glaze on upper part over white slip. Lower part has dark surface; inside and under base red. Very slight grey core in places. White deposit inside.

From destruction-level F10 above silt. Early 16th-century (FIG. 55, nos. 4–6)

4. Plain base of jug. Fabric almost identical with no. 3 with same darkening outside. White deposit inside.

5. Rim of dish. Hard fine sandy ware, unglazed, brown surfaces with thin red margins and thick grey core; inside surface streaked with red where the two colours have merged.

6. Base of heavy vessel. Unglazed except for few spots under base. Fine sand-tempered, light red fabric with thick grey core, three incised lines and single thumb print on base. Inside, strong wheel-marks; outside of base, turning marks.

From river filling F42 and F9. Before 1600 (FIG. 55, nos. 7–10)

7. Jug rim of sandy red ware. Band of white slip painted round neck is unglazed.

8. Rim of pipkin. Fine red ware with thin light brown glaze on inside. Outside of rim slightly reddened.

9. Rim of black-glazed mug. Red fabric, mottled blackish brown glaze both sides.

10. Bifid rim of pipkin. Red ware with light brown glaze inside, red wash outside. Similar fabric to no. 8.

[55] J. G. Hurst, 'The kitchen area of Northolt manor, Middlesex', *Med. Archaeol.*, v (1961), fig. 68.

[56] I am indebted to Mr. Norman Cook for identifying this sherd and for allowing me to study and illustrate (FIG. 55) the restored Guildhall example.

APPENDIX 3

MISCELLANEOUS FINDS (FIG. 56, nos. 1–4)

1. Sole of left-foot turnshoe, grain side inside. Split-closing stitch round edge had $3\frac{1}{2}$ to 4 stitches to the inch. Both surfaces show evidence of cuts as if sole had been used as working-surface before being discarded. From river-bed F11.

2. Horseshoe without calkin, comparable with one from Visby, Gotland.[57] Visby was sacked in 1361. From river-bed F11.

3. Strip of iron, 0.07 to 0.05 in. thick by 1.5 in. wide, suggestion of one square hole; possibly fragment of wheel strake. From river-bed F11.

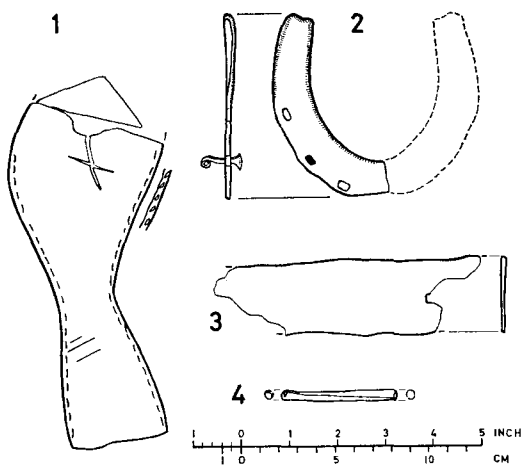

FIG. 56
WALTHAM ABBEY, ESSEX
From bridge over lower mill stream. 1, sole of turnshoe; 2, horseshoe; 3, strip of iron; 4, bronze tube (p. 144)

4. Bronze tube or container, 0.21 in. diam. by 2.3 in. long, formed from thin sheet with end left as projection to be bent over. Similar object from 13th-century deposit at Writtle[58] described as lace-end or ferrule. From lowest causeway deposit F21.

Clay pipes not illustrated. Where they contribute to dating, they have been included in Table I (pp. 129 ff.). Pipes in upper levels include: BURRS CUTTY on stem; C. KIFF, ST. ALBANS, on stem; crossed keys and leaves on bowl; DIEU ET MON DROIT round fragment of base of bowl.

[57] *London Museum, Medieval Catalogue* (1954), fig. 36, no. 12.

[58] P. A. Rahtz, *Excavations at King John's Hunting Lodge, Writtle, Essex, 1955–57* (Soc. Med. Archaeol., monograph ser., no. 3, 1969), fig. 49, no. 87.

APPENDIX 4

ANIMAL BONES[59]

Bones from the site fall into two categories:

A. HORSE BONES

Many were complete and articulated. They were found in or on the river-bed F11 and were therefore deposited no later than the 16th century. Dimensions in millimetres are listed below:

TABLE III

	HORSE A RIGHT LEG	HORSE B RIGHT LEG	HORSE C LEFT LEG	HORSE D LEFT LEG
Humerus				
Length[60]	303	252+	—	—
P. width[60]	92	—	—	—
D. width[60]	82	70	—	—
Min. shaft	36	31	—	—
Radius				
Length	342 (416)[61]	303 (360+)	294	290 (340+)
P. width	84	74	73	70
D. width	79	70	63	67
Min. shaft	40	35	30	33
Metacarpal				
Length	240	209	—	221
P. width	53	53	—	49
D. width	51	47	—	47
Min. shaft	34	31	—	33

Other horse bones represented in the same deposit, but not clearly identified with a particular horse, include:

Right scapula	D. width	86
	Min. shaft	64
Left scapula	D. width	80
	Min. shaft	53
Left femur	D. width	80
	Min. shaft	31
Left tibia	Length	308
	P. width	86
	D. width	54
	Min. shaft	32
Left metatarsal	Length	238
	P. width	44
	D. width	43
	Min. shaft	27

Phalange	Length	92
	P. width	55
	D. width	50
	Min. shaft	37
Phalange	Length	92
	P. width	64
	D. width	53
	Min. shaft	42
Metatarsal	D. width	57

Thirty-six rib bones
Eleven vertebrae

Teeth:

Four molars (articulating)
Four incisors (minimum two animals)
One canine

[59] Compiled with the help of Miss E. Annette Clifford and Mr. John Atkinson, and with the use of the comparative osteology collection at the Passmore Edwards Museum, Stratford, E. London.

[60] Length, proximal width and distal width are maximum values.

[61] Figures in brackets give length of radius with ulna.

The horses which these bones represent are taken to have been accidentally drowned while the bridge was in use, probably just before it was destroyed. Horse A was probably about 14 or 15 hands high; the others were slightly smaller and of much more slender build. The pronounced trochanter of both humeri indicates a highly developed muscle for pulling or for carrying heavy packs. Horses A and B were therefore probably work-horses. All the bones and teeth were of mature animals. The teeth were very little worn and indicate an age of $2\frac{1}{2}$–3 years for one animal. The single canine belonged to a stallion.

B. FOOD BONES OF COW, SHEEP AND PIG

In the river-bed were twenty-five pieces of sheep bone including mandibles of three different animals, and eight pieces of cow bone representing a minimum of two animals. One cow horn-core measured 210 mm. round the base. There was one lower mandible of a pig.

Elsewhere on the site bones found were few and fragmentary.

APPENDIX 5

MOLLUSCA

Shells were collected from the surface of the water in trench A after the excavation had reached river-bed level. Most of them came from the bed deposits F11, F13 and F14, but some were trapped in the destruction-debris F10.

Miss Annette Clifford studied the shells and submitted the following report:

'Of the several hundred shells in the sample the table below gives identification of the main species represented with a rough estimate of their abundance and an account of their typical habitat:

TABLE IV

SPECIES	ABUNDANCE	TYPICAL HABITAT
Planorbis carinatus	common	common, rarely in small pieces of water
Theodoxus fluviatilis	common	fairly common, in small and large calcareous rivers, particularly in more rapid parts
Bithynia tentaculata	extremely common	common, rarely in small bodies of water, occasionally in small streams
Limnaea peregra	frequent	common and abundant species, not in pools
Planorbis contortus	frequent	common and widespread, variety of habitats
Planorbis spirorbis	occasional	common, typically in marshes and ponds which dry up, also in lakes
Valvata piscinalis	common	common in running water of all kinds if the current not too fast
Viviparus viviparus	2 specimens	river snail, common

The sample is probably from a fairly large river with a central faster part (*T. fluviatilis*) and some quiet backwaters (*P. spirorbis*). The water was calcareous (*T. fluviatilis*).'

Miss Clifford's conclusions fit the stream in question which would have been *c.* 17 ft. wide, reduced to 13 ft. between the abutments. The shells could cover the whole date range of the site (11th century or earlier to the 16th century).

The common European oyster (*Ostrea edulis*), the garden snail (*Helix aspersa*) and the brown-lipped snail (*Helix nemoralis*) were found in deposits of the 14th and 16th centuries and later. One common mussel (*Mytilus* sp.) represents food debris in the river-bed F11. There was one example each of the wandering pond snail (*Limnea peregra*), the ram's horn snail (*Planorbis planorbis*) and the great ram's horn snail (*Planorbis corneus*) from 16th-century deposits. Fresh water mussel (*Unio* sp.) and common whelk (*Buccinium undatum*) were found in 18th-century or later deposits.

ACKNOWLEDGEMENTS

The excavation, directed by P. J. Huggins, was carried out by Waltham Abbey Historical Society with the assistance of members of the West Essex Archaeological Group; the help of all workers, who had to brave water and mosquitoes, is gratefully acknowledged. Thanks are due to Sir Hereward Wake, Bart., lord of the manor of Waltham and, at the time of the excavation, owner of the freehold of the site, and to Mrs. I. D. Chapman, tenant of the abbey farm, and her son, for allowing the excavation to take place. Thanks are also due to J. S. Appleby, for the appendix on dendrochronology; to J. Atkinson for help with the bones; to Dr. K. N. Bascombe for the documentary study and for helpful suggestions at all stages; to J. T. A. Burton for assistance with the photography; to Miss Annette Clifford for her report on the mollusca and for help with the bones; to N. Cook and J. G. Hurst for advice on the pottery; to the Curator, Passmore Edwards Museum, Stratford, for use of the comparative osteology collection; to the Imperial College, London, sub-aqua club for the underwater investigation of Stony Bridge and for help with the measurements; to S. E. Rigold who has read the report and made many valuable suggestions; and to my wife for work on the pottery, bones and metalwork. The freehold of the site is now owned by the Lee Valley Regional Park Authority and their interest in the work is much appreciated. The finds and records will be kept in the collection of the Waltham Abbey Historical Society until the authority's museum is established at Waltham.