N6 KINNEGAD – ATHLONE SCHEME PHASE 2: KILBEGGAN TO ATHLONE DUAL CARRIAGEWAY

SITE A016/044; E2672: MOYALLY 2

FINAL REPORT

ON BEHALF OF WESTMEATH COUNTY COUNCIL

26 JUNE 2009

IAC Irish Archaeological Consultancy

PROJECT DETAILS

Project Reference No.	WH/00/112
Project	N6 Kinnegad - Athlone Road Scheme: Phase 2, Kilbeggan – Athlone Dual Carriageway
Ministerial Direction Reference No.	A016/044
NMS Registration Number	E2672
Excavation Director	David Bayley
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Client	Westmeath County Council
Site Name	Moyally 2
Site Type	Iron Age Bowl furnaces
Townland	Moyally
Parish	Kilmanaghan
County	Offaly
NGR (Easting)	E221011
NGR (Northing)	N237516
Chainage	15990
Height m OD	79.7m OD
RMP No.	N/A
Excavation Start Date	15 February 2006
Excavation Duration	8 Days
Report Type	Final
Report Date	26 June 2009
Report By	David Bayley

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This report has been prepared by Irish Archaeological Consultancy Ltd on behalf of Westmeath County Council and the National Roads Authority in advance of the construction of the N6 Phase 2: Kilbeggan to Athlone Dual Carriageway Scheme.

The excavation was carried out in accordance with the Directions of the Minister for the Environment, Heritage and Local Government (DOEHLG), in consultation with the National Museum of Ireland (NMI) issued under Section 14 of the National Monuments Acts 1930–2004.

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ABSTRACT

Irish Archaeological Consultancy Ltd (IAC), funded by Westmeath County Council (WCC) and the National Roads Authority (NRA), undertook an excavation in the townland of Moyally at the site of Moyally 2 in advance of the proposed N6 Phase 2: Kilbeggan to Athlone Dual Carriageway Scheme (Figure 1). The following report describes the final results of archaeological fieldwork at that site. The area was fully excavated by David Bayley under Ministerial Direction (A016/044) and NMS Registration Number E2672 issued by the DOEHLG in consultation with the National Museum of Ireland. The fieldwork took place between 15 and 24 February 2006.

Moyally 2 comprised two metalworking furnaces (C7 and C10). A double, figure-of-eight furnace (C7) was probably two separate furnaces that could have been used for smelting, while the larger of the furnaces (C10) was probably associated with bloom smithing. Both features contained charcoal rich fills and the cuts exhibited evidence of having being exposed to intense heat. Analysis of the metallurgical waste proved that the ore was of the bog ore variety while fragments of furnace/hearth wall was also identified. AMS Radiocarbon dating of the features produced 2 Sigma calibrated dates of 173–5 BC and 200–10 BC placing them both within an Iron Age date range. There were no finds recovered from this site.

CONTENTS

1 INTRODUCTION 1
1.1 General 1
1.2 Proposed Development 1
1.3 Archaeological Requirements 1
1.4 Methodology 2

2 EXCAVATION RESULTS 3
2.1 Phase 1: Natural Drift Geology 3
2.2 Phase 2: Iron Age Bowl Furnaces 3
2.2.1 Furnace C10 3
2.2.2 Double Bowl Furnace C7 3
2.3 Phase 3: Topsoil 4
2.3.1 Topsoil C1 4

3 SYNTHESIS AND DISCUSSION 5
3.1 Landscape Setting 5
3.2 Archaeological Landscape (Iron Age) 5
3.3 Archaeological Typology Background (Metalworking Furnaces) 7
3.4 Discussion 8
3.4.1 Phase 1: Natural deposits 8
3.4.2 Phase 2: Archaeological activity – Iron Age Bowl Furnaces 8
3.4.3 Phase 3: Topsoil 9

4 CONCLUSIONS 10

5 BIBLIOGRAPHY 11
5.1 References 11
5.2 Other Sources 13

PLATES 14

APPENDIX 1 CATALOGUE OF PRIMARY DATA i
Appendix 1.1 Context Register i
Appendix 1.2 Catalogue of Artefacts ii
Appendix 1.3 Catalogue of Ecofacts iii
1.3.1 Charcoal iii
1.3.2 Carbonised seeds iii
1.3.3 Metallurgical waste and associated samples iii
Appendix 1.4 Archive Checklist iv
Appendix 1.5 Copy of Registration No. Document from DoEHLG v
Appendix 1.6 Copy of Ministerial Direction Document vi

APPENDIX 2 SPECIALIST REPORTS vii
Appendix 2.1 Metallurgical Analysis – Dr. Effie Photos-Jones ix
Appendix 2.2 Charcoal and Wood ID Report – Ellen O'Carroll xix
Appendix 2.3 Radiocarbon Dating Results – QUB Laboratory/Beta Analytical xxiii

APPENDIX 3 LIST OF RMP SITES IN THE AREA xxvi

APPENDIX 4 LIST OF N6 SCHEME SITE NAMES xxvii

FIGURES

List of Figures:

Figure 1: E2672 Moyally 2 site location on OS Discovery Series background
Figure 2: E2672 Moyally 2 showing RMP with OS background
Figure 3: E2672 Moyally 2 location of site within development
Figure 4: E2672 Moyally 2 post-excavation plan
Figure 5: E2672 Moyally 2 sections
Figure 6: E2672 Moyally 2 matrix

List of Plates:

Plate 1: E2672: Pre-excavation of site, facing east
Plate 2: E2672: Double bowl furnace C7, mid-excavation, facing east
Plate 3: E2672: Double bowl furnace C7, post-excavation, facing north
Plate 4: E2672: Bowl furnace C10, mid-excavation, facing east
Plate 5: E2672: Furnace C10, post-excavation, facing north

1 INTRODUCTION

1.1 General

This final archaeological report describes the results of the excavation carried out at the site of Moyally 2 in the townland of Moyally, Co. Offaly (Figures 1 and 2) as part of an archaeological mitigation programme associated with the N6 Phase 2: Kilbeggan to Athlone Dual Carriageway Scheme. Archaeological fieldwork was carried out under ministerial direction by David Bayley of Irish Archaeological Consultancy Ltd (IAC Ltd) and was funded by Westmeath County Council & National Roads Authority under the National Development Plan 2000–2006, 2007–2013 and the EU Structural fund.

Moyally 2 (Figure 4; Plate 1) was identified as a result of archaeological assessment undertaken by IAC Ltd. in August 2005 (Ministerial Direction No. A016/029; NMS Registration No E3273). All features identified during the assessment phase (two furnace pits) were subsequently re-identified and the site was fully excavated during the full resolution phase of the project which took place between 15 and 24 February 2006 with a team of 1 director, 1 supervisor and a maximum of 4 site assistants.

The site was located in undulating pastureland at a height of 79.7m OD c. 150m to the north of the current N80, c. 1.5km southeast of Moate (Offaly OS sheet 1). To the north east c. 500m was the site of RMP OF001-002. Moyally 2 had not been previously identified and was not a recorded monument.

The site was assigned the following identification data:

Site Name: Moyally 2; Ministerial Direction No.: A016/044; NMS Registration No.: E2672; Route Chainage (Ch): 15990; NGR: 221008/237545.

1.2 Proposed Development

The proposed N6 Kinnegad–Athlone Scheme is to be constructed in two phases. The Phase 2 Kilbeggan–Athlone scheme will consist of a dual carriageway that will run for a distance of approximately 29km. The location of the route is predominantly to the south of the existing N6 and there will be access to the local road network through the seven grade separated junctions located at Athlone, Farnagh, Moate and Kilbeggan. The cross-section of the mainline consists of 2m wide verges, 2.5m wide hard shoulders, 7m wide two-lane carriageways and a 3m wide central reserve. This central reserve will accommodate 1m hard strips and a safety barrier. In addition to the mainline dual carriageway there is a further 0.3km of standard dual carriageway to the south of Athlone Interchange to connect to the existing N6 and 1.2km to the south of Kilbeggan Interchange to connect to the existing N52.

1.3 Archaeological Requirements

The archaeological requirements for the N6 Kilbeggan to Athlone Dual Carriageway Scheme, are outlined in the Ministerial Directions issued to Westmeath County Council by the Minister for Environment, Heritage and Local Government under Section 14A (2) of the National Monuments Acts 1930–2004 and in the terms of the contract between Westmeath County Council and Irish Archaeological Consultancy Ltd. These instructions form the basis of all archaeological works undertaken for this development. The archaeological excavation works under this contract are located between the townlands of Kilbeggan South, Co. Westmeath and Creggan Lower, Co. Westmeath.

The proposed N6 was subjected to an Environmental Impact Assessment, the archaeology and cultural history section of which was carried out by Sheila Lane and

Associates and presented in 2003. The Record of Monuments and Places, the Sites and Monuments Record, Topographical files, aerial photography, the Westmeath Archaeological Urban Survey and literary sources were all consulted. One phase of geophyiscal survey was also conducted at selected sites along the proposed route by Target Archaeological Geophysics. As a result of the paper survey, field inspections and geophysical survey, a number of potential sites were recorded in proximity to this section of the overall route alignment.

Advance archaeological testing was completed by IAC Ltd and excavation of the sites identified during testing was conducted by IAC Ltd on behalf of Westmeath County Council.

1.4 Methodology

The topsoil was reduced to the interface between natural subsoil and topsoil using a 20 tonne mechanical excavator equipped with a flat toothless bucket under strict archaeological supervision. The remaining topsoil was removed by the archaeological team with the use of shovels, hoes and trowels in order to expose and identify the archaeological remains. A site grid was set up at 10m intervals and was subsequently calibrated to the national grid using GPS survey equipment.

All features were subsequently fully excavated by hand and recorded using the single context recording system with plans and sections being produced at a scale of 1:50, 1:20 or 1:10 as appropriate.

A complete photographic record was maintained throughout the excavation. Digital photographs were taken of all features and of work in progress. These photos were supplemented by specialist aerial photographs.

An environmental strategy was devised at the beginning of the excavation. Features exhibiting large amounts of carbonised material were the primary targets and features containing metallurgical waste were fully sampled for analysis.

In the instances where artefacts were uncovered on site they were dealt with in accordance with the guidelines as issued by the NMI and where warranted in consultation with the relevant specialists. All artefacts, ecofacts and paper archive are currently stored in IAC offices, Lismore, Co Waterford and will ultimately be deposited with the National Museum of Ireland.

Radiocarbon dating of the site was carried out by means of AMS (Accelerator Mass Spectrometry) dating of identified and recommended charcoal samples. All calibrated AMS dates in this report are quoted to 2 Sigma.

All excavation and post excavation works were carried out in consultation and agreement with the Project Archaeologist, the National Monuments Section of the DOEHLG and the National Museum of Ireland.

2 EXCAVATION RESULTS

Detailed descriptions of contexts are listed in Appendix 1. The site matrix is detailed in Figure 6.

2.1 Phase 1: Natural Drift Geology

The dominant bedrock geology identified along the corridor of the proposed route are Lower Carboniferous rocks, mainly limestone lithologies, which overlay Devonian Old Red Sandstone rocks. Carboniferous volcanic rocks were also identified as being present locally in the form of sills passing through the bedrock sequences (Riada Consult, 2003). The underlying geology of the area is overlain by occasional moraines and small glacial hillocks covered by grey brown podzolic soils.

The subsoil C2 above bedrock encountered at Moyally 2 was uniform across the site and consisted of yellowish brown boulder clay.

2.2 Phase 2: Iron Age Bowl Furnaces

The Phase 2 archaeology at Moyally 2 comprised two metallurgical furnaces (Figure 6). These are described below.

2.2.1 Furnace C10

Context	Fill of	L(m)	W(m)	D(m)	Basic Description	Interpretation
C4	C10	1.32	0.9	0.09	Loose black charcoal-rich fill	Secondary fill
C8	C10	0.69	0.84	0.04	Loose dark brown silty sand	Primary fill
C9	C10	1.24	0.9	0.1	Oxidised clay layer	Oxidised subsoil
C10	N/A	1.32	0.92	0.17	Oval cut, flat base	Cut of furnace

Finds: None

Interpretation:
This furnace (Figures 4 and 5; Plates 4 and 5) was probably used for bloom smithing as part of the metalworking process. The base of the furnace was heavily oxidised and was filled by silty sand, charcoal flecks, slag and small stones. It is likely that the smaller, double bowl furnace C7 (Cf. Section 2.2.2) was used as two small smelting furnaces.

The regular nature and rectangular shape of the cut has led to the suggestion that it was used for bloom smithing as this, more often than not, is what rectangular structures are used for in the metalworking process. This furnace appears to be the result of a single industrial 'outburst' (Appendix 2.1).

AMS radiocarbon dating of charcoal (young oak; *Quercus* sp.; 0.2g (Appendix 2.2)) recovered from the secondary fill (C4) returned a date of 2090 +/- 40 BP (Beta-249539). The 2 Sigma calibrated date of this sample produced a date of 200–10 BC, dating it to the Iron Age (Appendix 2.3).

2.2.2 Double Bowl Furnace C7

Context	Fill of	L(m)	W(m)	D(m)	Basic Description	Interpretation
C3	C7	0.42	0.4	0.06	Black charcoal-rich sandy silt	Charcoal-rich fill
C5	C7	0.96	N/A	0.04	Soft mid brown sandy clay	Charcoal-rich fill
C6	C7	0.98	N/A	0.11	Firm mid red/brown sandy clay	Oxidised clay layer
C7	N/A	0.98	0.6	0.15	Figure-of eight shaped cut, irregular base	Cut
C11	C7	0.28	N/A	0.06	Loose dark brown silty sand	Charcoal-rich fill

C12	C7	0.2	N/A	0.05	Loose dark brown silty sand	Charcoal-rich fill
C13	C7	0.35	N/A	0.04	Black charcoal-rich sandy silt	Charcoal-rich fill

Finds: None

Interpretation:
This figure-of-eight shaped 'double' bowl furnace (Figures 4 and 5; Plates 2 and 3) was probably two separate pits, both of which could have been used as small smelting furnaces. Alternatively, one bowl could have been used for smelting while the other was used for drying or partial roasting of the ore or simply as a depository for the smelting waste.

The iron ore has been identified as bog ore that was most likely available locally. The furnaces were not very efficient and were more conducive to generating slag than producing iron. The amount of iron produced in the furnace would have been minimal, if any at all. The furnace appears to be the result of a single industrial 'outburst' in a landscape devoid of industrial activity (Appendix 2.1).

A 5g sample of charcoal (oak brushwood: *Quercus* sp.) (Appendix 2.2) from fill C3 was sent for AMS dating. It returned a date of 2076 +/- 24 BP (UBA 8594) The 2 Sigma calibrated result of this sample produced a date of 173–5 BC, dating it to the Iron Age, and contemporary with C10 (Appendix 2.3).

2.3 Phase 3: Topsoil

2.3.1 Topsoil C1

Context	Fill of	L(m)	W(m)	D(m)	Basic Description	Interpretation
1	N/A	N/A	N/A	0.4	Light brown sandy clay	Topsoil

Finds: None

Interpretation:
This phase represents the topsoil that sealed all of the archaeological deposits and features at Moyally 2. The topsoil had a depth of c. 0.4m.

3 SYNTHESIS AND DISCUSSION

3.1 Landscape Setting

The new route of the N6 runs from south of Kilbeggan town to east of Athlone Co. Westmeath, crossing through the northern part of Co. Offaly for approximately 7.5km of its entire length. The landscape of this area is comprised of generally flat to undulating terrain. The underlying geology of the area is dominated by carboniferous limestone and is overlain by occasional glacial features such as moraines and eskers. The eskers dominate to the north and south of most of the route, with moraines featuring along parts of the western section toward Athlone. The soil cover varies considerably across the scheme, passing through soil complexes, grey brown podzols, boglands and alluvial deposits. The area is drained by the River Shannon through its tributaries, the Brosna, Boor, Cloghatanny and Gageborough rivers.

The site at Moyally 2 was located 2km southeast of Moate town in a gently undulating field (79.7m OD). The underlying geology of the area is carboniferous limestone, which is overlain with occasional small glacial hillocks, forming a gently undulating low-lying landscape. Soil cover in this area consists of grey brown podzolics of the Patrickswell series. A bog is located in the northern part of the townland and lies 600m northeast of the site. A smaller bog is located 1km to the southwest of the site in Lurgan/Culleenagower/Newtown/Cloghanamina townlands (6" OS map 1834–1842). A small stream was recorded 600m north of the site on the 25" OS map (1887–1913).

3.2 Archaeological Landscape (Iron Age)

Apart from the publication of archaeological inventories in some midland counties, such as Offaly (O'Brien and Sweetman 1997) for example (there is, as yet, no archaeological inventory for Co. Westmeath), and peatland surveys by the Irish Archaeological Wetland Unit (see below) our knowledge of the prehistoric archaeology of the midlands is limited. We are reliant on data stored at the RMP (see Appendix 3) and information from a limited number of excavations within Westmeath and Offaly. This road scheme joins a number of recent large-scale commercially-driven archaeological excavations, most notably the gas pipeline to the west (Grogan *et al*. 2007) which runs mostly parallel a short distance to the north of the N6, but unfortunately evidence for Iron Age settlement and activity remains relatively minor in this region.

Excavations along the gas pipeline produced a small number of Iron Age sites (Grogan *et al*. 2007, 6), but none within the midland counties. The Iron Age was better represented by a number of ironworking sites and the settlement/cemetery site of Johnstown 1, Co. Meath, discovered in advance of the M4 which traverses counties Westmeath, Meath and Kildare (Carlin, Clarke and Walsh 2008). The site of Kinnegad 2, within the barony of Farbill, Co. Westmeath, revealed ironworking features dating to the early, middle and later parts of the period (Carlin 2008b, 2; table 1.1), while a small number of sites, mainly industrial-type features, in neighbouring County Meath were also dated to the Iron Age (*ibid*.). Survey and excavation of the midland bogs – mainly in Offaly but also Westmeath – have also revealed snippets of Iron Age activity. An Iron Age vessel, dating to 197 BC–AD 68, was recovered from Toar Bog, Co. Westmeath (Murray 2000), after initial survey (Irish Archaeological Wetland Unit 2000). The northern parts of Daingean Bog, within counties Offaly and Westmeath, revealed small deposits of brushwood and some roundwoods – one site was classified as a trackway – dating from the Iron Age onwards (McDermott 2001). To the south of Daingean, at Clonad Bog, a number of sites were discovered including three substantial trackways dating from the late Bronze Age/Iron Age (Murray 2001). Finally, four Iron Age Y-shaped pendants were

uncovered in the same region at Ballykean Bog, as part of the peatland survey in Offaly, as well as an early medieval palisaded habitation site and 12 trackways (Stanley 2003). The most significant recently discovered Iron Age site in the region is at Coolure crannog on Lough Derravaragh in the barony of Moycashel (O'Sullivan *et al*. 2007). A substantial plank palisade was dendrochronologically dated to AD 402 +/- 9 years placing a secondary construction phase of the crannog at the end of the Iron Age, 1200 years after it was originally built. This is a rare example of a crannog dating to the late Iron Age/early medieval transitional phase as most lake dwellings have been dated to the late Bronze Age/early Iron Age – for example Ballinderry crannog No. II, Co. Offaly (Hencken 1942; Newman 2002), – or securely to the late sixth and early seventh centuries (*ibid*.).

The N6 has produced a small number of sites that can be dated to the late Bronze Age/early Iron Age transitional phase such as the burnt mound sites at Williamstown 2 (Lyne 2009a), Seeoge 2 (Lyne 2009b) and Aghafin 1 (Lynch 2009a), some pits and postholes at Moyally 6 (Bayley 2009) and a possible hearth at Ballinderry Big 2 (Lynch 2009b). A burnt spread at Cregganmacar 1 was dated to 2 Sigma 399–235 BC while a similar date came from a pit at Cregganmacar 3 a short distance away (Lynch 2009c and 2009d). The figure-of-eight-shaped ironworking furnace was dated to the middle Iron Age at Moyally 2 and, finally, a ringditch was also dated to the same period at Cappydonnell Big (Coughlan 2009). The N6 findings mirror the results from other excavations within the region, such as the M4 and gas pipeline, and throughout Ireland generally where only a small number of sites dating to the Iron Age were revealed.

Iron working at Moyally 2

Surprisingly, given the surrounding landscape and the number of charcoal production kilns on the scheme, only a small number of features relating to ironworking have been uncovered and these include this figure-of-eight-shaped furnace and a possible smithing furnace at Moyally 2. The interpretation of the smithing furnace is based on its morphological similarities with other similar shaped features such as those found during the M4 excavations (Carlin *et al* 2008a). The majority of the smithing furnaces from the M4 had a distinctive rectangular plan with steep sides and a flat base. Most were 1m to 1.60m in length and between 0.10m and 0.40m deep and were probably utilised for bloom smithing (*ibid*.). Specialist metallurgical analysis has suggested that the figure-of-eight furnace be considered as two separate furnaces although this identification is not certain (Photos-Jones 2008). Usually, when two features come together in a figure-of-eight form it is possible that –

A. Both bowls were used as small smelting furnaces.
B. One bowl was used for smelting and the other for the ore drying/partial roasting.
C. One bowl was used for smelting the other as the depository of the waste (*ibid*.).

Similar figure-of-eight-shaped metallurgical features to that at Moyally 2 have been excavated at Killickaweeny, Co. Kildare (Walsh 2008) and Derrinsallagh 4, Co. Laois (Kenny 2007; Lennon 2007). The former measured 2.49m x 0.97m x 0.29m and has been interpreted as a smithing hearth based on its size and after tests for magnetic susceptibility revealed that some of the fills contained high levels of iron (Photos-Jones 2004, 52; Walsh 2008, 41). Two radiocarbon dates produced an early medieval date for the hearth – broadly spanning the seventh to early 11th centuries – and it was located outside an early medieval farmstead, dating between the eighth and 10th centuries AD, which enclosed a number of structures and another ironworking area.

Three figure-of-eight furnaces were uncovered at Derrinsallagh 4 among a range of other industrial features such as charcoal producing kilns, furnaces, hearths, working platforms and two possible structures (Kenny 2007; Lennon 2007; Photos-Jones and Wilson 2007). One example measured 1.21m x 0.64m x 0.43m and was similar in size to the Moyally furnace. The primary fills consisted of vitrified clay while the upper deposits contained frequent slag inclusions. The vitrified clay is suggestive that the bowls were clay-lined or indicates the presence of a superstructure. Two radiocarbon dates from bowl-shaped furnaces at Derrinsallagh produced dates spanning the middle Iron Age (10 BC–AD 250 and 50 BC–AD 240).

Without specialist metallurgical analysis, it is impossible to say how figure-of-eight-shaped ironworking features functioned – either as furnaces or smithing hearths – or whether they can be considered as a single structure or two separate features. Radiocarbon dates have also revealed that the Moyally furnaces and the Killickaweeny smithing hearth – although similar in form – were utilised hundreds of years apart. Ironworking features altered little from late prehistory until the 17th century (Carlin *et al* 2008a) and clearly specialist metallurgical analysis is needed to understand the function and uses of these features.

3.3 Archaeological Typology Background (Metalworking Furnaces)

Furnaces, used for the smelting of ores into an iron bloom prior to the smithing stages, survive in the archaeological record as small shallow heat-scorched pits, usually oval or hemispherical in shape, containing fills of iron slag, charcoal and, in many cases, oxidised clay. Dense blocks of slag commonly form at the bottom of the furnace which have been termed plano-convex or 'furnace-bottoms' (Scott 1990, 155–6). A total of 30 furnaces – with approximate diameters of between 0.40m and 0.70m and depths not exceeding 0.20m – were identified in advance of the M4 road scheme and survived as bowl-shaped pits, with heat-reddened sides and bases, which contained slag and, in many examples, vitrified clay fragments (Carlin *et al* 2008a, 94). A recent summary of furnaces associated with raths has revealed similar morphological characteristics and deposits whereby they were all heat-scorched small pits containing charcoal, slag and burnt clay in many instances (Comber 2008, 115–7).

Much of the technology associated with the primary stages of iron production such as charcoal production kilns, furnaces and smithing hearths, during the bloom smithing process, were located close to natural resources such as wood and bogland. This is not surprising because oak was the preferred fuel for charcoal production as it is denser and burns for longer than softer woods (Raftery 1994, 148; Tylecote 1962), while bog ore was more readily available and required less work to extract compared to mining and was also a regularly renewable resource (Mytum 1992, 230). The primary stages of ironworking generally took place away from dwellings due to the dangers associated with the production, such as the risk of fire and the toxic nature of the process. The results from recent excavations, such as along the M4 (Carlin *et al* 2008a) and the M7/M8 (Kenny 2007) testify to this as the majority of furnaces were located in marginal places, availing of the limited drier and sloping ground, close to bog and woodland and away from settlements. However, furnaces do occur within enclosed early medieval settlements in some instances, such as Killickaweeny, Co. Kildare (Walsh 2008), and it appears that iron smelting was practised sometimes within enclosures, possibly in controlled safe environments away from the dwellings.

The ironworking processes remained largely static until the 17th century so the features that survive archaeologically today appear similar in form even though they span the centuries between late prehistory and the later middle-ages. Diagnostic artefacts are also mainly absent so radiocarbon dating is vital for determining the age

of various metallurgical features, including smelting furnaces. Radiocarbon-dated examples of furnaces from the M4 show that, despite their morphological similarities, they were in use from the beginnings of the fifth century BC until the late medieval period with the majority dating to the early middle ages (Carlin *et al* 2008a, 104). A number of possible furnaces along the M7/M8 (specialist metallurgical reports are awaited) have also produced dates spanning the middle Iron Age through to the later medieval period (Kenny 2007).

Debates have recently focused on the arguments for (Carlin *et al* 2008a; Crew and Rehren 2002, 96; Mytum 1992, 231) and against (Pleiner 2000; Scott 1990; Raftery 1994, 148) the existence of the low-shaft furnace in Ireland with the former mainly arguing that the low-shaft furnace, in contemporary use in Britain, was more efficient than the bowl furnace. This view was based, to a large extent, on the experimental work on bowl furnaces by O'Kelly (1961) and later by Tylecote (1986). Bowl furnaces consisted of pits containing charcoal, positioned close to the air hole, and ore that were sometimes clay-lined and may have had a low dome-shaped clay roof (Scott 1990, 159). Low-shaft furnaces differed in that they were clay-lined and clay sides were constructed above ground into the shape of a conical- or a cylindrical-shaped chimney (Carlin *et al* 2008a, 92). They also differed to the bowl furnace because the charcoal and ore were placed in alternating layers (Mytum 1992, 231). Archaeologically, however, it is difficult to distinguish between the two because both survive as heat-scorched pits containing charcoal and slag deposits and, in many cases, vitrified clay fragments. The presence of the latter cannot be used as evidence for the existence of the low-shaft furnace because bowl furnaces may also have been clay-lined or roofed by a clay dome. Regardless of the existence, or not, of the low-shaft furnace, the large number of furnaces found in excavations across the country demonstrate that iron smelting was an integral part of the iron production process and it usually occurred in marginal places, in proximity to raw materials, and away from settlements where the final process – iron forging – was frequently practised.

3.4 Discussion

3.4.1 Phase 1: Natural deposits

This phase represents the natural subsoil, which was cut or sealed by all subsequent archaeological features (Figure 6). At Moyally 2 the subsoil was uniform throughout consisting of a yellowish brown silty boulder clay.

3.4.2 Phase 2: Archaeological activity – Iron Age Bowl Furnaces

Phase 2 represents the main archaeological activity at Moyally 2 (Figure 6). The site comprised two metalworking furnaces, C7 and C10 (Figures 4 and 5; Plates 1–5). Both features contained charcoal rich fills and the cuts exhibited evidence of having being exposed to intense heat. Slag and other metallurgical waste were recovered from the fills of both features. AMS Radiocarbon dating of oak brushwood recovered from fill C3 of furnace C7 produced a 2 Sigma calibrated date of 173–5 BC. AMS Radiocarbon dating of young oak from fill C4 of furnace C10 produced a 2 Sigma calibrated date of 200–10 BC, placing the site in an Iron Age date range (Appendix 2.3).

A total of 1.6kg of slag from various contexts (C9, C10, C3, C5 and C7) was recovered from site and subsequently sent to Dr Effie Photos Jones for analysis (Appendix 2.1).

Of the total weight of material sent for analysis 1kg was identified as being slag of largely an iron silicate whilst 0.6kg was identified as being fragments of a furnace or

hearth wall. On examination of the material it has been suggested that C7 could be two furnaces rather than one based upon the lack of superstructure and the shallowness of the cut. In support of this a number of potential options for usage of such a feature were put forward including the following: both bowls were used as small smelting furnaces, one bowl is used for smelting and the other for the ore drying/partial roasting or one bowl is used for smelting with the other being the depository of the waste.

The ore recovered is of the bog ore variety. Although no particular source was evident, it was most likely to be available locally. The furnaces appear to be the result of a single industrial 'outburst' in a landscape devoid of any industrial activity. The conditions within the furnace indicate that it was more conducive to generating slag than producing iron. This coupled with the fact that only 1kg of slag was recovered suggest that the amount of iron generated by these furnaces would have been minimal, if any at all (Appendix 2.1).

The charcoal recovered from the furnaces was young oak and oak brushwood (*Quercus* sp. (Appendix 2.2)). Oak is a dense wood and burns to a high temperature which makes it very suitable for use in smelting activities. The oak identified suggests that there was a supply of oak in the surrounding environment in the Iron Age and this wood was specifically collected and used in the bowl furnaces. Ash was also present in the surrounding environment during the Iron Age (Appendix 2.2).

3.4.3 Phase 3: Topsoil

This phase represents the topsoil that sealed all of the archaeological deposits and features on site.

4 CONCLUSIONS

Moyally 2, comprised a figure-of-eight bowl furnace used for smelting iron ore and a smithing furnace. Although iron appears to substitute bronze as the primary metal in the middle first millennium BC, little evidence exists for iron-making and working activities in the period from 500BC to the first few centuries AD. The bowl furnaces from Moyally 2 date to this period, as 2 Sigma calibrated dates of 173–5 BC (UBA 8594, Appendix 2.3) and 200–10 BC (Beta 249539, Appendix 2.3) were produced for these features, placing the site in an Iron Age date range.

Smelting of iron ore during this period was generally undertaken in simple bowl furnaces. It has been suggested that some of these furnaces could have been low shaft furnaces, but there was no evidence for a shaft on either of the pits at Moyally 2. These simple furnaces comprised small pits which were lined with clay into which charcoal and iron ore were placed. The slag was not tapped but formed in the bottom of the furnace along with the charcoal while the metallic iron was left to form a bloom.

In bloomery, metallic iron was reduced from its ore while in a solid state; i.e. the iron was never intentionally molten. As a result, the numerous slag impurities trapped within the bloom had to be hammered out, resulting in a billet that was subsequently shaped or forged into the desired artefact.

For most primitive bloomeries, it is assumed that primary (smelting) and secondary (smithing) activities would be taking place side by side, and this appears to be the case at Moyally 2. It is difficult to differentiate between primary and secondary activities when the only available evidence is slag.

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PLATES

Plate 1: E2672: Pre-excavation of site, facing east

Plate 2: E2672: Double bowl furnace C7, mid-excavation, facing east

Plate 3: E2672: Double bowl furnace C7, post-excavation, facing north

Plate 4: E2672: Furnace C10, mid-excavation, facing east

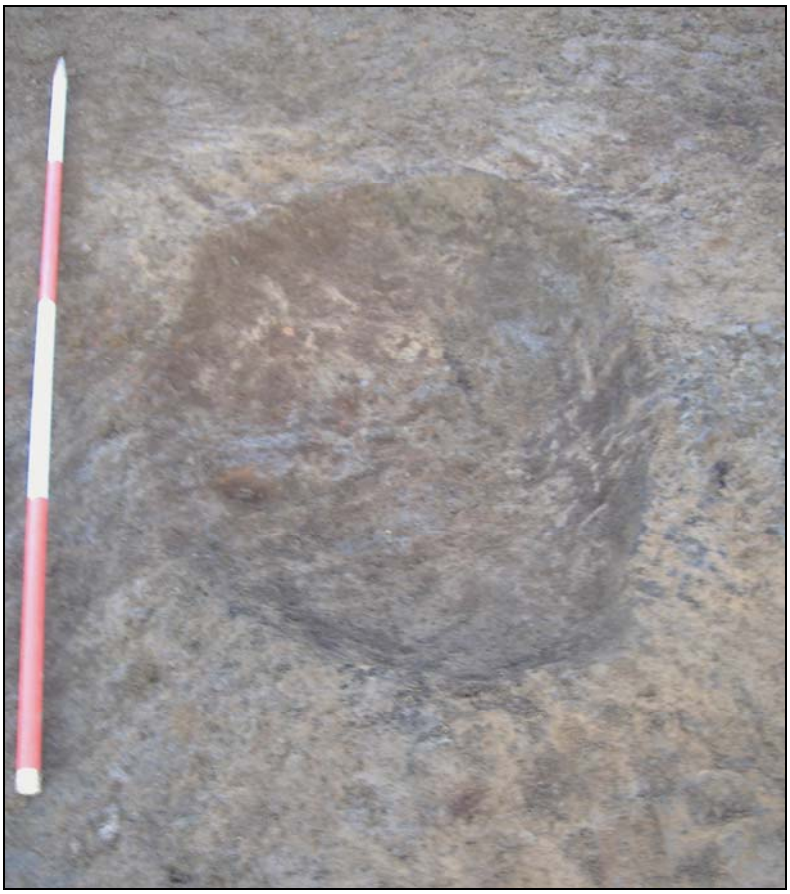


Plate 5: E2672: Bowl furnace C10, post-excavation, facing north

APPENDIX 1 CATALOGUE OF PRIMARY DATA

Appendix 1.1 Context Register

Context	Fill of	L(m)	W(m)	D(m)	Interpretation	Description	Finds
1	N/A	N/A	N/A	0.4	Topsoil	Light yellowish brown sandy clay.	N/A
2	N/A	N/A	N/A	N/A	Natural subsoil	Yellow brown boulder clay.	N/A
3	C7	N: 0.42 S: 0.36	0.4 (max)	0.06(max) 0.03(min	Charcoal fill / burnt deposit of double bowl furnace.	Black sandy silt, 70% charcoal flecks and lumps, occasional slag inclusions more concentrated to moderate at northern end.	N/A
4	C10	1.32	0.9	N/A	Top charcoal fill / burnt deposit of furnace.	Black charcoal fill with frequent flecks of oxidised clay and occasional small pebble inclusions loose compaction.	N/A
5	C7	0.96	N/A	0.04	Fill of double bowl furnace.	Mid brown sandy clay with moderate charcoal fleck inclusions, soft compaction.	N/A
6	C7	0.98	0.6	0.11	Primary fill, formed when the intense heat from the above burning charcoal deposits (C03) caused the oxidisation of the natural clay below.	Mid red/brown sandy clay with moderate oxidised clay fleck inclusions, firm compaction.	N/A
7	N/A	0.98	N/A	0.15	Cut of double-bowl furnace.	Figure-of eight shaped cut, no corners sharp break of slope at top gradual sloping sides onto irregular concave base. N–S orientation.	N/A
8	C10	0.04	0.69	0.84	Fill of furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck inclusions, loose compaction.	N/A
9	C10	0.1	1.24	0.9	Oxidisation of natural clay created by intense heat from burning charcoal above.	Oxidised clay layer mixed with dark brown clayey silt, concrete compaction.	N/A
10	N/A	1.32	0.28	0.92	Cut of furnace.	Oval shaped cut, NE–SW orientation sharp break of slope at top, sharp concave sides, slight break of slope at base, flat base.	N/A
11	C7	0.28	N/A	0.06	Fill of double bowl furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck and slag inclusions, loose compaction.	N/A
12	C7	0.2	N/A	0.05	Fill of double bowl furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck and slag inclusions, loose compaction.	N/A
13	C7	0.35	N/A	0.04	Charcoal fill / burnt deposit of double bowl furnace.	Black sandy silt, 70% charcoal flecks and lumps, occasional slag inclusions.	N/A

Appendix 1.2 Catalogue of Artefacts

There were no artefacts recovered from this site

Appendix 1.3 Catalogue of Ecofacts

A total of 11 bulk soil samples were taken during the course of excavation at this site, with both features being 100% sampled. Of these, 4 were processed by means of flotation and sieving through a 250/300µm mesh. The resulting retrieved samples of this process are listed below. The remaining samples were sent for metallurgical waste examination and charcoal Identification analysis (Appendix 2.1 and Appendix 2.2 respectively).

1.3.1 Charcoal

Context number	Sample number	Feature	Sample weight (g)
C3	1	Tertiary fill of C7	236.2g
C5	2	Secondary fill of C7	38.5g
C4	4	Tertiary fill of C10	485.7g

1.3.2 Carbonised seeds

Context number	Sample number	Feature	Sample weight (g)
C5	2	Secondary fill of C7	0.1g

1.3.3 Metallurgical waste and associated samples

Context number	Sample number	Feature	Sample weight (g)
C3	1	Tertiary fill of C7	525g
C5	2	Secondary fill of C7	475g
C9	11	Oxidised layer of C10	600g

Appendix 1.4 Archive Checklist

Project: N6 Kilbeggan – Athlone	**Irish Archaeological Consultancy Ltd**	
Site Name: Moyally 2		
Licence Number: E2672		
Ministerial Direction No.: A016/044		
Site director: David Bayley		
Date: 31 October 2008		
Field Records	**Items (quantity)**	**Comments**
Site drawings (plans)	2	
Site sections, profiles, elevations	1	
Other plans, sketches, etc.	0	
Timber drawings	0	
Stone structural drawings	0	
Site diary/note books	0	
Site registers (folders)	1	
Survey/levels data (origin information)	29	
Context sheets	13	
Wood Sheets	0	
Skeleton Sheets	0	
Worked stone sheets	0	
Digital photographs	29	
Photographs (print)	0	
Photographs (slide)	0	
Finds and Environ. Archive		
Flint/chert	0	
Stone artefacts	0	
Pottery (specify periods/typology)	0	
Ceramic Building Material (specify types eg daub, tile)	0	
Metal artefacts (specify types - bronze, iron)	0	
Glass	0	
Other find types or special finds (specify)	0	
Human bone (specify type egg cremated, skeleton, disarticulated)	0	
Animal bone	0	
Metallurgical waste	3	
Enviro bulk soil (specify no. of samples)	11	
Enviro monolith (specify number of samples and number of tins per sample)	0	
Security copy of archive	1	On IAC server

Appendix 1.5 Copy of Registration No. Document from DoEHLG

National Monuments
Acts (1930-2004)
Ministerial Directions
Record Number for
archaeological activity

AN ROINN COMHSHAOIL, OIDHREACHTA AGUS RIALTAIS ÁITIÚIL
DEPARTMENT OF THE ENVIRONMENT, HERITAGE
AND LOCAL GOVERNMENT

File: Direction No. A16

Registration Number: E2672

Directions have been issued to Murty Hanly on behalf of Westmeath County Council in order to regulate archaeological activities carried out on N6 Kilbeggan to Athlone (Phase 2).

Application having been duly made to me by Mr. David Bayley of Irish Archaeological Consultancy, 8 Dunngar Terrace,, Dun Laoghaire,, Co. Dublin.

For a registration number to record excavation at the site of Moyally 044 being part of the townland of MOYALLY in the County of Offaly.

This registration is not an archaeological licence or consent but it is issued solely for archive purposes and to allow for the material from the activity to be registered with the National Monuments Service and the National Museum.

Signed .....

31 October 2006

Appendix 1.6 Copy of Ministerial Direction Document

Section 14A(2) National Monuments Acts 1930-2004

Directions to Westmeath County Council for the carrying out of archaeological works on the N6 Kinnegad to Athlone dual carriageway road scheme (Phase 2 * Kilbeggan to Athlone).

1. Introduction

The project is an approved road development, having been approved by An Bórd Pleanála on 26th March 2004.

The development will consist of a dual carriageway that will run for a distance of approximately 57.5km.

In line with recommendations in the Environmental Impact Assessment for the scheme, archaeological investigations included site specific testing followed by a centreline test trench with staggered offsets. The request for directions has an attached strategy document that covers the proposed resolution works

These directions relate to Phase 2 works and are issued following the receipt by the Minister of reports on the testing work carried out in Phase 1.

2. Directions

All aspects of the archaeological works should be conducted in accordance with provisions of the policy and advice notes on archaeological excavations issued by the Department and in line with the provisions of the Code of Practice agreed with the National Roads Authority. Archaeological works shall be carried out in accordance with the Strategy for Proposed Works submitted with the application seeking Directions.

3. Project Archaeologist

The Project Archaeologist appointed for the road development should ensure that the archaeological works are carried out in accordance with the terms of the directions.
· Any changes to the agreed method statement for the excavations should be submitted to the National Monuments Section for approval.
· Any proposal to change any named director of a specific excavation should firstly be notified to the National Monuments Section for approval.

4. Conduct of Archaeological Excavations:

a) The archaeological excavations should be carried out in accordance with the specifications set out in the strategy document submitted to the Minister.
b) The National Monuments Section should be notified of the commencement date of the works on site.
c) The names of the archaeological consultants, including site directors should be submitted to the National Monuments Section in advance of the works commencing.

d) Where necessary the layout of the archaeological trenches should be adjusted to include additional archaeological features and deposits or areas of archaeological potential.
e) All archaeological objects recovered in the course of the test excavations should be treated and conserved in line with the advice notes and guidelines issued by the National Museum of Ireland.
f) A report on the progress of the archaeological works shall be submitted to the National Monuments Section every 4 weeks.

5. Record Number for the scheme:

The record number for the recording of archaeological works is A016/000. Sub-numbers may be allocated by the Project Archaeologist to the additonal works. These numbers should be notified to the National Monuments Section for agreement with full details of the archaeological works involved.

6. Detection Device:

Detection devices may be used as appropriate in the course of archaeological works to recover archaeological objects. Details of proposed methodologies should be notified to the National Monuments Section.

7. Reports:

1. A report on the results of the archaeological excavations should be submitted to the National Monuments Section within 4 weeks of the completion of the works on site. Should additional time be required to complete the report the National Monuments Section should be notified before the expiration of the 4-weeks period. A copy of the report should be sent to the National Museum of Ireland.
2. A summary of the excavation results for the site should be published in the Excavations Bulletin for the year when works are undertaken.

8. National Monuments (Subsection 14A(4)):

If during the carrying out of the archaeological excavations a site should prove to be a National Monument within the meaning of the National Monuments Acts (1930-2004) all works should stop and the National Monuments Section should be informed immediately.

9. Inspection of Works

Officers, servants or agents of the Minister may inspect the archaeological works at any time and full co-operation should be given to them in carrying out the inspections.

APPENDIX 2 SPECIALIST REPORTS

Appendix 2.1: Metallurgical Analysis – Dr. Effie Photos-Jones

Appendix 2.2: Charcoal and Wood ID Report – Ellen O'Carroll

Appendix 2.3: Radiocarbon Dating Results – QUB Laboratory/Beta Analytical

-RAF ANALYSIS

SASAA 323.1
April 2008

Metallurgical Waste Examination & Analysis of samples from Moyally 2, Co Offaly (A016/044)

Introduction

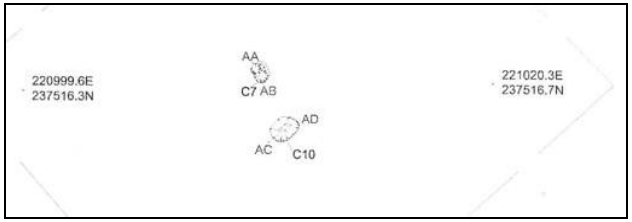
Metallurgical waste from the site of Moyally 2, Co Offaly, part of the N6 Kinnegad-Athlone Motorway Scheme, was presented to us for examination and analysis following assessment (SASAA 303) (see Table 1 below). The site comprised of a double bowl furnace C7 and a single furnace C10 (see images in Figure 1a–f). The evidence shows that both features contained slag and charcoal rich fills. (IAC Stratigraphic Report E2672, 2008). The total weight of the collection was 1.6kg derived from context C9, fill of C10 and C3 and C5, fills of C7; of that 1kg is slag and 0.6kg is the fragments of the furnace/hearth wall. The radiocarbon date for charcoal from C3 is reported to be Cal 152–49 BC (1Sigma), placing at least one of the two furnaces between the 2nd and the 1st century BC.

Two samples of metallurgical waste, highlighted below, were subjected to technical characterisation and the results of this investigation are presented here. It was suggested that 'the larger of the two furnaces, C10, was probably used for the primary smelting, while the smaller, double bowl furnace, C7, was probably used for refining secondary smelting'. (IAC Stratigraphic Report E2672, 2008). We propose an alternative interpretation.

Table 1.

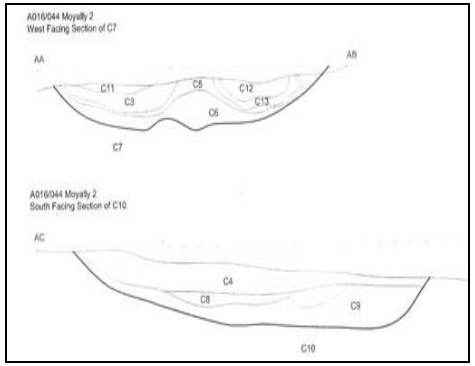
SASAA no	Site Name & Code	Sample #	Context #	Typology	Description	Weight (g)	Dimensions
323.8	Moyally 2 A016/44	11	9	frgts of furnace hearth/furnace wall?	two large plate-like but slightly concave frgts of orange coloured ferruginous mass which appears to consist of part earthy material, part slag; also many smaller frgts of seemingly the same material	600g	frgt.1:8x8x2cm; fgrt.2:8x6x2cm
323.9	Moyally 2 A016/44	2	5	slag	two larger frgts with accumulation of many smaller frgts; amorphous, black, highly porous, light, ferruginous material; typical of bloomery smelting but could come from bloom smithing or smelting as well	475g	2 frgts<5cm each
323.15	Moyally 2 A016/44	1	3	slag	collection of small frgts of slag ranging in size; amorphous, dark-brown, porous, ferruginous deriving from bloomery smelting/bloom smithing/smithing	525g	<1cm

Figure 1a–f: site plans and photos, after IAC 2008



Location of two furnaces C7 and C10 at Moyally 2

Pre-ex of site looking E



Sections of two furnaces C7 and C10

Mid-ex of double bowl furnace C7 looking E

Mid-ex of bowl furnace C10 looking E

Double furnace C7 after excavation

Tables 2 and 3: Features Specifications and interpretations, after IAC 2008.

Context	Fill of	L(m)	W(m)	D(m)	Interpretation	Description
4	C10	1.32	0.9	N/A	Top charcoal fill / burnt deposit of bowl furnace.	Black charcoal fill with frequent flecks of oxidised clay and occasional small pebble inclusions loose compaction.
8	C10	0.04	0.69	0.84	Fill of bowl furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck inclusions, loose compaction.
9	C10	0.1	1.24	0.9	Oxidisation of natural clay created by intense heat from burning charcoal above.	Oxidised clay layer mixed with dark brown clayey silt, concrete compaction.
10	N/A	1.32	0.28	0.92	Cut of bowl furnace.	Oval shaped cut, NE–SW orientation sharp break of slope at top, sharp concave sides, slight break of slope at base, flat base.

Context	Fill of	L(m)	W(m)	D(m)	Interpretation	Description
3	C7	N: 0.42 S: 0.36	0.4 (max)	0.06(max) 0.03(min	Charcoal fill / burnt deposit of double bowl furnace.	Black sandy silt, 70% charcoal flecks and lumps, occasional slag inclusions more concentrated to moderate at northern end.
5	C7	0.96	N/A	0.04	Fill of double bowl furnace.	Mid brown sandy clay with moderate charcoal fleck inclusions, soft compaction.
6	C7	0.98	0.6	0.11	Primary fill, formed when the intense heat from the above burning charcoal deposits (C03) caused the oxidisation of the natural clay below.	Mid red/brown sandy clay with moderate oxidised clay fleck inclusions, firm compaction.
7	N/A	0.98	N/A	0.15	Cut of double-bowl furnace.	Figure-of eight shaped cut, no corners sharp break of slope at top gradual sloping sides onto irregular concave base. N–S orientation.
11	C7	0.28	N/A	0.06	Fill of double bowl furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck and slag inclusions, loose compaction.
12	C7	0.2	N/A	0.05	Fill of double bowl furnace.	Dark brown silty sand with frequent charcoal fleck, occ small stone and oxidised clay fleck and slag inclusions, loose compaction.
13	C7	0.35	N/A	0.04	Charcoal fill / burnt deposit of double bowl furnace.	Black sandy silt, 70% charcoal flecks and lumps, occasional slag inclusions.

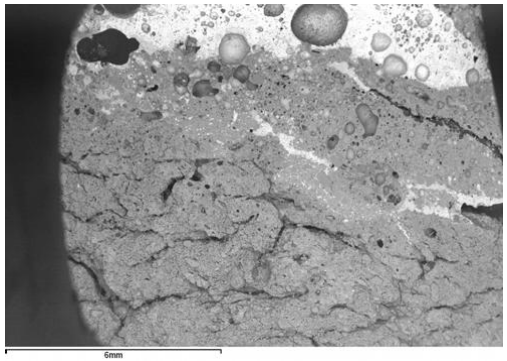
Sample Preparation and Analysis

The samples chosen for SEM-EDAX analysis (SASAA 323.08 and .09) were mounted in resin and ground and polished with 6micron and 3micron diamond pastes. They were subsequently carbon-coated for SEM-EDAX analysis. The sensitivity of the analysis for most elements is 0.2%. Results are normalised (calibrated to 100%). The SEM facility used is a FEI Quanta 200F Environmental SEM. Results are normalised (calibrated to 100%). Quantitative SEM-EDAX analyses are undertaken first on the entire surface of the polished block (area analyses) at different locations within the sample, and subsequently on each of the different mineralogical or glassy phases observed (spot analyses). It is important to report both area and spot analyses, since it is the individual phases that can shed light into the conditions applicable within the furnace, the ore used, and the rates of cooling of the slag. All SEM images reproduced here are BS (backscattered electron) images to reflect sample composition.

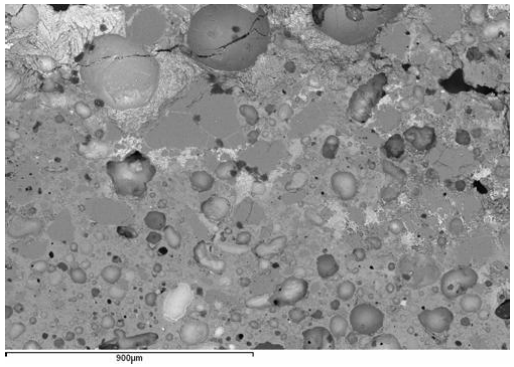
Table 4: table of analyses

SASAA 323.8	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O5	MnO	FeO	BaO	Totals
spot ana on glass -image 2a	2.57	0.05	14.87	36.27	5.86	0.43	4.32	8.37	0.1	0.18	1.3	21.2	4.51	100.03
spot ana on fyalite-image 2a	0.22	0.34	0.24	34.72	0.15	0	0	0.99	0.03	0.1	3.86	59.41	0.06	100.12
spot ana on wustite-image 2a	0.04	0.14	1.14	1.44	0.15	0.27	0.02	0.18	0.21	0	1.88	94.84	0	100.31
area ana on sintered matrix	1.25	1.77	15.07	72.15	0.4	0.09	2.29	0.3	0.49	0	0.28	5.65	0.44	100.18
area ana on clay matrix-image 3	1.31	1.46	15.96	61.19	0.24	0.3	2.12	0.67	0.46	0.29	0.11	15.65	0.12	99.88
spot ana on bright grain-image 6	0.28	0.29	2.81	24.76	2.28	0.09	0.09	0.58	0	0	0.99	67.62	0.03	99.82
spot ana on matrix- image 6	7.48	0.35	3.38	61.14	1.33	0.26	5.82	3.51	0.2	0	0.3	16.28	0	100.05
sppot ana on silica grain-image 7	0.92	0.44	7	82.05	0	0.02	1.89	0.19	0.44	0.04	0	7.25	0	100.24
spot ana -angular grains-image 14	0.16	0.89	0.16	35.18	0.58	0.5	0.05	1.95	0.06	0.06	4.63	55.9	0	100.12
spot ana on dark glass-image 14	2.12	0.11	11.54	41.59	4.19	0.66	2.3	14.8	0	0	0.6	19	3.13	100.04
spot ana on large mass-image 14	0.81	0.06	0.07	22.39	9.45	0.06	0.01	0.77	0	0.26	0.07	66.01	0	99.96
SASAA 323.9	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**P2O5**	**SO3**	**K2O**	**CaO**	**TiO2**	**V2O5**	**MnO**	**FeO**	**BaO**	**Totals**
area ana-image 5	0	0.66	0.19	35.68	1.13	0.1	0	1.66	0.02	0.03	7.39	53.41	0	100.27
spot ana on fayalite	0	0.82	0.48	32.85	1.02	0	0	1.9	0	0	7.7	55.25	0.19	100.21
spot ana on fayalite-image 2	0.48	0.14	0.74	33.43	2.17	0.07	0	2.66	0	0.17	5.98	54.05	0.56	100.45
spot ana on wustite-image 2	0	0	0.86	0.41	0.11	0	0	0.19	0	0.17	2.71	95.56	0.11	100.12
spot ana on ore particle- image 3	0.68	0.31	10.88	14.14	7.52	0.45	0.05	0.23	0	0.13	0.49	64.73	0.46	100.07
image 6 ore next tometallic iron	0.48	0.04	8.27	12.83	6.64	0.55	0.12	0.33	0.16	0.19	0.25	69.66	0.23	99.75
spot ana on barium sulphate-image 7	0	0.07	0.09	0.17	0	26.93	0.09	1.08	0.1	0	0	0.76	70.85	100.14

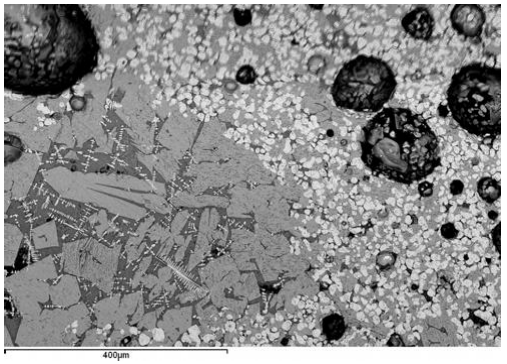
Figure 2a–e: sample 323.08



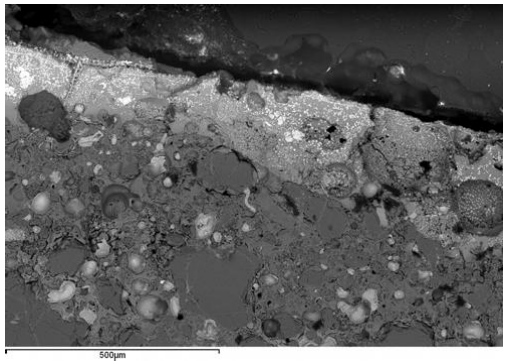
SEM-BS image of a section of 323.08 image 9 showing three distinct areas within this metallurgical ceramic/furnace wall fragment: from surface to interior: slag (bright), well fused ceramic and sintered ceramic fabric



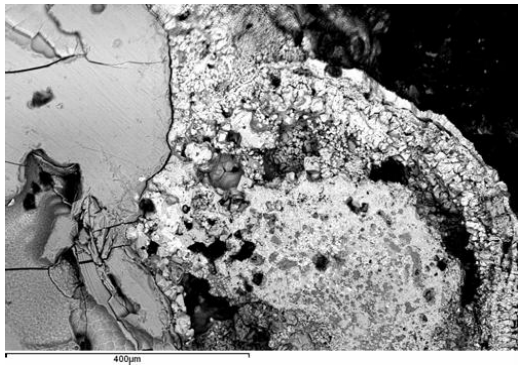
SEM-BS image of a section of 323.08 image 8 showing a close up of the area of sintered ceramic fabric



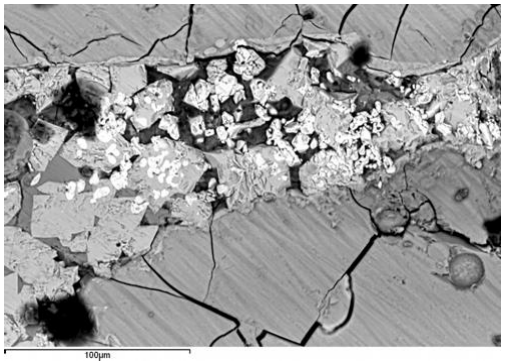
SEM-BS image of a section of 323.08 image 2 showing a close-up of the area of the slag on the surface of the sample; the area consists of dendrites of wustite, narrow needles of fayalite and interstitial glass



SEM-BS image of a section of 323.08 image 6 showing a surface zone rich in fayalite and iron oxides

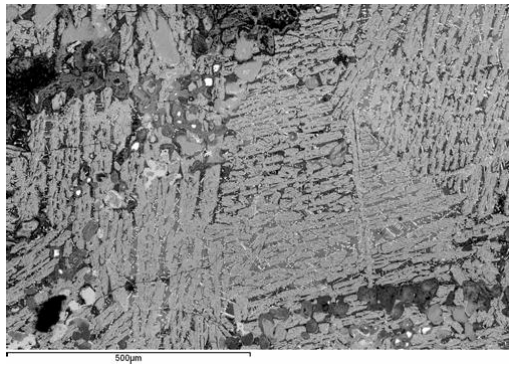


SEM-BS image of a section of 323.08, image 5 showing partially reacted particle of ore on the surface of the ceramic.

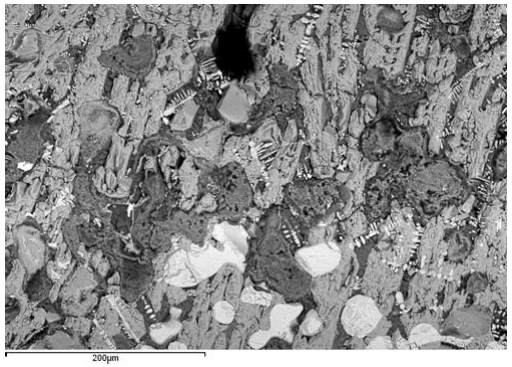


SEM-BS image of sample 323.8, image 14

Figure 3a–e: sample 323.09



SEM-BS image of a section of 323.9 image 5 showing fayalite with sparse iron oxides and interstitial glass



SEM-BS image of a section of 323.9 image 2 close up of image 5; the sample is heavily weathered as can be seen from the rough surface of the mineral grains and the interstitial glass.

SEM-BS image of a section of 323.9 image 3 showing iron ore particle with considerable levels of phosphorus, c. 7%P

SEM-BS image of a section of 323.9 image 8 showing particle of un-reacted/partially reacted ore in the middle of the fayalite needles, wustite and interstitial glass

SEM-BS image of a section of 323.9 image 7 showing bright barium sulphate inclusions

Discussion

The materials

The ore
The ore is of the bog ore variety, namely iron oxy-hydroxides. No particular source is known to the author but it is expected to be available in the immediate vicinity to the site; although there is no physical evidence of ore in the shape of a hand specimen, there is plenty of evidence in small particles thereof trapped within the slag. These particles have partly reacted with fuel/fuel ash. The result is an intermediate non-crystalline phase, alumino-silicates of iron with a high phosphorus content and varying manganese presence, as shown in Figure.3c and 3d and corresponding entries in Table 2.

The slag
The slag, 323.09, is largely an iron silicate of fayalitic composition (an iron silicate). It contains the typical three phases, shown in Figures 3b and 3d, namely fayalite (iron silicate), wustite (iron oxide) and a glass phase. Small inclusions of barium sulphate are also evident Figure 3e. The slag is weathered and the small grain size suggests that it cooled rapidly. This is expected on account of the small dimension of the furnace – no shaft- and the uneven conditions within the primitive bowl. No metallic inclusions are evident.

Furnace/hearth wall
Sample 323.08 was a fragment of furnace/hearth wall, the clayey wall surface having reacted with the ore and charcoal resulting in the 'slagging' of the surface of the wall. This fragment of the wall must have been originally located near the bellow/air supply, which may have sat on C5. There is normally a flat stone to be found between the two furnaces where the bellows would have rested.

The metal
No evidence thereof within the sample analysed.

The charcoal
Pending examination.

The features
In examining the evidence relating to the two features C10 and C7 we make the following observations.

The Figure 8- type of bowl furnace (see Figure 1), as a type of single furnace, has been well reported in many excavations in Ireland. It consists essentially of two bowls, one next to the other. We suggest that the 'Figure 8' accurately represents the cut is however misleading when

referring to it as a bowl furnace typology. We recommend that rather than considering C7 as a single cut/ type of furnace we should consider it as two separate bowl furnaces, using the Figure 8 nomenclature merely for the cut.

Separating the Figure 8-type of furnace in two single furnaces is more than a matter of semantics. Firstly the reported measurements of the L/W/D for the Figure 8 type furnace distort the conventional nomenclature whereupon for every bowl furnace, the ratio of height to width is 1 (H/W=1) and length and width are usually equal. When C7 is seen as two separate furnaces (North and South) with dimensions given in Table 3, then each complies with that general rule (H/W=1). The depth of the cut is shallow. It was reported that there was no evidence for superstructure and we are doubtful there would be any.

Secondly, in order to be certain of the function of each bowl we need to ascertain the temperature regimes within each, since differentiation on the basis of the contents i.e. charcoal, slag and remnants of ore is not very helpful. The same materials are included in both furnaces. At the Iron Age site of Derrinsallagh, Co Laois, we carried out magnetometer survey study of the cut of a dual bowl furnace cluster (SASAA 204.1). We measured the K value (mag susc) at regular points from the exterior of the walls, the base, and the opposite wall, the area between the two bowls, the walls and base of the second furnace. K values were higher in the first furnace than in the second. We extrapolated these K values to Temperatures following experiments on heated soils with no charcoal or other inclusions. The relationship between mag susc and temperature is linear meaning that in the case of the Derrinsallagh furnaces, the first furnace reached higher temperature than the second.

At Derrinsallagh, Co Laois there were clusters of furnaces in groups of two, three, four and even five (SASAA 271). Each furnace has been reported on its own, but part of a cluster of furnaces.

Unless mag susc measurements of the bowl cuts had been carried out, and assuming there was a temperature differential between the two Moyally furnaces we cannot know for certain the function of each. There are a number of options.

A. both bowls were used as small smelting furnaces.
B. One bowl is used for smelting and the other for the ore drying/partial roasting.
C. One bowl is used for smelting the other as the depository of the waste.

We turn now to furnace C10. The shape of the cut is that of a shallow rectangle. It is rectangular in plan. It is not known whether the fragment of the furnace/hearth wall was found in situ, but we suggest that it was originally part of one of the two furnaces in C7 as suggested by its pronounced curvature. These rectangular structures are more often than not associated with bloom smithing and this is how we would interpret C10.

Site

Moyally 2 is a site of two furnaces. There seems to be little associated evidence for occupation /habitation in the immediate vicinity or indeed permanent structures which would have been delineated by the presence of post holes. These furnaces appear as a manifestation of a single industrial 'outburst' in a landscape devoid of any industrial activity. It appears, from the 'distance' of 2000 years that at Moyally 2, an Iron Age man /woman were 'overtaken' by the desire to make iron and sat down to make it.

Since the slag generated is only 1kg and the conditions within the furnace more conducive to generating slag rather than iron, the iron (s)/he would have made would have been minimal, if any at all. Yet as shown at Derrinsallagh, Co Laois, these small furnaces with their sporadic slag reflect a common practice which would have been known to many.

References

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Photos-Jones E, 2007, *Assessment of metallurgical waste along the N6*, SASAA 303.
Wilson L and Photos-Jones E 2006, *Derrinsallagh 4, Co. Laois, Eire, In-Situ Magnetic Susceptibility Data: Preliminary Report*, SASAA 204.1

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SASAA would like to acknowledge the assistance of the following
- Peter Chung, Dept of Earth Sciences, University of Glasgow, Glasgow .
- Staff at IAC Ltd, Ireland

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CHARCOAL IDENTIFICATIONS

N6 KINNEGAD – ATHLONE SCHEME
PHASE 2: KILBEGGAN TO ATHLONE
DUAL CARRIAGEWAY

MINISTERIAL DIRECTION NUMBER: A016/044
NMS REGISTRATION NUMBER: E2672
MOYALLY 2

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Introduction

Three samples were submitted for analysis. The charcoal was sent for species identification prior to ^{14}C dating and also to give an indication of the range of tree species, which grew in the area at the time of use of the site. Charcoal analyses may provide information on the utilization of certain species for various functions. Wood used for fuel at pre-historic sites would generally have been collected at locations close to the site. Therefore charcoal identifications may, but do not necessarily, reflect the composition of the local woodlands. Larger pieces of charcoal, when identified, can provide information regarding the use of a species for certain structural requirements or particular functions.

This site is located in the townland of Moyally, County Offaly, c. 1.5km east of Moate, County Westmeath. The archaeological excavation was carried out by Irish Archaeological Consultancy Ltd on behalf of Westmeath County Council and the National Roads Authority in advance of the construction of the N6 Phase 2: Kilbeggan to Athlone Dual Carriageway Scheme.

Two furnaces containing iron slag in all fills were discovered. The first furnace was an irregular sub-oval shaped bowl furnace measuring 0.28m in length by 0.92m in width. The second furnace, a double bowl furnace was sub-oval in shape and measured 0.98m in length.

One sample analysed was retrieved from C3, a bowl furnace dated to CAL 173–5 BC, the other from C4 dated to Cal 200–10 BC, both Iron Age dates. The pits are all related to industrial activities at the site.

Methods

The process for identifying wood, whether it is charred, dried or waterlogged is carried out by comparing the anatomical structure of wood samples with known comparative material or keys (Schweingruber 1990). The identification of charcoal material involves breaking the charcoal piece along its three sections (transverse, tangential and radial) so clean sections of the wood pieces can be obtained. This charcoal is then identified to species under a Nikon SMZ800 zoom stereomicroscope at magnifications x 10–190 and a transmitted light compound microscope at magnifications of x 10–400. By close examination of the microanatomical features of the samples the species were determined. The diagnostic features used for the identification of charcoal are micro-structural characteristics such as the vessels and their arrangement, the size and arrangement of rays, vessel pit arrangement and also the type of perforation plates. The charcoal samples were identified by weight and fragment count whereby each species was grouped together and a total weight and fragment count was obtained.

Results

Table 1: Results from charcoal identifications

Site Number	Context Number	Context Type	Sample Number	Species	Comment
A016/44	3	Bowl furnace	1	Oak (7g*, 50f*)	Cal 173–5 BC
A016/44	4	Bowl furnace	2	Oak (2.5g, 50f), Ash (0.1g, 1f)	Cal 200–10 BC
A016/44	5	Bowl furnace	4	Oak (3g, 50f) , Ash (0.01g, 1f)	

* = grammes * = fragment count

Discussion & Conclusions

Oak (*Quercus* sp) was the dominant taxon identified from the charcoal remains associated with the Iron Age metalworking activities from bowl furnaces C3, C4 & C5. Two small fragments of ash wood was also identified from the assemblage. The charcoal is related industrial activities and fuel used for the smelting and workings of the ores.

Oak is a dense wood and burns to a high temperature which makes it a very suitable wood for use in smelting activities. It also makes good firewood when dried and will grow in wetland areas when conditions are dry. Oak also has unique properties of great durability and strength. Sessile oak (*Quercus petraea*) and pedunculate oak (*Quercus robur*) are both native to and common in Ireland. The wood of these species cannot be differentiated based on its microstructure. Pendunculate oak is found on heavy clays and loams particularly where the soil is of alkaline pH. Sessile oak is found on acid soils often in pure stands and although it thrives on well-drained soils it is also tolerant of flooding (Beckett 1979, 40–41). Both species of oak grow to be very large trees (30–40m) and can live to an age of about 400 years.

The oak identified suggests that there was a supply of oak in the surrounding environment in the Iron Age and this wood was specifically collected and used in the bowl furnaces associated with metal working activities in the area. Ash was also present in the surrounding environment during the Iron Age.

Further analysis, discussions and comparisons of results will form part of a final integrated charcoal and pollen study of the sites and the surrounding environment on this scheme which is being undertaken as part of the authors PHD thesis. These results will be published accordingly.

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RADIOCARBON DATING RESULTS FOR MOYALLY 2

CHRONO LABORATORY, QUEENS UNIVERSITY BELFAST AND BETA ANALYTICAL, RADIOCARBON DATING LABORATORY, FLORIDA

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Rep. of Ireland
VAT No. IE8288812U

^{14}CHRONO Centre
Queens University
Belfast
42 Fitzwilliam Street
Belfast BT9 6AX
Northern Ireland

Radiocarbon Date Certificate

Laboratory Identification:	UBA-8594
Date of Measurement:	2008-03-18
Site:	A016/44 Moyally
Sample ID:	S1 C3
Material Dated:	Oak Brushwood
Pretreatment:	AAA
Submitted by:	IAC

^{14}C Date: 2076±24
AMS δ^{13}C: -29.3

Information about radiocarbon calibration

```
            RADIOCARBON CALIBRATION PROGRAM*
                      CALIB REV5.0.2
        Copyright 1986-2005 M Stuiver and PJ Reimer
 *To be used in conjunction with:
 Stuiver, M., and Reimer, P.J., 1993, Radiocarbon, 35, 215-230.
          Annotated results (text) - -
          Export file - cl4res.csv
```

```
S1 C3
UBA-8594
Radiocarbon Age BP   2076 +/-   24
Calibration data set: intcal04.14c                  # Reimer et al. 2004
  % area enclosed       cal AD age ranges              relative area under
                                                     probability distribution
  68.3 (1 sigma)      cal BC 152- 138                        0.151
                             113- 49                         0.849
  95.4 (2 sigma)      cal BC 173- 40                         0.999
                             7- 5                            0.001
```

```
 References for calibration datasets:
PJ Reimer, MGL Baillie, E Bard, A Bayliss, JW Beck, C Bertrand, PG Blackwell,
  CE Buck, G Burr, KB Cutler, PE Damon, RL Edwards, RG Fairbanks, M Friedrich,
  TP Guilderson, KA Hughen, B Kromer, FG McCormac, S Manning, C Bronk Ramsey,
  RW Reimer, S Remmele, JR Southon, M Stuiver, S Talamo, FW Taylor,
  J van der Plicht, and CE Weyhenmeyer (2004), Radiocarbon 46:1029-1058.

Comments:
* This standard deviation (error) includes a lab error multiplier.
** 1 sigma = square root of (sample std. dev.^2 + curve std. dev.^2)
** 2 sigma = 2 x square root of (sample std. dev.^2 + curve std. dev.^2)
where ^2 = quantity squared.
[ ] = calibrated range impinges on end of calibration data set
0* represents a "negative" age BP
1955* or 1960* denote influence of nuclear testing C-14

NOTE:  Cal ages and ranges are rounded to the nearest year which
       may be too precise in many instances.  Users are advised to
       round results to the nearest 10 yr for samples with standard
       deviation in the radiocarbon age greater than 50 yr.
```

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.8:lab. mult=1)

Laboratory number: **Beta-249539**

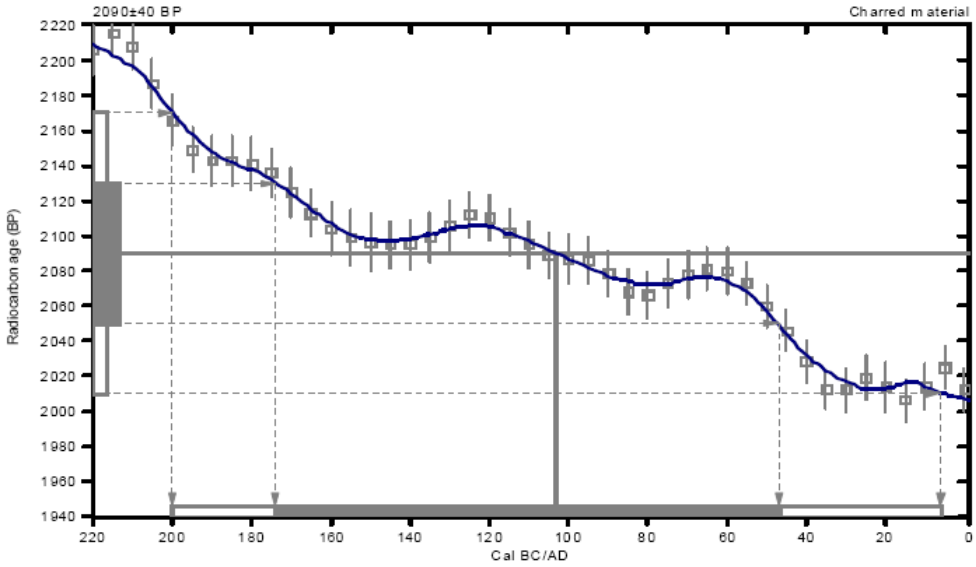
Conventional radiocarbon age: **2090±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 200 to 10 (Cal BP 2150 to 1960)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 100 (Cal BP 2050)

1 Sigma calibrated result: (68% probability) Cal BC 170 to 50 (Cal BP 2120 to 2000)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 249539	2100 +/- 40 BP	-25.8 o/oo	2090 +/- 40 BP

SAMPLE : E2672C4S4
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 200 to 10 (Cal BP 2150 to 1960)

APPENDIX 3 LIST OF RMP SITES IN THE AREA

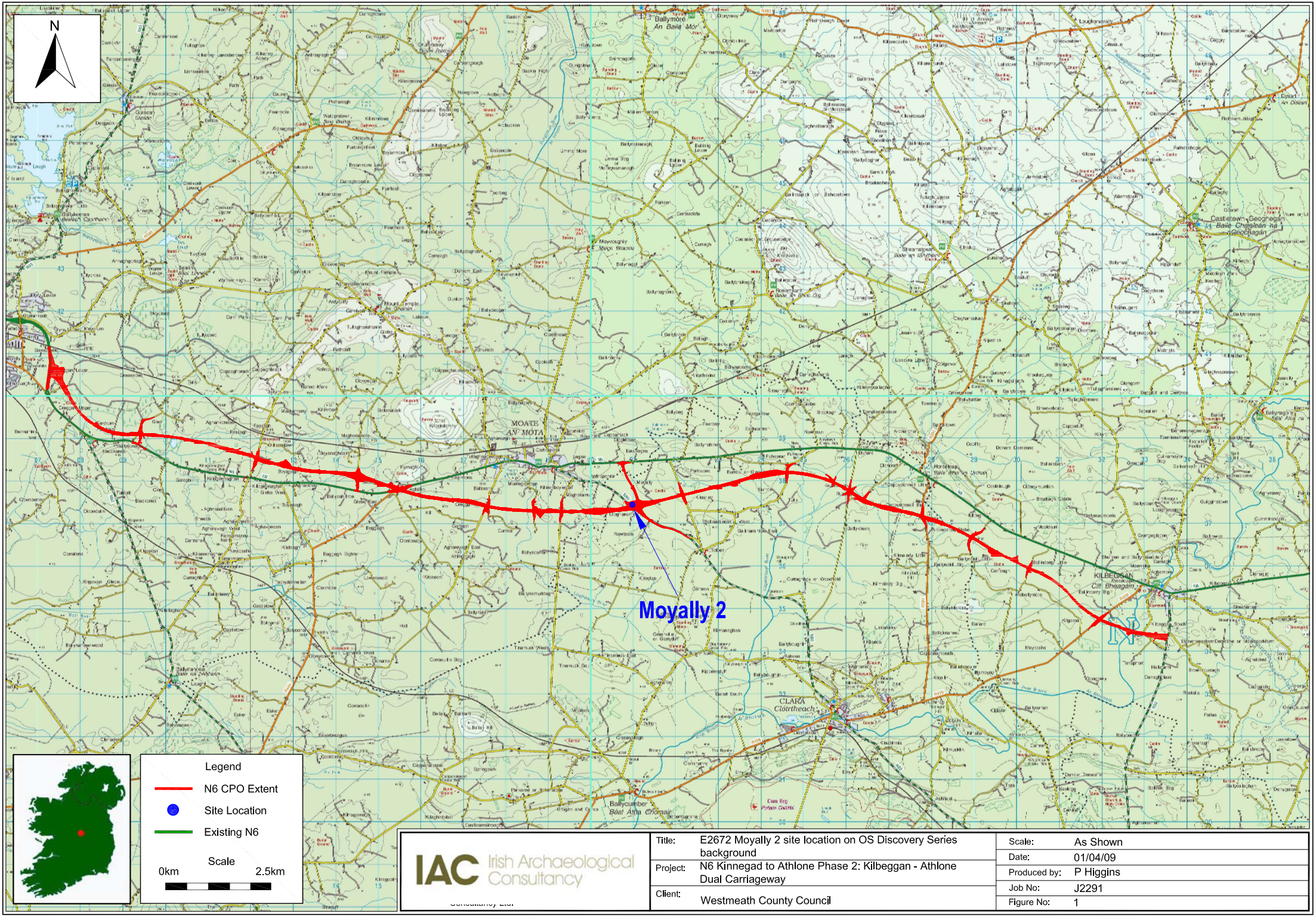
RMP No	Description
WM030-114	Enclosure site
WM030-115	Ringfort - Rath
OF001- 00201	Tower house and bawn
OF001- 00202	Earthworks
OF001-003	Mound (possible)
OF001-004	De-listed
OF001-005	Enclosure

See Figure 2 for location.

APPENDIX 4 LIST OF N6 SCHEME SITE NAMES

Site Name	Ministerial Direction No.	NMS Registration Number
Seeoge 2	A016/007	E2635
Moyally 7	A016/015	E2643
Kilcurley 1	A016/019	E2647
Cappydonnell Big 1	A016/025	E2653
Ardballymore 2	A016/028	E2656
Creggan lower 1	A016/030	E2658
Creggan lower 2	A016/031	E2659
Williamstown 1	A016/032	E2660
Williamstown 3	A016/033	E2661
Williamstown 4	A016/034	E2662
Boyanaghcalry 1	A016/035	E2663
Seeoge 1	A016/036	E2664
Aghafin 1	A016/037	E2665
Cregganmacar 1	A016/038	E2666
Cregganmacar 2	A016/039	E2667
Cregganmacar 3	A016/040	E2668
Curries 1	A016/041	E2669
Curries 2	A016/042	E2670
Culleenagower 1	A016/043	E2671
Moyally 2	A016/044	E2672
Moyally 1	A016/046	E3274
Moyally 3	A016/047	E2674
Moyally 5	A016/048	E2675
Moyally 6	A016/049	E2676
Tober 1	A016/051	E2677
Burrow or Glennanummer 1	A016/052	E2678
Burrow or Glennanummer 2	A016/053	E2679
Burrow or Glennanummer 3	A016/054	E2680
Russagh 4	A016/055	E2681
Russagh 1	A016/056	E2682
Russagh 2	A016/057	E2683
Russagh 3	A016/058	E2684
Kilbeg 1	A016/059	E2688
Kilbeg 2	A016/060	E2689
Kilbeg 4	A016/062	E2691
Kilbeg 5	A016/063	E2692
Kilbeg 6	A016/064	E2693
Kilbeg 7	A016/065	E2694
Correagh 1	A016/066	E3374
Ballinderry Little 1	A016/067	E2695
Ardballymore 1	A016/068	E2696
Kilgaroan 1	A016/069	E2697
Kilgaroan 2	A016/070	E2698
Kilgaroan 3	A016/071	E2699
Kilgaroan 4	A016/072	E2700
Kilgaroan 6	A016/074	E2702
Ballinderry Big 1	A016/076	E3275
Ballinderry Big 2	A016/077	E3276
Ballinderry Big 3	A016/078	E3277
Tonaphort 1	A016/079	E3278
Tonaphort 2	A016/080	E3279
Tonaphort 3	A016/081	E3280

Site Name	Ministerial Direction No.	NMS Registration Number
Kilbeggan South 1	A016/082	E3281
Kilbeggan South 2	A016/083	E3282
Kilbeggan South 3	A016/084	E3283
Cregganmacar 4	A016/085	E2703
Williamstown 2	A016/086	E2704
Kilbeg 8	A016/087	E3966



IAC Irish Archaeological Consultancy

Title:	E2672 Moyally 2 site location on OS Discovery Series background
Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway
Client:	Westmeath County Council

Scale:	As Shown
Date:	01/04/09
Produced by:	P Higgins
Job No:	J2291
Figure No:	1

N

CLOGHBANE

CAPPANTACK

LEGAN
(ED MOATE)

FEARBOY

BALLYNAHINCH

BAWNOGES

MOYALLY

PARKWOOD

ARDNAPONRA

MOYALLY

KILLENBOYLEGAN

MAGHERAMURRY

MOYALLY
Maigh Eille

KILCURLEY
Cill Choirill

CULLEENAGOWER
CULLEENAGOWER

CLOGHANAMINA
Tulcháin na Muimhneach

TOBER
An Tobar

NEWTOWN
Dúchoill
ED GORTEEN
An Goirtín

BALLINAM
Béal Átha

OF001-001

WM30-114

WM30-115

Moyally 1 A016/046

OF001-003

Moyally 2

Moyally 3

Moyally 4

Moyally 5

Moyally 6

Moyally 7

OF001-002

Kilcurley 1

Tober 1

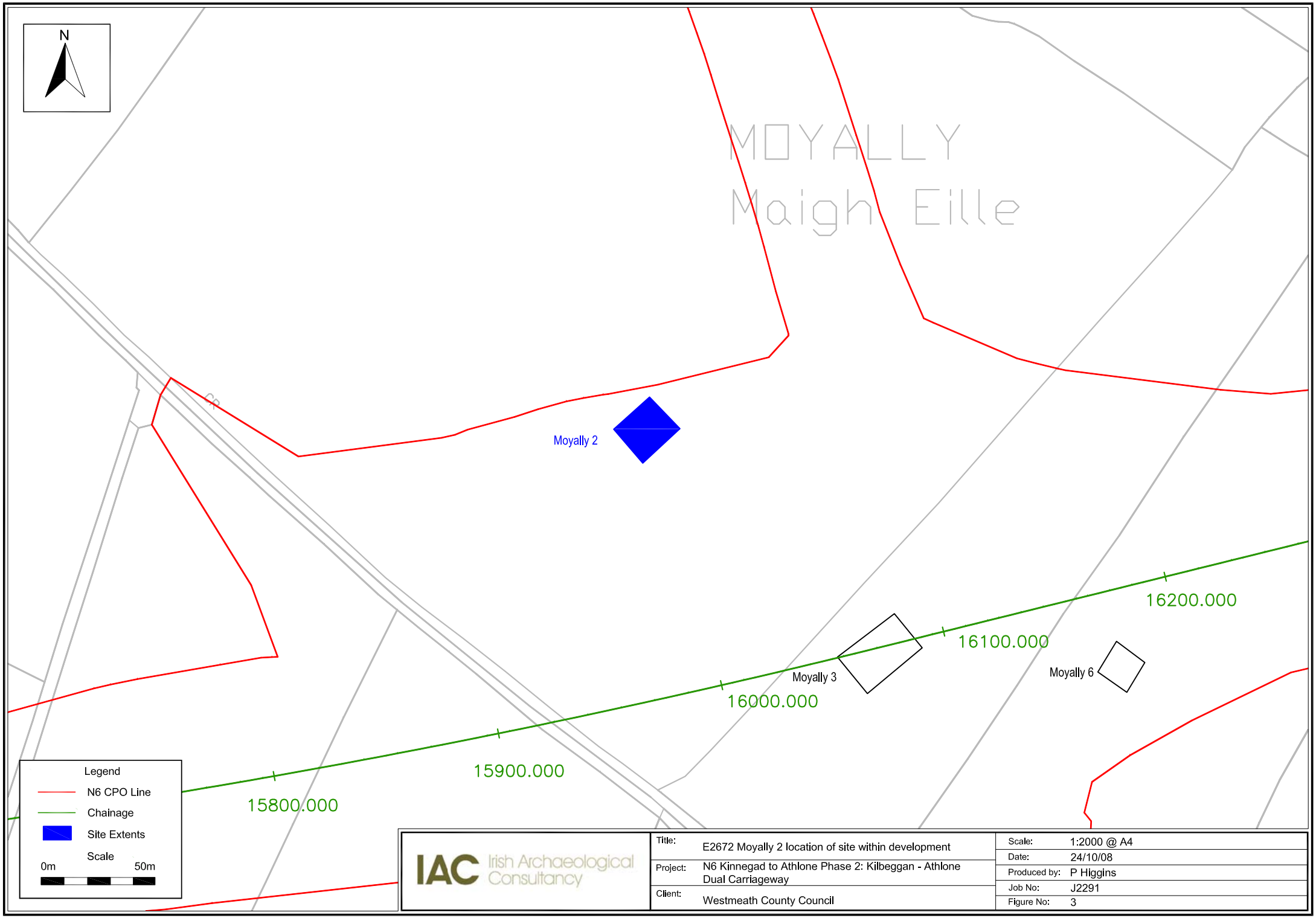
Culleenagower 1

OF001-005

OF001-004
DE-LISTED

Legend
N6 CPO Line
RMPs
Scale
0m 250m

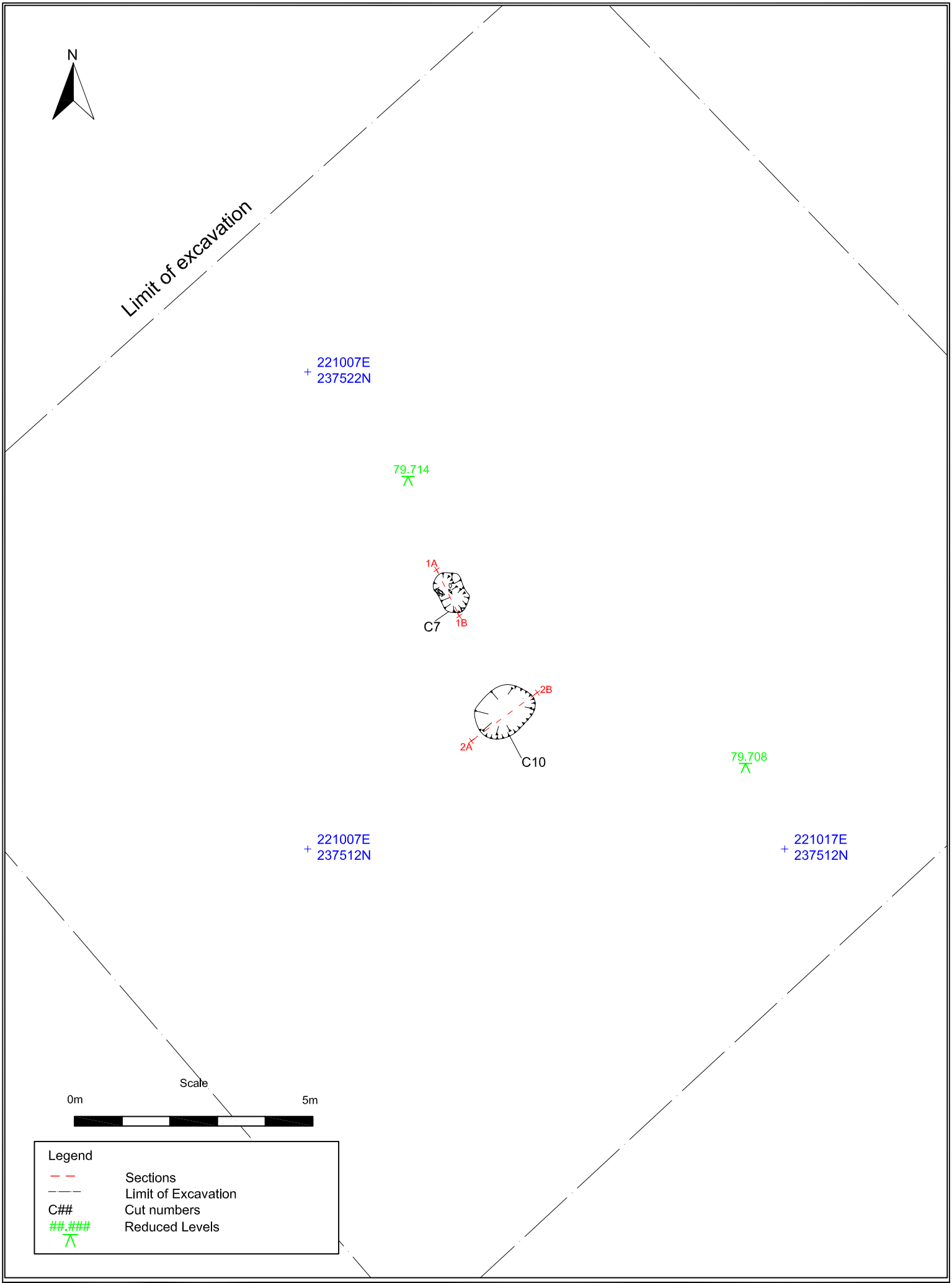
Title:	E2672 Moyally 2 showing RMPs with OS background		
Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway		
Client:	Westmeath County Council		
Scale:	1:10000 @ A3	Job No: J2291	IAC Irish Archaeological Consultancy
Date:	23/10/08	Figure No: 2	
Produced by:	P Higgins		



IAC Irish Archaeological Consultancy

Title:	E2672 Moyally 2 location of site within development
Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway
Client:	Westmeath County Council

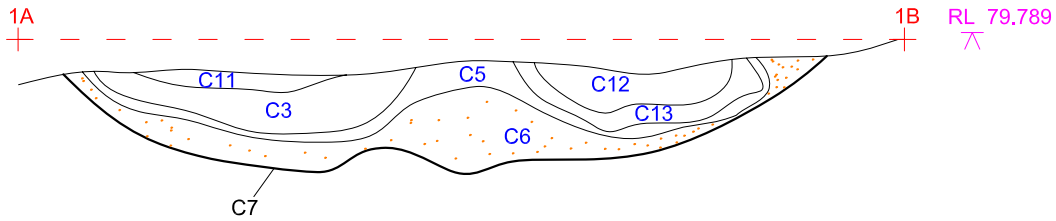
Scale:	1:2000 @ A4
Date:	24/10/08
Produced by:	P Higgins
Job No:	J2291
Figure No:	3



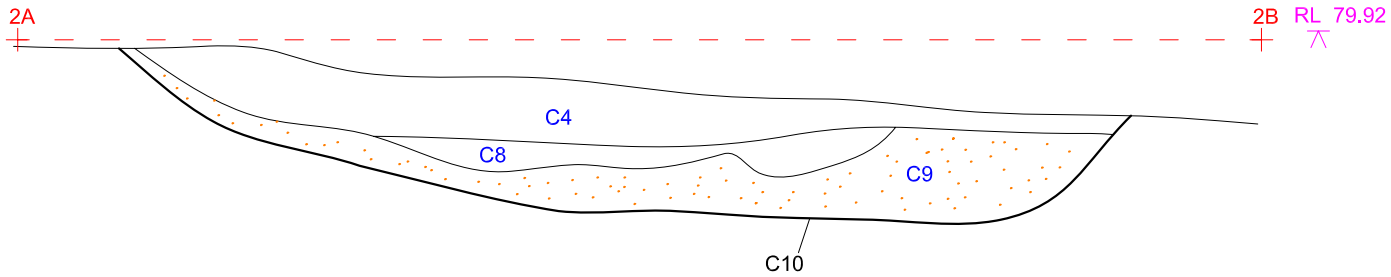
IAC Irish Archaeological Consultancy

Title:	E2672 Moyally 2 post-excavation plan
Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway
Client:	Westmeath County Council
Scale:	1:100 @ A4
Date:	24/10/08
Produced by:	G Kearney
Job No:	J2291
Figure No:	4

Moyally 2
Southwest Facing Section of C7



Moyally 2
Southeast Facing Section of C10



Scale

0m 0.5m

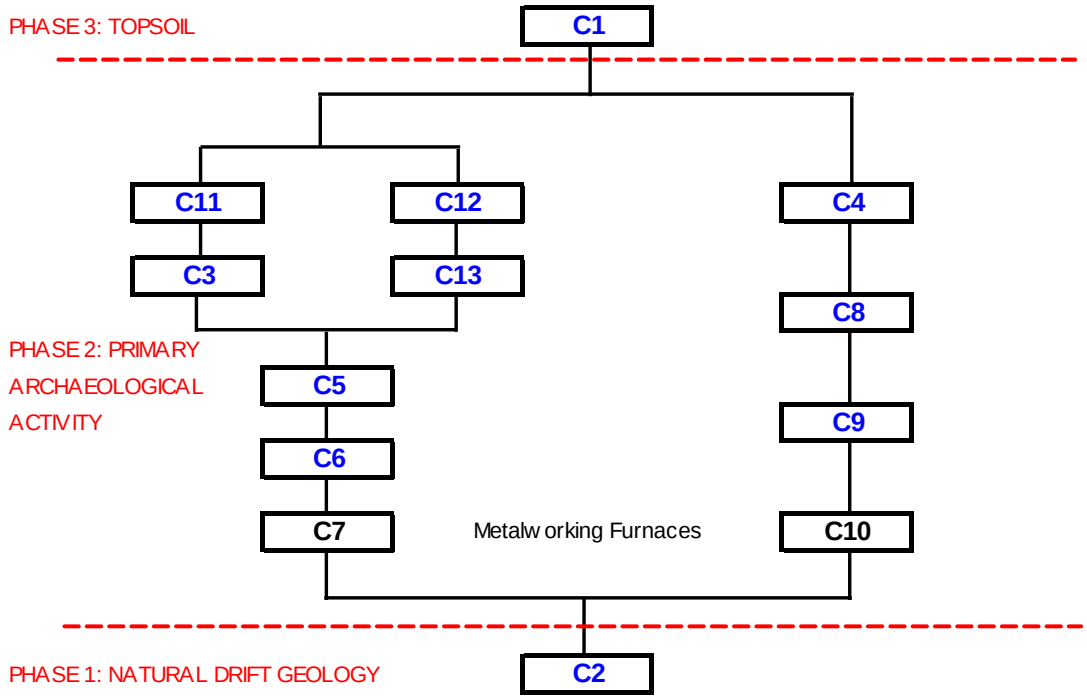
Legend

° ° °	Oxidised clay
C##	Cut numbers
C##	Fill Numbers
###.##	Reduced Levels

IAC Irish Archaeological Consultancy

Title:	E2672 Moyally 2 sections
Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway
Client:	Westmeath County Council

Scale:	1:10 @ A4
Date:	24/10/08
Produced by:	G Kearney
Job No:	J2291
Figure No:	5



CXXX = SPREADS AND FILL CONTEXTS
CXXX = CUT CONTEXTS

IAC Irish Archaeological Consultancy	Title:	E2672 Moyally 2 matrix	Scale: N/A
	Project:	N6 Kinnegad to Athlone Phase 2: Kilbeggan - Athlone Dual Carriageway	Date: 25/03/09
	Client:	Westmeath County Council	Produced by: G Kearney
			Job No: J2291
			Figure No: 6