PUCKLECHURCH TO SEABANK PIPELINE: SEDIMENT STRATIGRAPHIC AND PALAEOENVIRONMENTAL DATA FROM THE AVONMOUTH LEVELS

by Stephen Carter[1], Julie Jones and Bridget McGill

[1] Corresponding author, Headland Archaeology Ltd, 13 Jane Street, Edinburgh, EH6 5HE

Construction of a gas pipeline in 1997 between Pucklechurch, east of Bristol, and the gas-fired power station at Seabank, north of Avonmouth provided an opportunity to study an 8 km transect across the alluvial sediments of the Avonmouth Levels. The project produced a more-or-less complete record of the Holocene alluvial sediments along the route of the pipeline; boreholes were commissioned for palaeoenvironmental studies at three locations along the route and palaeoenvironmental data were also collected from excavations of a Prehistoric and Romano-British site close to Easter Compton. The results of the project allow a review of Holocene landscape evolution in the Avonmouth Levels and a re-assessment of the evidence for buried soil profiles within the marine alluvium. Collation of data on soil profiles from this and other studies suggests that there are significant problems both with the identification and dating of buried soils within the alluvium.

INTRODUCTION

In 1997, a gas pipeline was constructed between Pucklechurch, east of Bristol, to the gas-fired power station at Seabank, north of Avonmouth. The western end of the pipeline lay on the Avonmouth Levels and this provided an opportunity to study an 8 km transect across the alluvial sediments (Figure 1, overleaf). The pipeline reaches the levels at Woodcock Hill, 1 km to the north of Almondsbury, and then runs close to the landward edge of the alluvium for 6 km past Easter Compton to Elmington Manor Farm. Here it turns abruptly to the northwest and runs directly out across the alluvium for 2 km to the power station at Seabank. The pipe was laid in an open trench for most of the first 6 km but the final 2 km out to Seabank was tunnelled.

The project included a full programme of archaeological work, specified by South Gloucestershire Council; this was carried out by McGill Archaeological Consultants on behalf of the main contractor for the project, Entrepose-Laing JV. A full archive report has been prepared and a copy has been deposited in the South Gloucestershire SMR (McGill Archaeological Consultants 1998-2001). The principal results of the project relating to the Avonmouth Levels are published in two papers. The first, in the *Transactions of the Bristol and Gloucestershire Archaeological Society* deals with excavations at three Romano-British sites, including new data from the well-known Crook's Marsh site (Masser *et al* forthcoming). In this, the second paper, we present a synthesis of the sediment stratigraphic and palaeoenvironmental data collected during the project.

METHODS

The data presented in this paper were obtained from a number of sources, of variable quality, some archaeological and some geotechnical. The archaeological programme was preceded by geotechnical investigations (not monitored by archaeologists) comprising hand augering and boreholes along the proposed route. The archaeological programme itself followed a standard three-stage approach with an evaluation phase (walkover survey and trial trenches) followed by larger scale excavations at one site (Farm Lane, Easter Compton) and the commissioning of three boreholes for

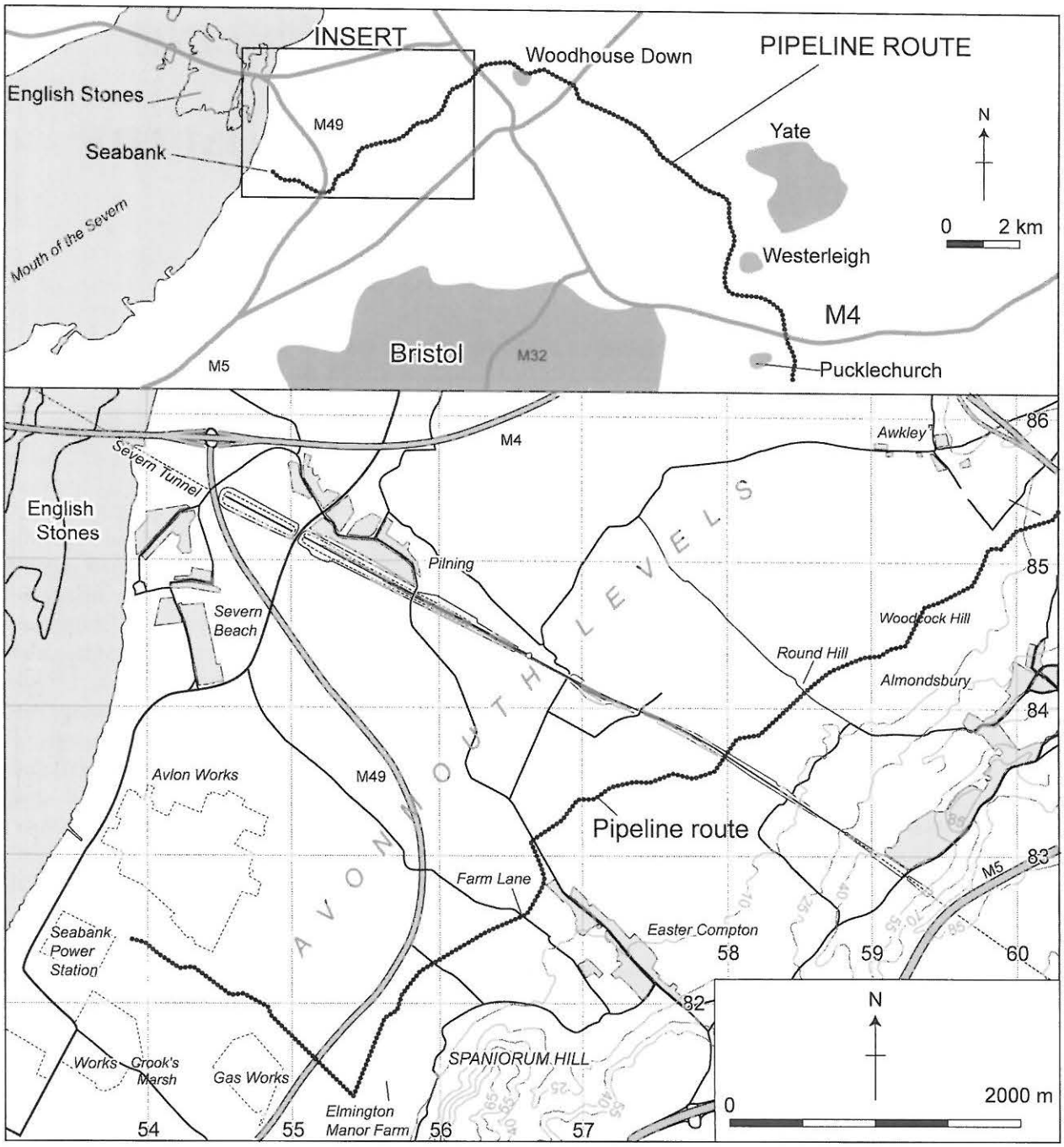

Figure 1: Avonmouth Levels. Route of the Pucklechurch to Seabank Pipeline.

palaeoenvironmental sampling. Finally a watching brief was maintained during the construction of the pipeline.

The data obtained are all presented in the archive report and can be summarised as follows:

Hand augering (geotechnical). Sediments were recorded by hand augering (one record per field) for all except the final 2 km of tunnelling. Only the top 2 m were logged and records were not tied to Ordnance Datum.

Boreholes (geotechnical). Eight boreholes were commissioned at three points along the route before Elmington Manor Farm where the pipe had to be tunnelled under the railway and roads. 28 boreholes were completed in the final 2 km

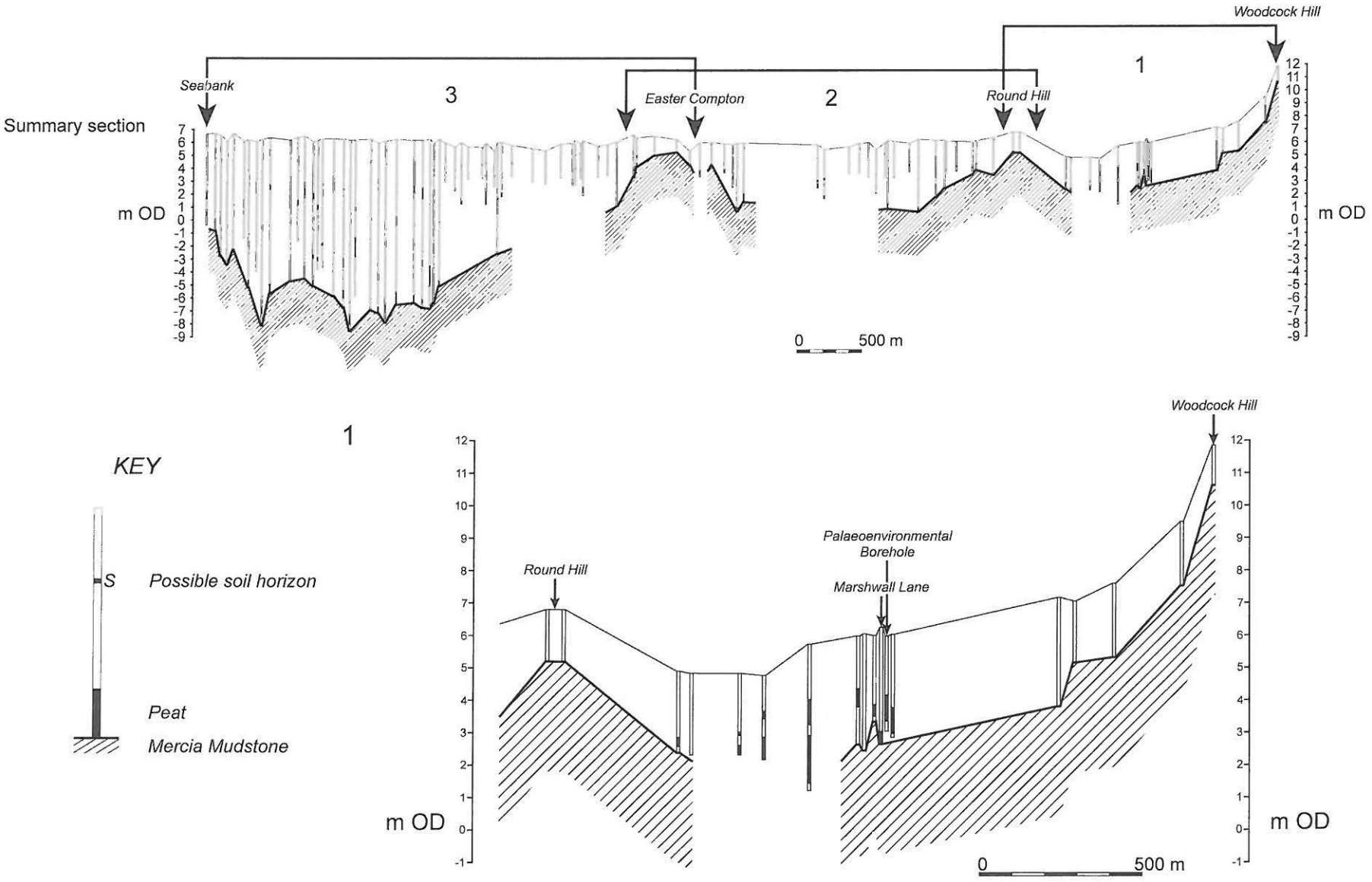

Figure 2: Pucklechurch to Seabank Pipeline - borehole transect (continued overleaf).

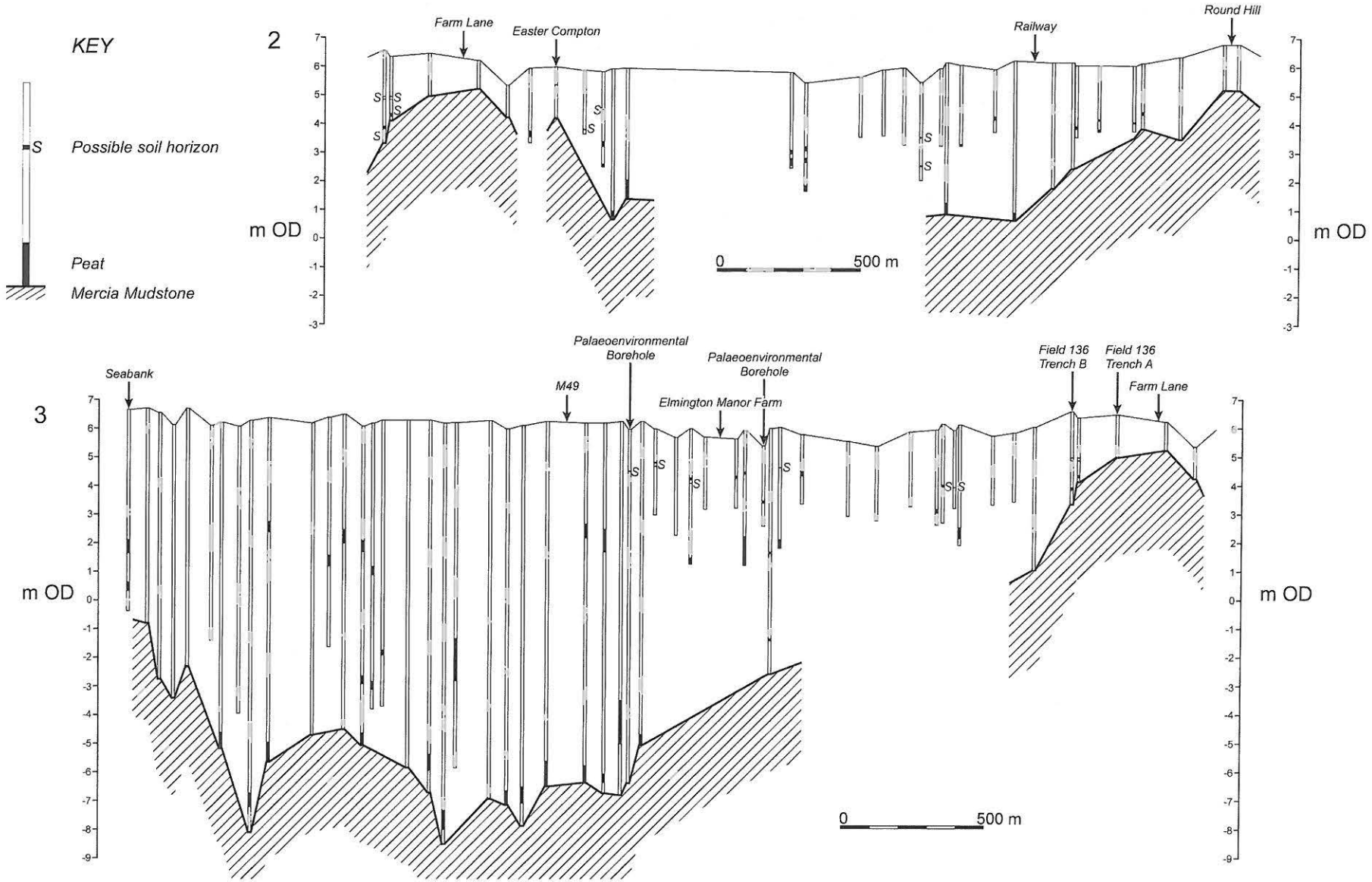

Figure 2 (continued): Pucklechurch to Seabank Pipeline - borehole transect.

tunnelled section. All boreholes were recorded relative to Ordnance Datum and most reached solid rock, providing a full Holocene sequence. However, it appears that only major peat layers were recorded (more than 0.2 m thick) and sediment textural descriptions are imprecise.

Boreholes (archaeological). Three additional boreholes were commissioned specifically to provide samples for palaeoenvironmental investigations. Samples were assessed for pollen, diatoms, foraminifera and plant macrofossils. Radiocarbon dates were obtained from peat layers in one borehole.

Trial trenches. Trial trenches were machine excavated under archaeological supervision at seven locations along the route with supposed higher potential for archaeological features. Two 10 x 2 m trenches were excavated at each location (or 2 x 2 m pits where trenching proved impossible) to a depth of 2.5-3 m. The stratigraphy of each trench was recorded and tied into Ordnance Datum. In most cases, these records were made from outside the trench for safety reasons and therefore no detailed inspection or sampling of sediments was possible.

Excavation. Additional excavation was undertaken at Farm Lane, Easter Compton, where a Romano-British site could not be totally avoided by the pipeline. This work allowed detailed recording and analysis of the pre-Roman sediment stratigraphy including buried soils and evidence for prehistoric activity. Analyses included pollen, diatoms, foraminifera and micromorphology. Radiocarbon dates were obtained for basal soil layers.

Watching brief. A watching brief was maintained during topsoil stripping on the pipeline easement and excavation of the pipe trench and drilling pits (the ends of tunnelled sections). The stripped easement was 28 m wide and the standard pipe trench was 2 m deep. Excavation of drilling pits reached 4 to 5 m below ground level. Records from the watching brief primarily comprise measured sections tied to Ordnance Datum. In two cases more detailed records were obtained of possible buried soil horizons, including radiocarbon dates.

STRATIGRAPHIC DATA

The project produced a more-or-less complete record of the Holocene alluvial sediments along the 8 km of pipeline on the levels. Figure 2 provides a summary of the relevant data, indicating the height of bedrock and any recorded peat and possible buried soil horizons. This transect may be conveniently described in three contrasting sections:

Woodcock Hill to Round Hill (Figure 2, section 1)

This section crossed what is interpreted here as a partially enclosed embayment of the levels that lies between Woodcock Hill and Round Hill. The dryland margin at Woodcock Hill was not examined in any detail but there appears to be a wedge of colluvium up to 2 m deep at the foot of the hill that must interdigitate with alluvium from 6 m OD downwards. Bedrock is recorded at 2 to 3 m OD below 3.5 m of sediment except in one area where 4.5 m was encountered without reaching the rockhead. This area contains the only substantial development of peat recorded along the pipeline with individual layers up to 1.5 m thick. Four radiocarbon dates were obtained from peat at 3.61 to 4.16 m OD with ages ranging from 2860 to 2300 cal BC (Marshwall Lane, Table 1).

The presence of thick peats may account for the exceptionally low modern ground levels recorded in this area (below 5 m OD), as peat would be susceptible to compression and loss through oxidation following drainage. This area is one of the few on the Avonmouth Levels classified by Rippon (1997, figure 39) as having an 'intermediate' landscape morphology, indicating relatively recent reclamation. This combination of characteristics: deep peat, low surface levels and regular field morphology (recorded as old withy beds by the Ordnance Survey) makes it a rare example of a former back fen in the Avonmouth Levels.

Round Hill to Easter Compton (Figure 2, section 2)

At Round Hill the bedrock rises from below 2 m OD to 5 m OD, only 1.5 m below present ground level. Round Hill is now a small island in the

Site	NGR	Context	Height (m OD)	Material dated	Date uncal BP	Lab ref	Calibrated age range	Comments
Farm Lane Tr.136 B	ST 5632 8243	22 (Base)	3.81*	Organic matter (humin fraction)	4060±50	Wk 6228	2860-2460 BC	Base of buried topsoil. Same horizon as Wk 6229
Farm Lane Tr.136 B	ST 5632 8243	22 (Top)	3.86*	Organic matter (humin fraction)	4110±60	Wk 6229	2880-2490 BC	Top of buried topsoil. Same horizon as Wk 6228
Farm Lane Tr.136 B	ST 5633 8244	7 (Base)	4.20*	Organic matter (humin fraction)	4140±70	Wk 6231	2890-2490 BC	Base of buried topsoil. Same horizon as Wk 6230
Farm Lane Tr.136 B	ST 5633 8244	7 (Top)	4.25*	Organic matter (humin fraction)	4140±100	Wk 6230	2920-2460 BC	Top of buried topsoil. Same horizon as Wk 6231
Farm Lane Tr.136 A	ST 5649 8255	50	5.11*	Organic matter (humin fraction)	3870±180	Wk 7059	2900-1850 BC	Buried topsoil. Seals cut containing Wk 7060
Farm Lane Tr.136 A	ST 5649 8255	11	4.90*	Wood charcoal (*Quercus*)	4550±90	Wk 7060	3550-2900 BC	Fill of cut feature. Sealed by buried topsoil Wk 7059
Crook's Marsh	ST 5393 8245	47	4.62	Organic matter (humin fraction)	3670±60	Wk 6232	2130-1740 BC	Possible buried topsoil
Elmington Manor Farm	ST 5555 8171	3 (Top)	4.43	Organic matter (humin fraction)	4510±180	Wk 6233	3700-2650 BC	Top of possible buried topsoil. Same horizon as Wk 6234
Elmington Manor Farm	ST 5555 8171	3 (Base)	4.30	Organic matter (humin fraction)	3240±160	Wk 6234	1950-1050 BC	Base of possible buried topsoil. Same horizon as Wk 6233
Marshwall Lane	ST 5935 8466	Peat	4.16	Organic matter (humin fraction)	3860±50	AA 30865	2470-2140 BC	Top of peat layer
Marshwall Lane	ST 5935 8466	Silty clay and peat	3.91	Organic matter (humin fraction)	4030±45	AA 30866	2860-2460 BC	Below AA 30865
Marshwall Lane	ST 5935 8466	Peat	3.76	Organic matter (humin fraction)	3965±50	AA 30867	2580-2300 BC	Below AA 30866
Marshwall Lane	ST 5935 8466	Peat	3.61	Organic matter (humin fraction)	4045±50	AA 30868	2860-2450 BC	Below AA 30867 (base of peat possibly not recovered)

*Table 1: Pucklechurch to Seabank Pipeline. Complete list of radiocarbon dates obtained by the project from the Avonmouth Levels. Calibrated age ranges were calculated using OxCal v3.5 Bronk Ramsey (2000). Heights marked * are for contexts on bedrock.*

levels but it is connected to higher land to the south-east by a rock ridge just below present ground level. The pipeline cut through this buried ridge and archaeological features associated with 1st century AD pottery were encountered here (Masser *et al* forthcoming). The bedrock falls away again from 5 to 0.5 m OD over a distance of 700 m and remains at this level for the next 1.5 km of the transect. The present day ground level in this section remains about 6 m OD with 5.5 m of predominantly mineral sediment recorded in the boreholes and deeper excavations. A basal peat (up to 0.7 m deep) is present from the foot of the bedrock slope at Round Hill but only very thin peats (0.1 m thick) are recorded higher in the sequence at a range of heights between 2.5 and 4.5 m OD.

At Easter Compton, the bedrock surface rises again to between 4 and 5 m OD where it forms the buried extension of the low rise that creates the dry site for the village of Easter Compton, now barely perceptible above the surface of the levels. Again, archaeological features were encountered at Farm Lane, Easter Compton. These included slight evidence for prehistoric activity on the sub-alluvium ground surface: two small cut features and two flints (a non-diagnostic core fragment and flake) from the overlying ground surface (Field 136 Trench A). Wood charcoal from one cut feature was dated to 3550-2900 cal BC (Table 1, Farm Lane Trench 136 A). This feature was sealed by a peaty topsoil that was dated in three places at Farm Lane. Four dates from two profiles at about 4 m OD yielded dates between 2920 and 2460 cal BC (Table 1, Farm Lane Trench 136 B), a single determination from higher on the bedrock ridge at 5.11 m OD was possibly slightly younger (2900-1850 cal BC). An extensive Romano-British site (2nd to 4th centuries AD) was encountered at Farm Lane comprising ditches cut from a high level into the shallow alluvium covering the rock ridge (Masser *et al* forthcoming)

Easter Compton to Seabank (Fig 2, section 3)

Total sediment depths between Easter Compton and the end of the pipeline at Seabank are significantly greater than those recorded before Easter Compton and, as a result, only boreholes have yielded complete Holocene sediment records. There is only one borehole record for the 1.5 km of pipeline from Easter Compton to Elmington Manor Farm so the deeper sediments in this section (ie those below 1 m OD) are poorly understood. The final section from Elmington Manor Farm to Seabank is covered by the numerous boreholes that were required for the tunnelling operations.

The bedrock ridge at Easter Compton falls relatively steeply to the southwest, from around 5 m OD on the crest of the ridge to –3 m OD and then –5 m OD by Elmington Manor Farm. The 9 to 11 m depth of sediment in this section is predominantly mineral in composition with limited evidence for a widespread peat layer at 1 to 2.5 m OD and a much thinner peat band or peaty soil horizon at around 4 to 4.5 m OD. This upper horizon was dated at Elmington Manor Farm with determinations from the base and top of the layer. The dates were reversed relative to their stratigraphic position: 1950-1050 cal BC from the base and 3700-2650 cal BC from the top (Table 1, Elmington Manor Farm).

From Elmington Manor Farm to Seabank, the numerous boreholes provide a record of the complete Holocene stratigraphy. The route followed by the pipeline at this point is very close to the line of the auger transect recorded by Juggins for his unpublished university dissertation (Juggins 1982). Juggins' hand auger records are limited to the top 6 m of sediments but they are sufficient to demonstrate that the Seabank geotechnical borehole logs failed to record any thin peat bands and were inconsistent in their detection of thicker peats. For example, Juggins recorded a persistent peat at 1.5 to 2.5 m OD but this is recorded only in a minority of the Seabank boreholes. According to Juggins' data this layer is thinnest close to the coast (0.1 m) and thickens inland up to 0.75 m. He also recorded a persistent thin peat or peaty soil horizon, 0.05 to 0.2 m thick, at 3.5 to 4.5 m OD; this is totally missing from the Seabank boreholes but is probably the same horizon recorded and dated in the pipe trench before Elmington Manor Farm (see above). This soil was definitely recorded during the present project in the open pipe trench at Crook's Marsh at 4.62 m OD and a date of 2130-1740 cal BC was obtained (Table 1, Crook's Marsh). This section of the pipe trench at Crook's Marsh also cut through ditches of 3rd/4th century date forming part

of the extensive field and settlement site recorded by Juggins (see Masser *et al* forthcoming).

Despite these difficulties with the data, some general observations can be made on the stratigraphy of this section. The bedrock remains low, varying between –5 and –8.5 m OD until close to Seabank where it rises again, reaching 0 m OD by the end of the pipeline. It may be noted that the final two boreholes close to Seabank record a layer of sand and gravel up to 1 m thick over the Mercia Mudstone bedrock. This has previously been described by Hawkins (1990) and has been assigned a pre-Holocene date. A basal, or near basal peat up to 0.9 m thick is recorded in most boreholes before the bedrock rises at Seabank. This is overlain by predominantly mineral sediments that tend to be silty sand in texture below 1 m OD and silty clay above this level (this tentative observation is confirmed by Juggins' more precise observations). Peat layers are occasionally recorded below 1 m OD including isolated deep layers that are assumed to be channel fills. The first general peat layer occurs between 1 and 2.5 m OD, as noted above.

PALAEOENVIRONMENTAL DATA

Borehole locations

Following evaluation of the results of archaeological trial trenching, it was decided that three locations warranted further examination on palaeoenvironmental grounds. Sediments at these locations were sampled using a powered percussion auger to obtain further palaeoenvironmental data and material for radiocarbon dating. In view of difficulties encountered in the retrieval of retained cores, resulting in loss of sediment and compression of some cores, investigation of pollen, plant macrofossils, foraminifera and diatoms was only carried out to assessment level. However important data were obtained which allow some interpretation of the stratigraphic sequences and associated environmental conditions to be put forward.

Full assessment reports are contained in Volume 3 of the project Archive Report, copies of which may be consulted in the South Gloucestershire SMR or at Bristol Museum. The following reports were completed:

Sediment Descriptions - H.C.M Keeley
Diatoms - N.G Cameron & S.J Dobinson
Plant Macrofossils - A. Clapham & R.G. Scaife
Pollen - R.G. Scaife
Foraminifera - M. Godwin

Marshwall Lane (Field 189)

The shallowest sequence investigated was from Marshwall Lane in the area of the pipeline between Woodcock Hill and Round Hill. This was the furthest sequence from the coast and has been interpreted as one of the back fen areas of the Avonmouth Levels. Although the junction of the peat and the underlying grey gritty clay was lost, dating of the lowest level (3.6-3.61 m OD) showed that this peat formed shortly before 2700-2460 cal BC. An accumulation of over 0.5 m of highly humified detrital peat, with some banding of grey silty clay occurred; the top of the sequence at 4.15-16 m OD dated to 2470-2190 cal BC. Plant macrofossils preserved in the peat suggest this formed under freshwater conditions, with a peak of alder (*Alnus*) pollen indicating local alder carr woodland with herbaceous fen vegetation. Evidence of the regional woodland is also suggested by high percentages of oak (*Quercus*) pollen, with hazel (*Corylus*), birch (*Betula*), pine (*Pinus*), elm (*Ulmus*) and ash (*Fraxinus*). A range of marine, brackish to freshwater diatoms present in a silty clay band within the peat suggests there may have been periodic tidal inundation. As the sediment changes to an accumulation of grey silty clay from 4.16 m OD, a dominance of marine diatoms, including planktonic species *Paralia sulcata* and *Cymatosira belgica* and a lower saltmarsh foraminiferal assemblage, suggest the onset of estuarine conditions. Deposition of over 1 metre of alluvium occurs and although preservation is poor through much of this sequence, the presence of a similar lower saltmarsh foraminifera assemblage at 5.16 m OD suggests there was little change in environmental conditions. The top of the sequence was at 5.96 m OD.

Field 182

The deepest of the three boreholes was in Field 182, close to Elmington Manor Farm, with a depth

of 12.56 m reaching -6.42 m OD. Pollen examined from a black organic silty clay, encountered at -5.56 to -5.63 m OD suggest a freshwater environment, with no indications of marine influence; unfortunately neither foraminifera nor diatoms were preserved. The regional woodland is suggested by relatively high pollen values of pine, oak and hazel, the absence of lime (*Tilia*) and alder, combined with the depth of the sequence suggesting an early Holocene date, although no radiocarbon dating was done to confirm this. The overlying grey silty clays illustrate the onset of marine conditions associated with rising sea level, with at first some indications from foraminifera at -4.46 m OD, that although the environment was predominantly marine, freshwater fluvial influences remained. From about 0 m OD predominantly marine conditions prevail; the foraminifera suggesting a high intertidal flat environment.

Field 186

The third sequence, also close to Elmington Manor Farm, was chosen to investigate a possible palaeochannel identified during evaluation work

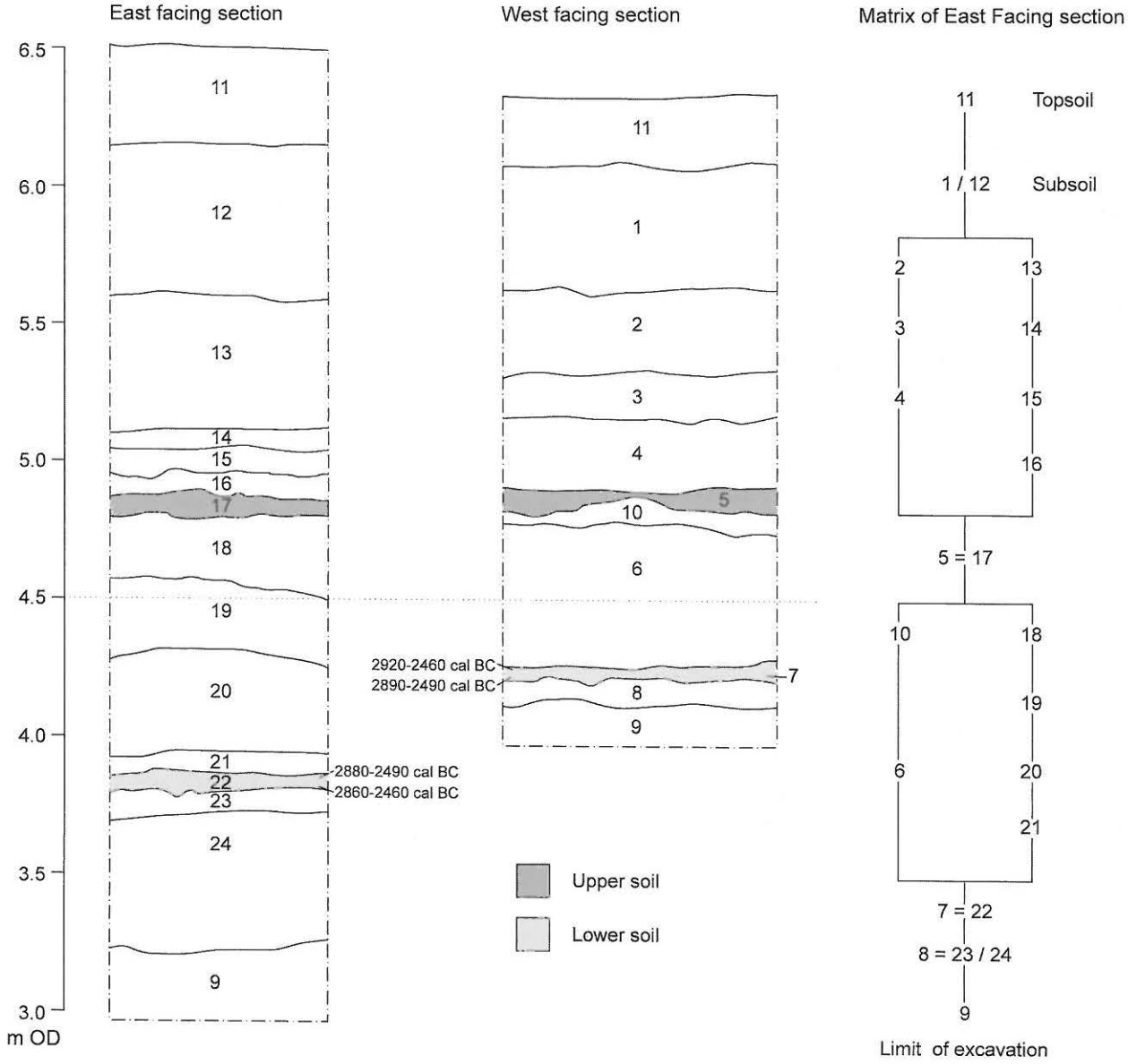

Figure 3: Farm Lane, Easter Compton. Field 136 Trench B. Sections drawings of west and east ends of trench.

in Field 186. Two bands of intercalated peat deposits occur within what appear to be marine/ saltmarsh sediments, although neither of these has been dated. The lower peat at -1.35 to -1.45 m OD was more silty than the upper peat and macrofossils suggest a local fen carr community. Oak and hazel pollen dominate the dryland woodland. Similar herbaceous fen species occurred in the upper peat between 1.59 to 2.06 m OD, with local variation in the carr community indicated by fluctuations in alder and willow (*Salix*) pollen. Little change occurs in the regional woodland cover; oak remains important, together with hazel and lime. The transition into the overlying silty clay is marked by the presence of Chenopodiaceae pollen, with supporting macrofossils, marine, brackish and freshwater diatoms, suggesting recolonisation by saltmarsh communities. Over 1.8 m of blue-grey clay with laminated layers of sand and organics are then deposited, indicating a high energy depositional environment. Where preserved, diatoms are marine to brackish, marsh creek foraminifera suggesting a mid to low saltmarsh.

FARM LANE (FIELD 136B) EXCAVATION

The site at Farm Lane, close to Easter Compton, lies within a few hundred metres of the 10 m OD contour and about 3 km from the coast (Figure 1). Excavation as part of the exploration of a Romano-British settlement site (Masser *et al* forthcoming) exposed over 2.5 m of alluvium with what were interpreted in the field as two buried soils. Figure 3 shows the sequence of estuarine alluvium overlying the solid Mercia Mudstone [9], which varied in depth across the trench from 2.92 m in the east to 3.95 m in the west. Above the Mercia Mudstone [9], a silty sand [8/23/24] represents the mineral subsoil horizon. Overlying this, a soft dark grey/black silty sand [7/22] was shown by micromorphological analysis to be a well developed topsoil. There follows at least 0.5 m of highly laminated clay silt alluvium [6 (also 21/20/19)], over which a thin layer of relatively non-laminated sediment [10/18] is in turn overlain by what was thought in the field to be an upper soil horizon [5 and 17]. There is then a further sequence of alluvial clays [4/3/2 and 16/15/14/13] beneath the subsoil [1/12] and topsoil [11].

The basal topsoil [7 and 22] (Figure 4)

Radiocarbon dating of this horizon shows that this represents a mid Holocene land surface prior to the onset of deposition of estuarine alluvium. The base of [7] at 4.20 m OD gave a result of 3300-2200 cal BC and [22] at 3.81 m OD gave a result of 2870-2470 cal BC. The top 10 mm of this horizon was also dated (2930-2460 cal BC for [7] and 2890-2490 cal BC for [22] (Table 1). This shows there is no significant difference in age, indicating the effective mixing of older and younger organic matter within the A horizon. As discussed later in the paper, interpretation of dates from bulk organic matter in palaeosols should be interpreted with caution, but the range shown by the radiocarbon determinations for the lower soil of 3300-2200 cal BC can be used to suggest maximum age estimates for the onset of alluvium deposition at this altitude.

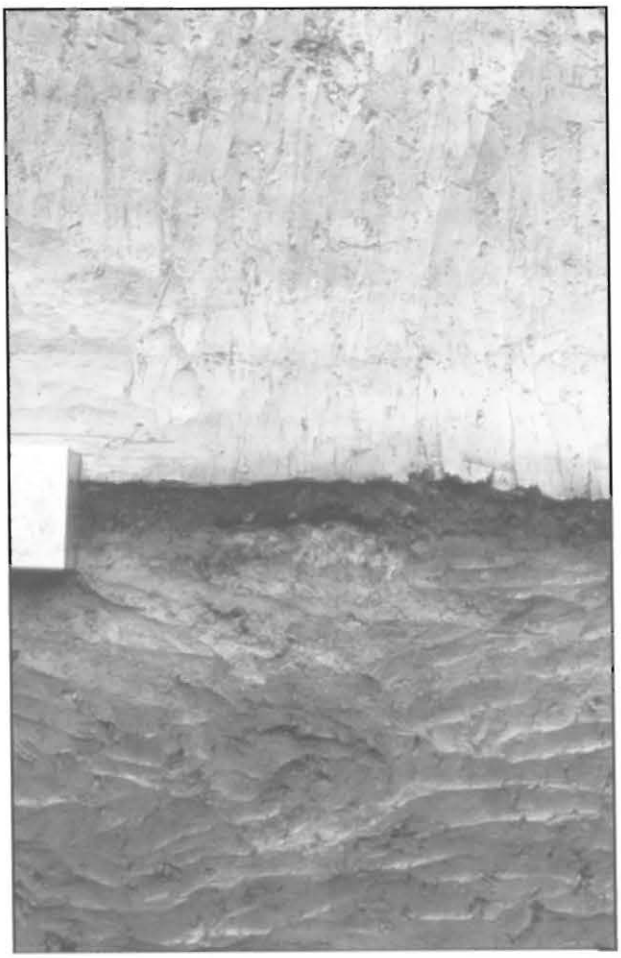

Figure 4: Farm Lane, Easter Compton. Field 136 Trench B. Lower buried soil in west-facing section (height of Kubiena Tin 8 cm).

While there are differences in the two horizons from the east and west sections, in thin section the soil horizons both comprise highly organic silty sand with *c*.30% organic matter, [22] containing additional thin surface layers interpreted as the remains of grassy turf with vegetation and fresh litter. The absence of these two layers in [7] in the upslope profile indicates that it was partially eroded before burial, losing its turf probably at the onset of alluvium deposition. In contrast [22] seems to have been buried intact. There is little evidence for pedogenesis with no distinct B horizon in [7] and this together with high levels of organic matter in the A horizon, make it seems likely that this soil was a humic gley, tending to peaty gley. The well-preserved organic tissues in [22] do not include woody plants and are suggestive of herbaceous vegetation, perhaps wet pasture.

Pollen preservation was better in the east facing section so analysis was concentrated here. Preservation was poor in the buried sub-soil [8], but analysis of 5 samples from the A horizon of the lower soil [7] is consistent with the interpretation of the surface as an *in situ* soil developed beneath a herbaceous vegetation cover (despite suffering surface erosion prior to burial). The herbaceous pollen taxa are similar in all samples and are therefore treated as one assemblage. It is dominated by Poaceae (grasses), Chenopodiaceae (goosefoot family) and *Solidago virgaurea* type (sea aster, daisy, etc), typical of weedy disturbed grassland or saltmarsh communities, likely to represent the encroaching saltmarsh in this case. The presence of a freshwater fen at the landward margin of the saltmarsh is shown by herb taxa such as bulrush (*Typha latifolia*), marsh marigold (*Caltha palustris*) and whorled water-milfoil (*Myriophyllum verticillatum*). The diversity and type of disturbance indicators are typical of grazed areas; perhaps some seasonal grazing occurred associated with lower water tables in the summer. Diatom assemblages from this level [22] are essentially those of a freshwater environment that would have been little affected by tidal incursions, given the low percentage of brackish species and lack of marine diatoms present. The profile is dominated by the taxa *Fragilaria brevistriata*, *Fragilaria elliptica* and *Fragilaria pinnata*, which have optimum growth in freshwater, but are tolerant of brackish conditions. The *Fragilaria* species tend to be opportunistic suggesting that the aquatic habitat available was to some degree ephemeral. Therefore although this is essentially a grassland environment, associated with freshwater communities, other plant communities influenced by the incursion of salt water were probably growing very close-by, or the grassland may have been flooded by the sea at times of high water or storm surges, encouraging the growth of some halophytes.

During this period pollen of trees and shrubs forms around 50% of total pollen showing the proximity of the Farm Lane site to the higher, drier land to the immediate southeast. Mixed woodland would have consisted primarily of oak, lime (*Tilia*) and hazel, with some birch, elm, ash and field maple (*Acer campestre*). The occurrence of occasional pollen grains of Ericaceae (Heather family) and spores of *Sphagnum* (bog moss) could have originated from raised bog communities somewhere in the vicinity.

Overlying alluvial deposition

The excellent state of the lower turf line in [22] and preservation of sedimentary laminae in [6], suggests that at first alluvial deposition was rapid. Above the basal soil at least 0.5 m of highly laminated clay silt alluvium [6 (also 21/20/19)] built up. Neither diatoms nor foraminifera were preserved in the alluvium and although pollen preservation was poor in the three samples examined from [6], a similar fairly open and grassy environment with some deciduous woodland is indicated. High concentrations of charcoal, perhaps indicating anthropogenic burning from nearby woodland, also occur in this deposit and together with the pollen are likely to have been washed into the site. Above the blue-grey alluvium, a thin layer of relatively non-laminated sediment [10] is in turn overlain by a humic dark grey clay [5/17].

Upper humic horizon [005/017]

[5], identified in the field as a buried soil, was shown by thin section analysis to consist of laminated layers of alluvium with an enhanced organic content, possibly accumulated during a period of reduced sediment deposition, allowing a

greater concentration of plant leaf litter and root debris to accumulate. The survival of sedimentary fabric shows that this did not develop into a mature soil profile with a distinct structure. Pollen preservation in this material was poor and concentrations low; no diatoms or foraminifera were present.

This period of enhanced organic matter deposition was ended by the deposition of clay silt [4], which lacks the elevated levels of organic matter seen in [5]. There was virtually no pollen here and neither diatoms nor foraminifera were present.

DISCUSSION

Landscape evolution

It is not our intention to attempt a detailed review of the Holocene evolution of the Avonmouth Levels and the reader is referred to existing publications (Allen 1990; Gardiner *et al* 2002; Gilbertson *et al* 1990; Hawkins 1990). However, the results of the present project have provided new evidence relevant to particular aspects of landscape evolution:

- The old course of the Severn
- The Seabank/Pilning island
- Back fens on the landward edge of the levels

The presence of a deep buried valley beneath the levels has been known for some time (Hawkins 1990, figure 4) and the borehole data from this present project have confirmed its presence between Spaniorum Hill and Seabank with lowest recorded level of -8.5 m OD. This valley can be traced from Northwick south and then south-west under the levels, re-joining the present channel of the Severn at Avonmouth. Hawkins interprets it as a former course of the Severn, blocked at its northern end by fluvioglacial gravels during the Wolstonian Glaciation. Therefore by the early Holocene it would have been a broad marshy depression and not an active river valley.

The area between the old and present (Holocene) courses of the Severn was an island of higher land with bedrock reaching at least 0 m OD at Seabank. Its extent is revealed in part by the present day outcrop of bedrock at the English Stones and it lies buried beneath Pilning, Severn Beach and Seabank. The date at which this area became an actual island can be estimated from published sea level curves (Hawkins 1990, figure 5). Deposition of marine sediments at –8.5 m OD probably started around 7500 uncal BP and the floor of the old course of the Severn would have been below high water spring tides by about 6500 uncal BP. These estimates may be compared with a radiocarbon date of 6220-5720 cal BC for the top of the basal peat at –6.9 m OD in Avonmouth (GX 1112, Skempton *et al* 1969). With a rapid rise in sea level, marine deposition then occurred up to roughly 1 m OD, dominated by silty sands indicating that the intertidal environment was generally one of low tidal flats up to about 5000 uncal BP. By this date the Seabank/Pilning island, at *c*.0 m OD would have passed below high tide level, although the presence of bedrock and gravel high in the intertidal zone must have continued to affect sediment deposition and creek formation in this area.

To the east of the old course of the Severn the ground rose abruptly to over 50 m OD between present-day Shirehampton and Spaniorum Hill. North of here the gradient was much less steep with gentle slopes up to 30 m OD before the steep scarp was reached. This created a low-lying area of land roughly 2 km wide between the old course of the Severn and the high ground to the east. The majority of the Seabank pipeline ran through this area (Woodcock Hill to Easter Compton) and demonstrated the presence of a more-complex buried topography with low ridges rising some 5 m above the general level. This relatively sheltered environment at the landward edge of the levels contains a rare example of a back fen in the Avonmouth Levels with significant development of peat. In addition to the peat deposits recorded in the vicinity of Marshwall Lane during the present project, up to 4.5 m of well-preserved fen peats were recorded only 1 km to the north at Awkley Lane during work on the Second Severn Crossing (Lawler *et al* 1992; Gardiner *et al* 2002). The only other published record of a deep peat sequence is from Gordano at the opposite end of the Avonmouth Levels where several metres of peat formed behind a sand bar in a very sheltered position (Gilbertson *et al* 1990).

With much of this landscape lying between 0 and 5 m OD, it would have been progressively affected by rising sea level throughout the later prehistoric period (5000 to 2000 uncal BP) and it therefore offers significant potential for buried dryland archaeological sites of Neolithic to Iron Age date, enhanced by the possibility of preserved organic structures from wetland sites in the intervening back fens. The identification of a complete buried soil profile and slight evidence for an occupation site of Neolithic date at Farm Lane, Easter Compton, during the present project begins to realise this potential. This type of landscape may be contrasted with the near-coast open salt marsh character of most of the Avonmouth Levels and has much in common with the peat-filled valleys of central Somerset.

Buried soil horizons within the alluvium

A recent paper by Locock has drawn attention to the presence of buried soil profiles within the marine alluvium of the Severn Estuary Levels (Locock 1999a). In this paper, he attempted to classify the range of soil profiles present within the alluvium and, more importantly, he explored the palaeoenvironmental implications of their characteristics. The present project has contributed new evidence on this topic that relates directly to two of the main issues raised by Locock:

- The need for detailed analysis to determine the nature of a suspected soil
- Difficulties associated with radiocarbon dating of soil horizons

Analysis of the upper and lower buried soils at Farm Lane, Easter Compton has confirmed the value of thin section micromorphology as a technique to explore the nature of suspected buried soils. In this case, the contrast between the two soils was extreme. The lower soil was identified as a mature peaty gley with excellent preservation of its surface organic horizon, including an intact litter layer. This result allowed the associated pollen data to be interpreted with confidence and a reconstruction of the immediate pre-alluvium environment was possible. In contrast, the upper 'soil' was found in thin section to be no more than a concentration of organic residues in a restricted layer of alluvium with no evidence for soil ripening. This lack of evidence for soil formation was supported by the pollen analysis that demonstrated the presence of degraded pollen grains and abundant fern spores, both phenomena associated with sediment derived from pre-existing soils.

The conclusion that the upper soil at Farm Lane is not actually a soil has implications for other possible soils at the same altitude identified during this project. A soil or thin peat was noted in numerous sediment exposures between Easter Compton and the end of the pipeline at Seabank, generally lying between 4 and 4.5 m OD. This horizon was also consistently recorded by Juggins in his transect from Elmington Manor Farm to Seabank (Juggins 1982). There was therefore good reason to correlate these numerous records and to interpret them as an extensive but relatively short-lived land surface. The micromorphological evidence now suggests that this is not a soil, at least at Farm Lane. It is unfortunate that radiocarbon dating failed on the Farm Lane exposure (insufficient carbon) but dating of two other supposedly contemporary soil layers was undertaken. As has been reported above (Table 1), this yielded two stratigraphically reversed dates from Elmington Manor Farm (3700-2650 cal BC and 1950-1050 cal BC) and an intermediate date from Crook's Marsh (2130-1740 cal BC). Given the altitude of these horizons (4.3 to 4.6 m OD), it is clear that at least the upper date from Elmington Manor Farm must be affected by old carbon. The contrast between the two dates from this horizon suggests that a complex combination of old and contemporary carbon is present.

Consideration of a larger group of radiocarbon dates from the Avonmouth Levels provides more evidence for this phenomenon of old and contemporary carbon mixtures in the soil horizons and also points to a possible source for the old carbon. Figure 5 is an age/depth plot of dated peat and soil samples from between 1 and 6 m OD in the Avonmouth Levels; sources of the sample data used are given in Table 2. The peat samples display the expected age/depth relationship with the deepest samples dating to *c.*5000 uncal BP and the shallowest to *c.*2500 uncal BP. The range of sample depths for any given date (1 to 1.5 m) probably reflects both original surface relief and differential compression of the peat layers. The

soil horizons show no clear age/depth relationship and samples from 4.3 to 5.5 m OD have been dated to between 4800 and 2800 uncal BP. Most of the soil dates lie to the left of the peat dates at any given depth, indicating that they are older (ie too old for their depth). The variation in distance from the peat dates presumably results from different degrees of contamination with old carbon.

The maximum age possible for a soil horizon will be determined by the age of the carbon source. The oldest soil date obtained so far is 4780 ±90 BP (3720-3360 cal BC) and, if it is assumed that this approaches 100% old carbon, it indicates where we should look for the source. The diagram (Figure 5) shows that peat layers of this date are likely to occur between 1.5 and 2.5 m OD. This overlaps with the altitude of the only extensive thick peat layer reported in the Avonmouth Levels (at 1 to 2.5 m OD). In addition to the records from the present project between Easter Compton and Seabank (duplicated by the records of Juggins 1982), this peat horizon has been identified as a persistent layer in boreholes between Lawrence Weston and Avonmouth (Skempton *et al* 1969) and was also recorded over a distance of 1 km in the cutting for the Severn Railway Tunnel at Pilning (Juggins 1982). Dates obtained from this peat lie between 5000 and 4000 uncal BP (all dates below 2.6 m OD in Table 2).

It therefore seems likely that the large volume of peat that accumulated about 5000 to 4000 uncal BP has been partially recycled in more recent deposits – the process that John Allen graphically describes as stratigraphic 'roll-over' (Allen 2000, 26). Current records of soils with 'old' carbon suggest that substantial erosion and re-deposition of the peat did not start until after 3500 uncal BP. This could indicate the date at which coastal retreat started to expose the peat on the foreshore or possibly the start of a period of significant incision and erosion by creeks in the salt marsh.

The issue of how to date sediment layers with only a low organic matter content remains problematic. For layers with a high organic matter content (ie peats), it seems that contemporary (autochthonous) carbon swamps any old carbon that may be present. Where organic matter content is low, it is easy for a low concentration of old carbon to significantly affect the mean radiometric date of the layer. In cases like the upper soil at Farm Lane, Easter Compton, it is possible to demonstrate an absence of pedogenesis through micromorphological analysis. Accumulation of autochthonous organic matter is highly unlikely in this situation and any carbon present may be assumed to be re-cycled from older deposits. In cases where significant pedogenesis can be demonstrated in a potential soil horizon (again through micromorphological analysis) it is much more likely that any organic matter will be autochthonous and therefore date from the period of soil formation. Careful analysis of a potential soil is therefore essential before attempting radiocarbon dating.

Dating of soil organic matter, even in the absence of re-cycled carbon, is inherently imprecise as the result will always be a value that reflects mean radiometric residence time (MRRT). This is dependant on the length of time during which the soil formed and the rate of turnover of organic matter in the soil. It is rare that either of these variables can be controlled but, at least for the short-lived buried soils within the alluvium, it may be assumed that MRRT approximates to the age of the soil.

ACKNOWLEDGEMENTS

Archaeological work for the Pucklechurch-Seabank Pipeline Project was carried out on behalf of, and funded by Entrepose Laing Joint Venture, and the assistance particularly of Paul Malster and Steve Boothroyd of ELJV, and Colin Pyburn of Seabank Power is gratefully acknowledged. The results reported in this paper are the product of work by a wide range of palaeoenvironmental specialists whose reports can be read in full in the Project Archive Report (copy deposited in South Gloucestershire SMR). The assessment of the three palaeoenvironmental boreholes was co-ordinated by Helen Keeley who also undertook the description of the sediments. Other materials were assessed by Nigel Cameron and Simon Dobinson (Diatoms), Alan Clapham and Rob Scaife (Plant macrofossils), Rob Scaife (Pollen) and Mike Godwin (Foraminifera). Assessment and analysis of the samples from Farm Lane Field 136 Trench B was co-ordinated by Julie Jones.

Samples were analysed by Stephen Carter (Micromorphology), Nigel Cameron and Simon Dobinson (Diatoms), Heather Tinsley (Pollen) and Mike Godwin (Foraminifera and Ostracods). We would also like to thank Vanessa Straker for calibration of the radiocarbon dates and her advice throughout the whole project. The illustrations for this paper were drawn by Jonathan Miller of Headland Archaeology.

REFERENCES

Allen, J.R.L. (1990) The post-glacial geology and geoarchaeology of the Avon wetland. *Proceedings of the Bristol Naturalists' Society* 50, 28-46.

Allen, J.R.L. (2000) Sea Level, Salt Marsh and Fen: Shaping the Severn Estuary Levels in the Later Quaternary (Ipswichian-Holocene). *Archaeology in the Severn Estuary* 11, 13-35.

Barnes, I., Adam, N.J., Bellamy, P., Butterworth, C., Coe, D., Graham, A.H. and Powell, A. (1993) Second Severn Crossing: English Approaches. An interim statement on the 1992/93 fieldwork. *Archaeology in the Severn Estuary* 4, 5-29.

Gardiner, J., Allen M.J., Hamilton-Dyer, S., Laidlaw, M. and Scaife, R.G. (2002) Making the Most of it: Late Prehistoric Pastoralism in the Avon Levels, Severn Estuary. *Proceedings of the Prehistoric Society* 68, 1-40.

Gilbertson D.D., Hawkins, A.B., Mills, C.M., Harkness, D.D. and Hunt, C.O. (1990) The Late Devensian and Holocene of industrial Severnside and the Vale of Gordano: stratigraphy, radiocarbon dating and palaeoecology. *Proceedings of the Ussher Society* 7, 279-284.

Hawkins, A.B. (1990) Geology of the Avon Coast. *Proceedings of the Bristol Naturalists' Society* 50, 1-27.

Insole, P. (1996) An investigation of a medieval and post-medieval field boundary complex at British Gas Seabank, on the North Avon Levels. *Archaeology in the Severn Estuary* 7, 95-106.

Jones, J. (1997) Palaeoenvironmental assessment of deposits at Severn Beach Caravan Park. In *Seawall Caravan Park, Severn Beach, South Gloucestershire.* BARAS report 410/1997 (unpublished report).

Jones, J. (1998) Appendix 2. Palaeoenvironmental report. In *Archaeological watching brief on the laying of an effluent pipeline between Avonmouth Sewage Works and Seabank Power Station, Severnside, Bristol for Wessex Water plc.* BARAS report 265/1998 (unpublished report).

Juggins, S. (1982) *The Geoarchaeology of Hallen Marsh.* Joint Archaeology/Geology Summer Project, University of Bristol (unpublished manuscript).

Lawler, M., Parkhouse, J. and Straker, V. (1992) *Archaeology of the Second Severn Crossing: Assessment and recommendations for the English Approaches.* Glamorgan Gwent Archaeological Trust Ltd (unpublished report).

Locock, M. (1997) Rockingham Farm, Avonmouth, 1993-1997: moated enclosures on the North Avon Levels. *Archaeology in the Severn Estuary* 8, 83-88.

Locock, M. (1999a) Buried Soils of the Wentlooge Formation. *Archaeology in the Severn Estuary* 10, 1-10.

Locock, M. (1999b) Cabot Park, Avonmouth, Bristol: excavations on Later Bronze Age and medieval sites at Kites Corner and Moorend Farm, 1999. *Archaeology in the Severn Estuary* 10, 125-128.

Masser, P., Jones, J. and McGill, B. (forthcoming) Romano-British Settlement and Land-Use on the Avonmouth Levels: The evidence of the Pucklechurch to Seabank Pipeline Project. *Transactions of the Bristol and Gloucestershire Archaeological Society.*

McGill Archaeological Consultants (1998-2001) *Pucklechurch to Seabank Pipeline Archaeological Programme* 3 volumes (unpublished Archive report for Entrepose-Laing JV).

Murray, J.W. and Hawkins, A.B. (1976) Sediment transport in the Severn Estuary during the past 8,000-9,000 years. *Journal of the Geological Society* 132, 385-392.

Rippon, S. (1997) *The Severn Estuary. Landscape Evolution and Wetland Reclamation.* Leicester, Leicester University Press.

Skempton, A.W., Smotrych, S.W., Hibbert, F.A. and Haynes, J.R. (1969) *Holocene Stratigraphy and Sea-level Changes near Avonmouth, Gloucestershire* (unpublished manuscript, copy held in Department of Geography, University of Bristol).

The Committee is extremely grateful to Headland Archaeology for a grant towards the cost of this publication.