

APPLICATION NUMBER 324429
CUNLAGHFADDA GREEN ENERGY LTD.
110kV SUBSTATION

TO: An Coimisiún Pleanála
64 Marlborough Street
Dublin 1
D01 V902
Submitted via online portal

PLANNING REFERENCE:

Cunlaghfadda Green Energy Ltd.
SID Planning Application for 110kV Substation, Loop-In Grid Connection, and
Associated Infrastructure and Works in the townland of Cloonbaul, Co. Mayo

Submitted by:

Elizabeth Anthony Nestor, Knockroe, Mayo Abbey, Claremorris, F12 D326

Dear Sir or Madam:

As a resident of the Mayo Abbey area directly affected by the above-referenced application, I wish to lodge a formal objection to this proposal. While I support the development of and transition to sustainable, non-fossil fuel-based energy, this particular development raises grave concerns regarding its suitability for the proposed location.

Background

I am a recent arrival to the area, having moved here from the United States with my husband, who is a local native. He is from Barreel, a townland adjacent to Knockroe, and he has always been firm in his desire to settle together in Mayo Abbey. His family goes back for generations in the immediate area, as evidenced by his father's immediate family coming from the townland of Ballinaster, which shares the Irish root of our family name ([Baile an Astair/Ballinaster | logainm.ie](#), [Irish Surname Index | dúchas.ie](#)). We moved to our current house in Knockroe (house 90 on EIAR Ch. 5 figure 5-3) in 2020 and have found a home in the tight-knit community that is Mayo Abbey.

1. Improper Project Splitting

Basis of objection: Project Splitting for the purpose of avoiding comprehensive assessment is contrary to law, and the proposed development is part of a larger industrial-scale electrical infrastructure project, which to date includes three known elements:

- A. Cunlaghfadda Wind Farm, Mayo County Council Application No. 2660398 and ACP Appeal Case No. 501853;
- B. 110kV Substation, Loop-In Grid Connection, and Associated Infrastructure and Works, ACP Application Case no. 324429 (the proposal currently before An Coimisiún Pleanála); and
- C. Battery Energy Storage System (BESS) Compound and Associated Infrastructure and Works, Mayo County Council Application No. 2660653.

The applicant for all three proposals is Cunlaghfadda Green Energy, Ltd., and the proposed works are interconnected elements as indicated in the application materials for all three projects.

The seven-turbine Wind Farm (Project A) was the first project submitted, and planning permission for that project has been refused by Mayo County Council. Without the Wind Farm (Project A), the Substation (Project B) and BESS Compound (Project C) have no standalone justification, either independently or in combination, and neither should be considered in isolation from the overall project.

The EIAR and Natura Impact Statement documentation for the Wind Farm (Project A) and the Substation (Project B) references both projects throughout, and both are listed in the Table of Contents, Section 4.4 Proposed Project Components:

Wind Farm (Project A)



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Substation (Project B)



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The documentation for Project C is substantially similar, and references both the Wind Farm (Project A) and the Substation (Project B), again demonstrating that the overall project includes all three elements.

BESS (Project C)



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The Applicant treats the wind farm and grid connection, including the proposed on-site substation, underground cabling and end masts, as part of the overall project. If that is correct, then the developer has already characterised the wind farm and its electrical connection as one integrated project.

Therefore, the Substation (Project B) before you for consideration is not a freestanding piece of public infrastructure with a demonstrated independent need. It is designed as an enabling element of the seven-turbine wind farm project (Project A), permission for which has been refused.

Moreover, the Applicant's strategy of splitting the application into multiple elements in order to avoid assessment of the overall project is contrary to findings in law, see O'Grianna v. An Bord Pleanála (2014) etc., and common sense. Additionally, this strategy appears to intentionally raise both logistical and financial barriers to the submission of observations by concerned parties, which is profoundly inequitable.

Requested remedy: Prior to approval of any planning application An Coimisiún Pleanála must assess the complete project, not individually carved-out elements that may come before it as individual applications or appeals.

2. Cultural/Heritage/Historic Value and Archaeological Sensitivity

Basis of objection: The proposed development lies within an area rich in Medieval and earlier settlement activity that has recently begun to be explored and documented. The potential irrevocable loss of a concentration of historic evidence, fabric, and artefacts of national and international interest dating as far back as the Neolithic period is gravely concerning.

In 2022 I joined the Mayo Abbey Heritage Committee. I am a heritage preservation professional by training (MS in Historic Preservation, University of Pennsylvania) and was delighted to discover that I had inadvertently settled in a relatively unpublicised, but critically historically important center of medieval settlement and culture. In 2023 the committee submitted a successful funding application to the Heritage Council, and with the funds awarded undertook a preliminary LiDAR survey to establish the existence of medieval and earlier settlement patterns in the immediate vicinity of Mayo Abbey village. The findings were far richer than anticipated, and our goal is to continue the research in future years. *See Appendix 1: Mayo Abbey Heritage Committee LiDAR Report, 2023.*

The works proposed in the current application would destroy a documented Neolithic site. *See Appendix 2: Mayo-Galway Gas Pipeline, Kilbride Report, 2008.*

Neither of these reports nor their findings are referenced in the application. This suggests either, at best, a lack of detailed research into the value of the area, or worse, an intentional understatement or omission of the same. In either case, the application fails to address and protect the significant documented and undocumented heritage value of Mayo Abbey village, its hinterlands, and the specific sites proposed for the works.

Moreover, Mayo County Council has already found that the Wind Farm (Project A) would undermine the setting of Mayo Abbey Cemetery and Church ruins, described as a very important early Christian ecclesiastical site. Therefore, it is not only the village that must

be protected, but the wider area and its heritage landscape. It is critical that An Coimisiún Pleanála assess not only direct physical impact (destruction of known and unknown cultural and heritage assets), but also the severe impact on setting, character, approach, views and cultural landscape that this project and each of its elements will render on this culturally significant area.

Requested remedy: Prior to approval of any planning application or site disruption, further studies must be undertaken to confirm local knowledge, citizen science, and previous research. Until such research is completed by unbiased third parties and/or agencies, the Precautionary Principle must apply. Upon completion of such research, any finds must be protected by preservation in situ.

3. *Material Planning History*

Basis of objection: Mayo County Council has rejected the planning permission application for the seven-turbine Wind Farm (Project A) that would generate the power to be managed by the Substation (Project B). While this does not render the Substation application invalid, the reasons for rejection must be taken into account.

A. Mayo County Council has found the wider location unsuitable for major energy infrastructure

The refusal states that the development site is in an “open, exposed, populated rural area” and within Policy Area 4 of the landscape sensitivity matrix, with “high to medium potential to create adverse impacts on the existing landscape character.”

The substation and its associated works - compound fencing, transformers, gantries, lighting, end masts, cable works, access roads and earthworks - is also industrial infrastructure. The fact that it is lower than a turbine does not remove the planning problem as it sits within the same sensitive landscape envelope.

B. Mayo County Council has identified a serious heritage and setting issue

The refusal states that the proposed development would:

- “detract from the existing cultural heritage of the area”;
- “undermine the setting of Mayo Abbey Cemetery and Church ruins”;
- and adversely affect the “unique rural character of the immediate local area”.

Although less visually dominant than turbines, the proposed Substation and its associated works will damage the setting of this important ecclesiastical site. As the proposed Substation lies within the same visual catchment, approach, and setting as the Wind Farm (Project A), An Coimisiún Pleanála must engage with that earlier finding.

C. Mayo County Council has already found that the area is heavily constrained by nearby dwellings

Mayo County Council found that the extent of technology required to address shadow flicker for 40 residential properties showed the site was unsuitable for a wind farm of that nature and scale because of the level of surrounding residential development.

Therefore, Substation-specific effects that must be considered in the context of the populated rural area's residential amenity and human health include, but are not limited to:

- transformer hum or tonal noise;
- night-time low background noise sensitivity;
- security lighting;
- industrialisation of outlook;
- construction disturbance;
- traffic and abnormal load impacts.

D. Landscape, visual impact, and conflict with local policy

There is an existing planning finding that the location is in a sensitive landscape and affects a scenic route with a protected view. This is relying upon a recent formal decision that this is a landscape where major energy infrastructure causes unacceptable harm.

This finding should render the Substation application unacceptable due to

- the open and exposed nature of the receiving environment;
- the industrial character of the proposed compound;
- the visual effect of fencing, transformers, gantries, lightning protection, poles, end masts, lighting and access works;
- cumulative visual impact with any associated overhead infrastructure or cable terminal structures;
- visibility from public roads, scenic routes, protected views, the Abbey area, cemetery, church ruins and nearby dwellings.

In a protected rural and heritage-sensitive setting, even lower infrastructure can have a disproportionate effect. As outlined in C, above, the Substation on its own would create an unacceptable disturbance to the area and destruction of residential amenity. In combination with the Wind Farm and the BESS, it becomes a full-scale industrialization of a populated rural area.

4. Ecology

Basis of objection: The ecological value and sensitivity of the bogland, farmland, woodland, and waterways in which the proposed development is sited appear to be understated in the application.

Another benefit of living here is quiet enjoyment of the peaceful countryside. Unless a storm is blowing, our nights are silent. The dark skies have revealed any number of astronomical wonders, including the Aurora Borealis experiences of 2024. My interest in

nature is lifelong, but since coming to Knockroe I have become more curious and knowledgeable about the flora and fauna that surround us. In our own garden we have identified over 25 species of birds, including snipe (16 Feb 2021), Barn Owl (2025), and sparrowhawk (15 April 2026 and earlier). Irish Hare are regular garden visitors. From my first days here during the Covid pandemic, I took to countryside walks and exploring the bog – the site of the proposed development. I was disturbed the first time I saw Japanese Knotweed in the bog, as it's a scourge where I came from and I am acutely aware of the danger it poses to native flora. On my bog walks I've seen Devil's Bit Scabious (20 Aug 2024), which I understand is a primary food source for the critically endangered Marsh Fritillary butterfly. My knowledge of the affected ecologies is scant compared to that of my neighbors who've lived here for decades, but I believe my concerns that sensitive environmental issues are poorly investigated, minimized, and/or ignored within the application are legitimate and worthy of An Coimisiún Pleanála's consideration.

Requested remedy: Further studies must be undertaken to robustly verify information presented in the application and confirm local knowledge and citizen science. Until such research is completed by unbiased third parties and/or agencies, the Precautionary Principle must apply.

5. Human Health/Residential Amenity

Basis of objection: Significant missing data for shadow flicker, the omission of any data related to microplastics emissions due to Leading Edge Erosion, and questionable health research credentials of the writers of the population and human health report call into question the quality of human health data presented.

Missing Shadow Flicker Data

Section 5.2.3.5 of EIAR Chapter 5 states that “there are 90 sensitive receptors” (also known as houses and homes) that fall within the shadow flicker study area:

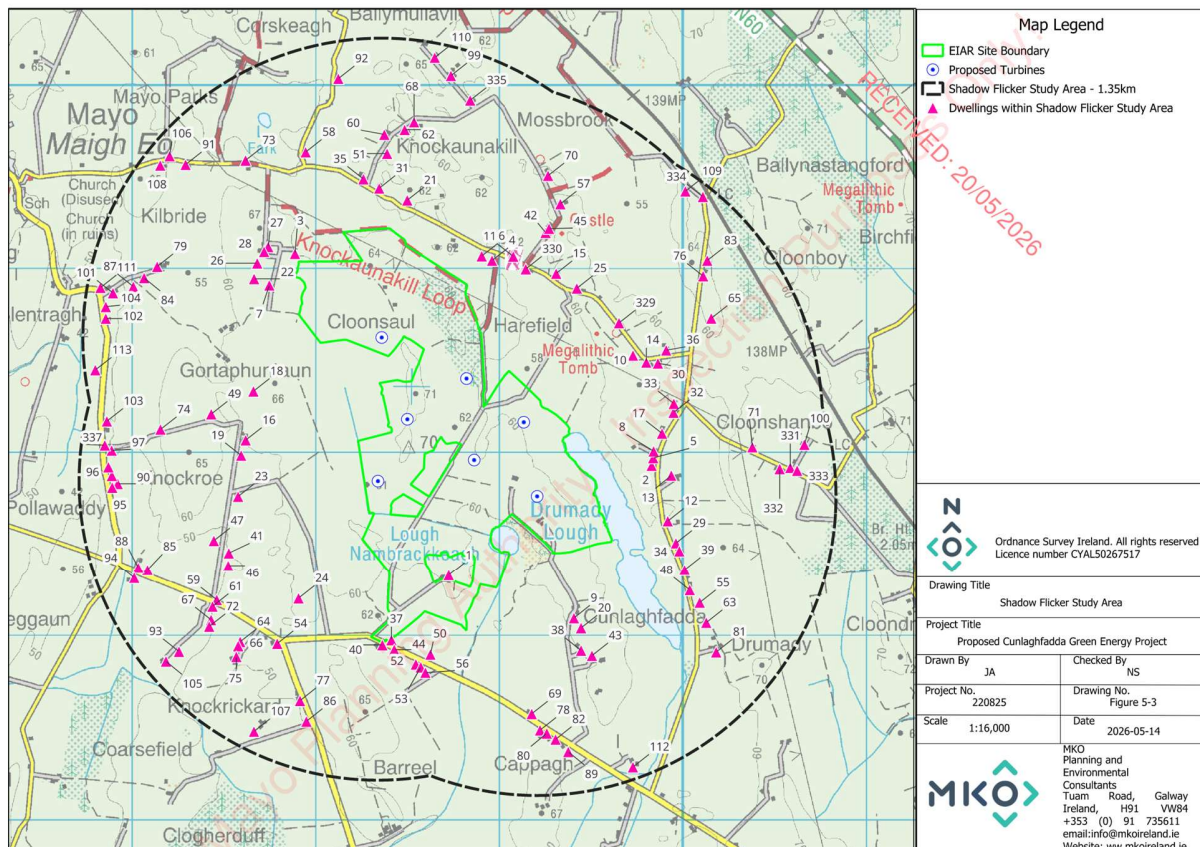
There are 90 sensitive receptors located within Shadow Flicker Study Area, 1.36 kilometres (10 x 136m rotor diameter) of the proposed turbine locations as shown in Figure 5-3 below. For the purposes of the shadow flicker assessment, all sensitive receptors within the Shadow Flicker Study Area were identified and mapped. In addition, a planning history search to identify properties that may have been granted planning permission, but have not yet been constructed, was carried out. Any property with a valid planning permission/application for a dwelling was also added to the sensitive receptor dataset. The Shadow Flicker Study Area and sensitive receptors' locations are shown in Figure 5-3, with all properties detailed in Table 5-9 in Section 5.4.1 below.

The shadow flicker study area presented in Figure 5-3 shows house IDs within 1.36 km of the turbine locations ranging from 1 to 113 (Dwellings) and 329 to 337 (Derelict), as indicated by the magenta triangles on the figure. Of these, two triangles – adjacent to IDs 53 and 90 – are not numbered. Additionally, ID numbers 98 and 336 are missing from the figure.

Contrary to the above statement, 130 sensitive receptors were identified and, presumably, studied. Shadow flicker data are not presented for 38 of these sensitive receptors. This omission includes any dwellings numbered between 88 and 113 (25 of 113, or 22%) and derelict structures numbered 321-328, 331, and 333-337 (13 of 17, or 83%), all of which are indicated within the study area illustrated in Figure 5-3 as shown below.

Consequently, occupants/owners of those properties are unable to assess their vulnerability to calculated potential shadow flicker. My own house is labeled as ID 90 on the EIAR Ch. 5 Shadow Flicker Study Area, Fig. 5-3, data for which is excluded from the presented study results in Table 5-9 (page 4 of 4), below.

EIAR Vol. 3 Chapter 5 - Figure 5-3 Shadow Flicker Study Area





74	527120	778142	Dwelling	1219	T1	00:26:00	03:19:00	06:40:39	T1, T2, T7
75	527534	776901	Dwelling	1232	T1	00:00:00	00:00:00	00:00:00	N/A
76	530080	778977	Dwelling	1262	T4	00:25:00	10:59:00	02:41:05	T4
77	527881	776662	Dwelling	1272	T1	00:00:00	00:00:00	00:00:00	N/A
78	529190	776502	Dwelling	1276	T5	00:00:00	00:00:00	00:00:00	N/A
79	527102	779029	Dwelling	1284	T7	00:24:00	08:11:00	02:00:01	T7
80	529227	776485	Dwelling	1294	T5	00:00:00	00:00:00	00:00:00	N/A
81	530151	776926	Dwelling	1296	T5	00:00:00	00:00:00	00:00:00	N/A
82	529275	776452	Dwelling	1329	T5	00:00:00	00:00:00	00:00:00	N/A
83	530102	779062	Dwelling	1333	T4	00:24:00	10:51:00	02:39:08	T4
84	527031	778067	Dwelling	1336	T7	00:23:00	07:12:00	01:45:36	T7
85	527049	777375	Dwelling	1348	T1	00:24:00	11:12:00	02:44:16	T1
86	527916	776550	Dwelling	1367	T1	00:00:00	00:00:00	00:00:00	N/A
87	526972	778920	Dwelling	1383	T7	00:00:00	00:00:00	00:00:00	N/A
329	529620.8	778721.7	Derelict	750	T4	00:52:00	13:58:00	21:00:51	T2, T3, T4, T6, T7
330	529112.5	779015.5	Derelict	679	T6	01:23:00	07:49:00	01:22:39	T2, T6, T7
332	530497.1	777927.2	Derelict	1331	T5	00:21:00	05:48:00	01:25:04	T5

The omission of 29% of the studied structures, even should the projected impact on them be zero, demonstrates either a lack of attention to detail or an intentional omission on the part of the Applicant. In either case, the validity of the application is called into question.

Microplastics/BPA

The application states that no emissions will be generated by the operations of the wind farm. This neglects to mention the inevitable coating loss and associated health risks. Moreover, the models in the attached study assume a monthly rainfall of 50 mm, which is far lower than that experienced in this location. Microplastics and the associated BPA – a neurotoxin and endocrine disruptor, which is a constituent of the epoxy coatings used on turbine blades – are detrimental to the wellbeing of both humans and livestock. See *Exhibit 3: Leading Edge Erosion and Pollution from Wind Turbine Blades, 2021*.

Report Writers' Credentials

It appears that the writers of the population and human health report have no formal education in healthcare, epidemiology or medicine. Moreover, their selection of publications appears biased, including publications sponsored by organizations with a conflict of interest in terms of health impact from wind turbines. Consequently, their assessment of “no significant health impact” is called into question and should not be accepted at face value.

Requested remedy: Prior to rendering any decision on the application, An Coimisiún Pleanála must critically assess the submitted documentation for errors, omissions, and biases. Further assessments must be undertaken by unbiased third parties and/or agencies. Until such reviews are completed, the Precautionary Principle must apply.

6. Application Process/Validity/Quality

Basis of objection: Factual errors and other flaws in the application process and documents raise concerns as to the accuracy and validity of the application as a whole.

Regarding the application itself, the documents demonstrate inaccuracies and significant missing data. The examples below are not meant to be an exhaustive list, but rather indicative of concerning levels of one or more of the following: incomplete research, lack of detail in preparation, or intentional omission of material facts.

A. Inaccurate Information - Basis of Application

At the time of applying for the Wind Farm (Project A), the Applicant stated that the site falls within Mayo County Council's *Tier 1 (Preferred) - Cluster* guidelines, defined as follows:

6.4.1 Wind Energy

On-shore wind energy

Map 1 Wind Energy classifies potential areas for on-shore wind energy development. There are 4 classifications identified:

- **Priority Areas** are areas which have secured planning permission and where on shore wind farms can be developed immediately.
- **Tier 1 - Preferred (Large Wind Farms)** are areas in which the potential for large wind farms is greatest.
- **Tier 1 - Preferred (Cluster of Turbines)** are areas identified as being most suitable for smaller clusters of wind turbines (clusters of up to three to five turbines depending on site conditions and visual amenity).
- **Tier 2 - Open for Consideration** identifies areas which may be considered for wind farms or small clusters of wind turbines but where the visual impact on sensitive or vulnerable landscapes, listed highly scenic routes, scenic routes, scenic viewing points and scenic

According to Mayo County Council RES 2011-2020, such a small cluster would accommodate up to **three to five** turbines. The current application is for seven turbines, exceeding the planned cluster size by ~30% to 60%.

Although the newest guidance approved by Mayo County Council in July, 2026 removed the cluster turbine count reference, this documentation indicates a lack of attention or an intentional violation of guidelines in place at the time of application. Thankfully, the permission for this element of the project has been rejected.

B. Inaccurate Information – Consideration of Reasonable Alternatives (Non-Technical Summary p. 8)



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The Applicant, Cunlaghfadda Green Energy Ltd. is an Irish owned developer with extensive experience in the design, construction and operation of onshore wind energy developments throughout Ireland. The Applicant is committed to playing a key role in helping the State achieve its CAP25 objectives while building upon its proven record of generating clean renewable energy to the national grid. As such, the option of an offshore project is not considered to be a reasonable alternative at this time.

The statement that the applicant has experience with onshore developments only, and offers no further rationale as to why an offshore project is not considered to be a reasonable alternative, does not justify dismissing that alternative out of hand.

C. Inaccurate Information – Scoping and Consultation (Non-Technical Summary pp. 6-7)

The Applicant implies that they have undertaken a comprehensive engagement campaign with the local community, as detailed below:

Scoping and Consultation

An EIAR scoping document, providing details of the Proposed Project, was prepared by MKO and circulated in May 2023. The scoping document provided details of the Proposed Project and set out the scope of work for the EIAR. Consultees were invited to contribute to the EIAR by suggesting baseline data, survey techniques and potential impacts that should be considered as part of the assessment process and in the preparation of the EIAR. A revised scoping exercise was carried out in February 2026 due to time elapsed from when previous scoping was carried out, updates in local and national policy and legislation, updates in relevant EIAR guidance, changes in the environmental baseline and refinement of the Proposed Project layout and design. Consultees were invited to contribute again to the EIAR, following these changes.

Pre-planning meetings were undertaken with MCC under the provisions of Section 247 of the Planning and Development Act 2000, as amended ('the Planning Act'), and ACP under the provisions of Section 182E of the Planning Act. A letter received from ACP dated the 4th of July 2024 stated that under Section 182E, it is the opinion of ACP that the Proposed Grid Connection falls within the scope of the Section 182A of the Planning Act. This confirmed that the Proposed Grid Connection constitutes Strategic Infrastructure Development and therefore the planning application should be made directly to ACP.

Community engagement has been undertaken by the Applicant, details of which can be found in Appendix 2-2 of the EIAR. The consultation process has been an extremely valuable exercise and has provided a detailed, and enhanced understanding of the key issues and concerns of the local community. There is currently on-going consultation with the local community, and it is the intention of the Applicant to continue with the consultation for the entire lifespan of the Proposed Project. The development of the Proposed Project will provide an enduring economic benefit to the communities surrounding the Proposed Project, through the community benefit package for residents and community groups, employment during the construction and operation of the Proposed Project and through the annual rates payable to the Local Authority.

The suggestion that there has been sufficient community consultation to provide “detailed and enhanced understanding of the the key issues of the local community” and that such consultation is “ongoing” is blatantly untrue. As a resident within the 1.36km shadow flicker study area, I have received three letters from the Applicant:

1. March 2026: Suggesting that something would be happening soon and that there would be a Community Benefit Fund associated with whatever it might be
2. May 25, 2026 stating that an application for Wind Farm planning permission had been lodged on May 20.
3. August 12, 2026: Notification that a planning permission application would be lodged for the BESS. This is the first communication referencing the BESS at all.

Of note, I am aware of no communication regarding the lodging of the application for the Substation (Project B) that is before you.

There was no public consultation or meeting. There was no community pre-planning meeting available for all affected residents, and those outside a 1 km radius were not invited to any meeting at all. No indication of the scope of the project has been made available to us or our near neighbours by the Applicant. The first indication of the project scope was notification that the planning application had been submitted. Only those with online access to the prohibitively complicated planning website and over 100 scanned documents were able to garner any indication of the potential impact on our homes. Moreover, once the community began to understand the ramifications of the proposed project, representatives of the Applicant refused to meet with us.

The process to date is a blatant attempt to obfuscate and railroad the community into accepting a project that forces severely negative impacts onto us as individuals, onto our community, onto our land, visual amenity, property values, and livelihoods.

The website associated with the Applicant ([Home - Cunlaghfadda Green Energy](#)) is sparse and provides little information as to the extent of the project, the Applicant stakeholders, and any other material project detail. It is internally inconsistent and vague regarding company ownership. Consequently, as an affected resident I am skeptical as to the legitimacy of the entire enterprise. It appears that a corporate interest shrouded in layers of subsidiaries is using greenwashing to exploit the general good nature of the Irish public.

Shrouding the application in the language of national energy targets, when Mayo has already exceeded its quota for renewable energy generation, does not justify destroying property values, community solidarity, and quality of life for hundreds of households. What's needed is a reasoned, serious, unified national policy. I suggest that An Coimisiún Pleanála can be in the vanguard by denying permission to this project and demanding such a policy be developed. If we miss a timeline, so be it. Better to pay a fine in the short term than to pay with our local and national character for decades to come.

D1. Inaccurate Information – 1.4 Description of Proposed Project (Non-Technical Summary p. 11)

The Site is located within a rural, agricultural setting in Co. Mayo, approximately 5.3km northwest of the town of Claremorris, and 16km southeast of the town of Castlebar. The nearest Natura 2000 site to the Site, i.e., Special Area of Conservation (SAC) or Special Protection Area (SPA), is the River Moy SAC which is located approximately 2.2km west of the nearest proposed turbine (T1). Elevations within the Site are relatively flat and low-lying, ranging from approximately 60mOD (metres above Ordnance Datum) to 70mOD.

D2. Inaccurate Information – EIAR Vol 1. Ch. 5 – Population and Human Health p. 5-26

5.3.1.7.3 Amenities and Community Facilities

There are no amenity or community facilities located within or adjacent to the Site, however there are several in the surrounding area. Claremorris GAA club is located approximately 7.2km southeast, Mayo Gaels GAA is 6.4km northwest, Claremorris Golf Club is approximately 7.8km southeast, Woodland Dog Park is 6.5km south, Hollymount GAA is 12.8km southwest, Balla GAA is 12km northwest, Davitts GAA is 12.8 southeast, Garrymore GAA is 13.1km south and Eastern Gaels is 15.8km east of the Site. Amenities and community facilities, including other sports clubs, youth clubs, and recreational areas are located in Claremorris and Castlebar.

The project description makes no mention of the village of Mayo Abbey, the community in which the project is sited, other than the erroneous statement that the Mayo Gaels GAA pitch is 6.4 km northwest. The Population and Human Health section lists amenities and community facilities in Claremorris, Castlebar, and further afield.

Amenities and community facilities in Mayo Abbey village include:

- Abbey Tots Creche
- Mayo Abbey primary school
- Mayo Gaels GAA pitch and clubhouse (erroneously noted as 6.4 km northwest)
- Byrnes General Merchant/General Store/Pub/Undertakers
- The Church of Our Lady Queen of Peace And St. Gerald
- Mayo Abbey Community Centre
- Mayo Abbey Parish Housing Association

All of these are less than 2.5 kilometres from T7, the nearest turbine.

The only mention of nearby Balla is the inaccurate statement that the Balla GAA pitch is 12 km northwest. It is 6.4 km northwest of T7, as is the Balla Golf Club and Balla Town Park. St Cronan's Church in Balla is 5.7 kilometres from T7.

E. Incomplete Data: Shadow Flicker

As presented above under Human Health/Residential Amenity, Section 5.2.3.5 of EIAR Chapter 5 states that “there are 90 sensitive receptors” (also known as houses and homes) that fall within the shadow flicker study area:

There are 90 sensitive receptors located within Shadow Flicker Study Area, 1.36 kilometres (10 x 136m rotor diameter) of the proposed turbine locations as shown in Figure 5-3 below. For the purposes of the shadow flicker assessment, all sensitive receptors within the Shadow Flicker Study Area were identified and mapped. In addition, a planning history search to identify properties that may have been granted planning permission, but have not yet been constructed, was carried out. Any property with a valid planning permission/application for a dwelling was also added to the sensitive receptor dataset. The Shadow Flicker Study Area and sensitive receptors' locations are shown in Figure 5-3, with all properties detailed in Table 5-9 in Section 5.4.1 below.

The shadow flicker study area presented in Figure 5-3 above shows house IDs within 1.36 km of the turbine locations ranging from 1 to 113 (Dwellings) and 329 to 337 (Derelict), as indicated by the magenta triangles on the figure. Of these, two triangles – adjacent to IDs 53 and 90 – are not numbered. Additionally, ID numbers 98 and 336 are missing from the figure.

Contrary to the above statement, 130 sensitive receptors were identified and, presumably, studied. Shadow flicker data are not presented for 38 of these sensitive receptors. This omission includes any dwellings numbered between 88 and 113 (25 of 113, or 22%) and derelict structures numbered 321-328, 331, and 333-337 (13 of 17, or 83%), all of which are indicated within the study area illustrated in Figure 5-3.

Consequently, occupants/owners of those properties are unable to assess their vulnerability to calculated potential shadow flicker. My own house is labeled as ID 90 on the EIAR Ch. 5 Shadow Flicker Study Area, Fig. 5-3, data for which is excluded from the presented study results in Table 5-9.

The omission of 29% of the studied structures, even should the projected impact be zero, demonstrates either a lack of attention to detail or an intentional omission on the part of the Applicant. In either case, the validity of the application is called into question.

Conclusion

I support our community and our countryside. I support sustainability in all its forms. And I support reasonable and fact-based discussion. Unfortunately, the application before you falls short on all of these criteria.

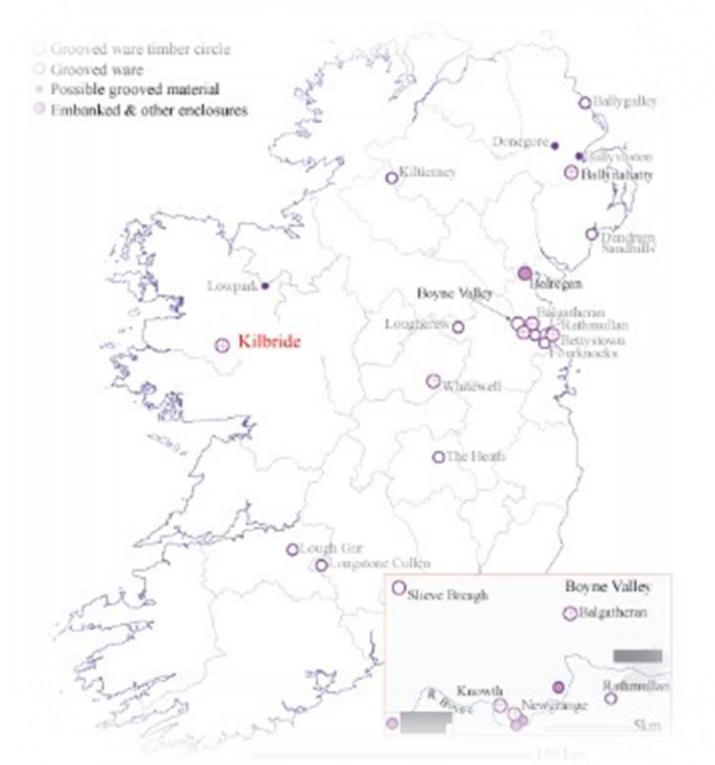
The four pillars of sustainability are widely accepted to be 1) the human pillar, 2) the environmental pillar, 3) the economic pillar, and 4) the cultural pillar. The development application in question appears to address only narrow elements of pillars 2 and 3, and to ignore pillars 1 and 4 entirely. I would respectfully request that An Coimisiún Pleanála consider all aspects of sustainability in mind when evaluating this application, and reject it.

Thank you for your attention and consideration.

Elizabeth Anthony Nestor, BA, MBA, MS, LEED AP
Knockroe
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Appendix 1:
Mayo Abbey Heritage Committee LiDAR Report, 2023

Report for the Mayo Abbey Heritage Committee, Mayo Abbey, Co Mayo.



By Patrick Walsh Licensed Archaeologist
funded by



1. Summary

In April 2023 Patrick Walsh's services as an archaeological consultant were retained by the Mayo Abbey Heritage Committee. The purpose of the consultancy was to provide guidance to the committee for the Lidar survey and to present details on the prehistory of the area - namely the Timber Circle Enclosure that was excavated in Kilbride a neighbouring townland to Mayo Abbey. The findings from this excavation were presented as part of the Heritage week celebration in conjunction with Dr Paul Naessens results from the Lidar survey of the Mayo Abbey landscape.

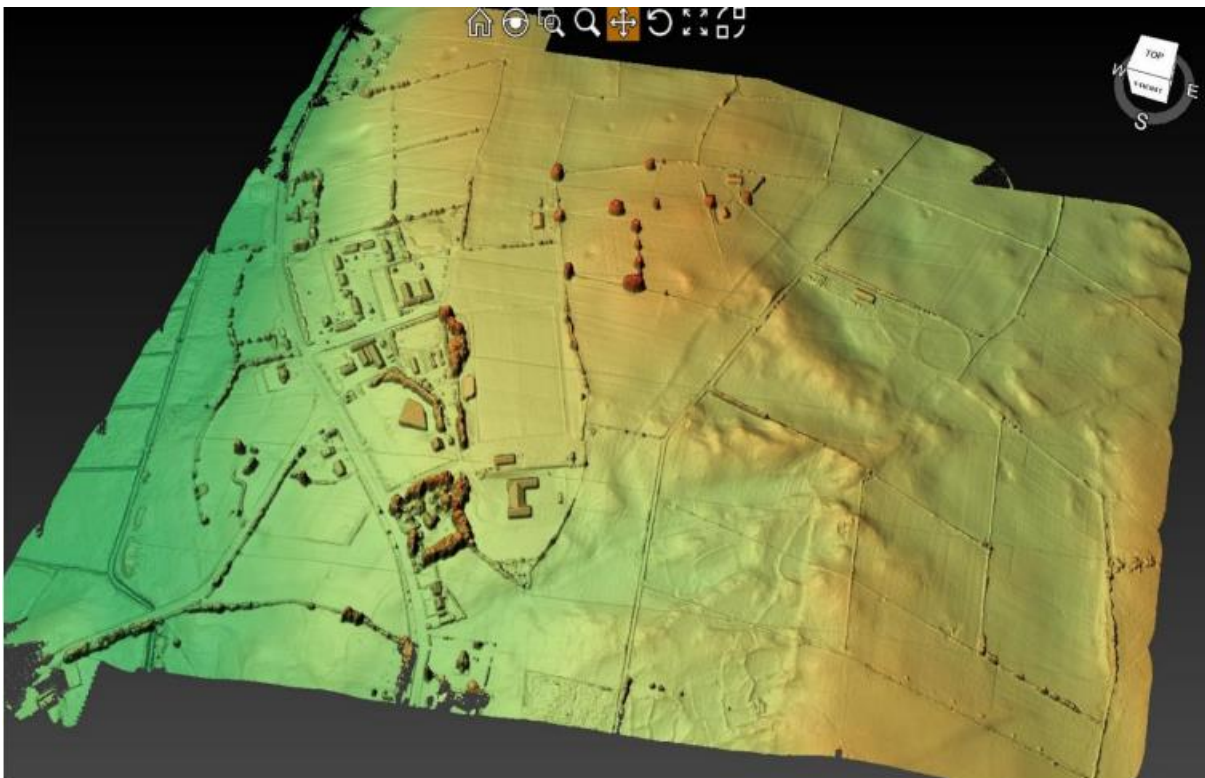


Figure 1: Lidar image from the Mayo Abbey Survey (Taken from the Mayo Abbey Lidar report).

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2. Background to the Study

2.1 Proposal

Project archaeologist Tom Delaney approached Patrick Walsh and provided the details of the project. The project included a non-invasive LiDAR2 survey to test and probe the nature and extent of any remaining visible evidence of early medieval settlement. The results from the survey are very interesting and provide a huge scope for further study. The image here seems to represent the original main approach to the monastery. Similarly in the southwest of the image a path appears to be visible leading to the earthworks to the southwest of the abbey site.

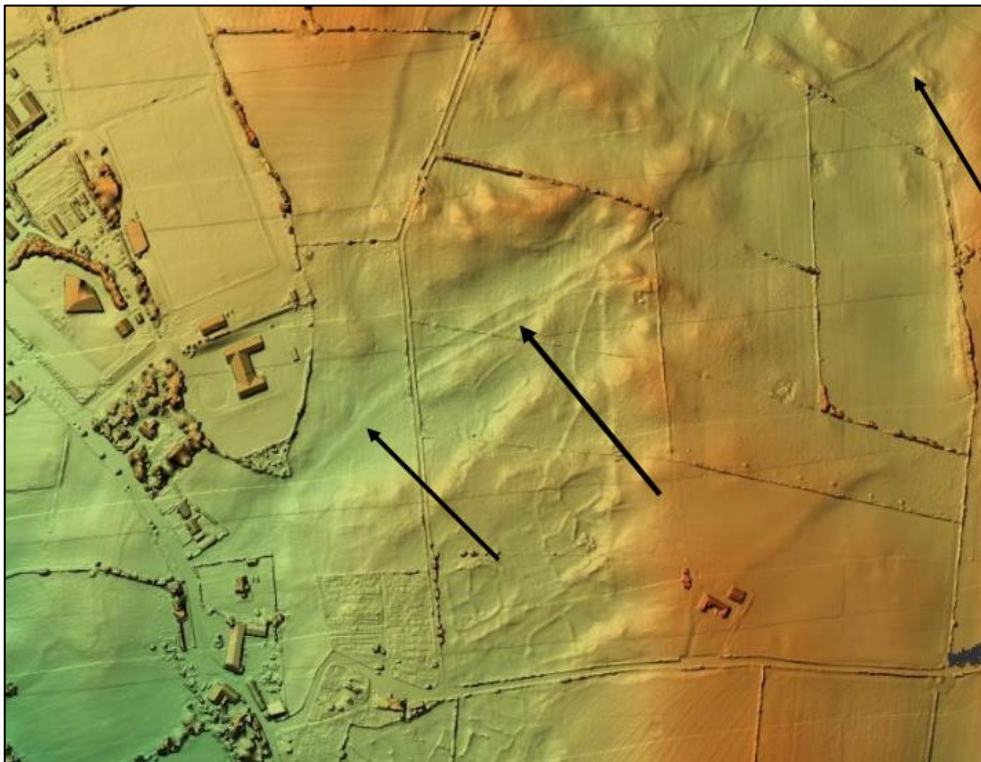


Figure 2: Lidar image from the Mayo Abbey Survey (Taken from the Mayo Abbey Lidar report).

Although the area is rich in medieval archaeology, I also wanted the committee and the locality to understand and consider the rich prehistory of the area.

3. Prehistoric sites of interest close to Mayo Abbey

Megalithic tombs are the best known and most prominent monuments of the Neolithic period in Ireland and examples are found in the Mayo Abbey landscape. There is a court tomb located approximately 2Km northeast of Mayo Abbey in Shinganagh townland (RMP MA091-007) and a wedge tomb at Srahyconigaun (RMP MA 037:102) to the west.

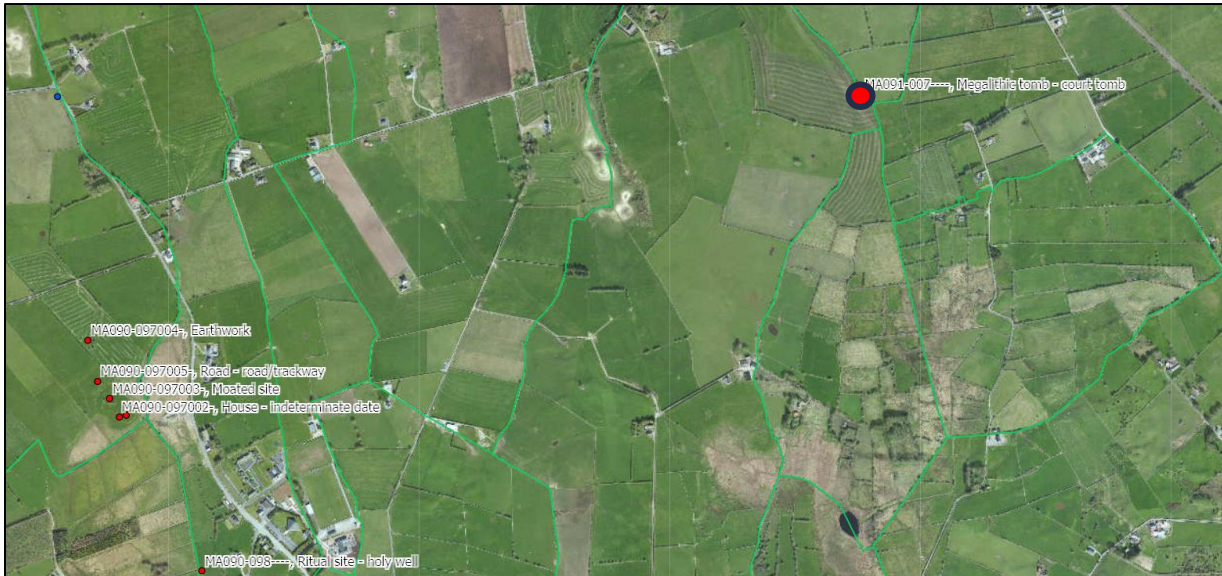


Figure 3: Shows the court tomb in Shinganagh Townland, to the northeast of the image.
(Basemap.www.archaeology.ie)

4. Site at Kilbride

4.1 Site Location

In 2005 I was part of the excavation team that worked on a very rare and unique site found at Kilbride just to the southeast of Mayo Abbey (Figure 4). The site at Kilbride dates to c.3160 BC and there can be no doubt that this area had considerable settlement in the neolithic (Mitchell & Ryan 2001). The site of the excavation was at NGR 127637,278879, the image below shows the location of the excavation in relation to Mayo Abbey.

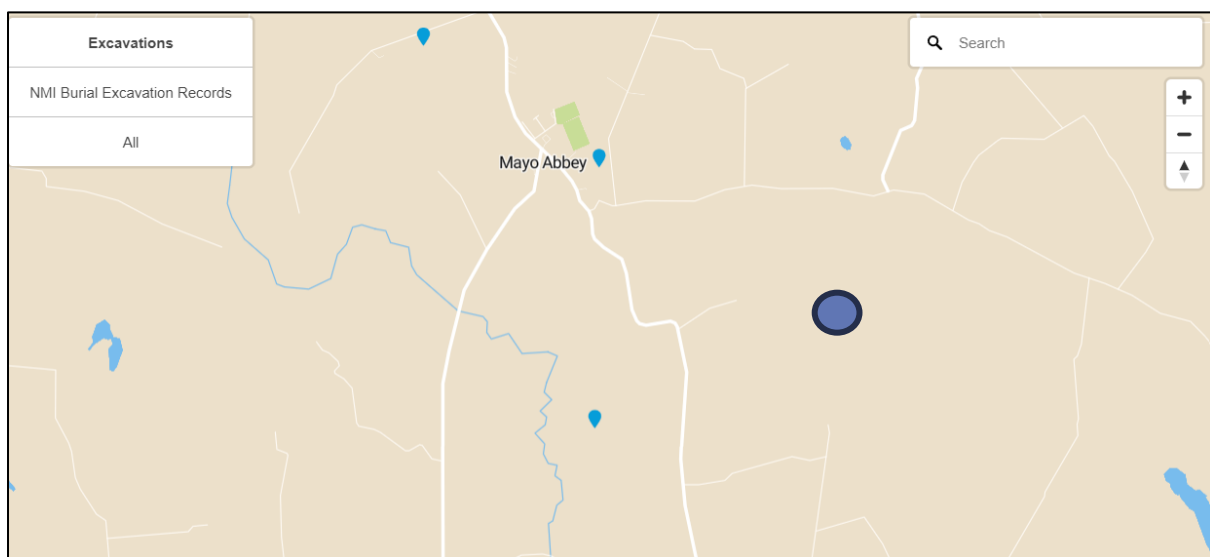


Figure 4: The site in Kilbride in relation to Mayo Abbey (Basemap.www.archaeology.ie)

4.2 Kilbride details

The principal feature of the site was a circular structure measuring 8m in diameter. The structure was formed of a ring of 19 postholes, within which four large postholes formed a rectangular pattern 4.6m x 3.6m. The main entrance to the structure faced south and an east/west row of postholes 1.5m to the south seemed designed to form an outer straight façade in front of the entrance. There was no evidence for an internal hearth, but a small area of burnt clay c. 11m to the south of the structure may have been the remains of an external hearth (Cotter 2005).

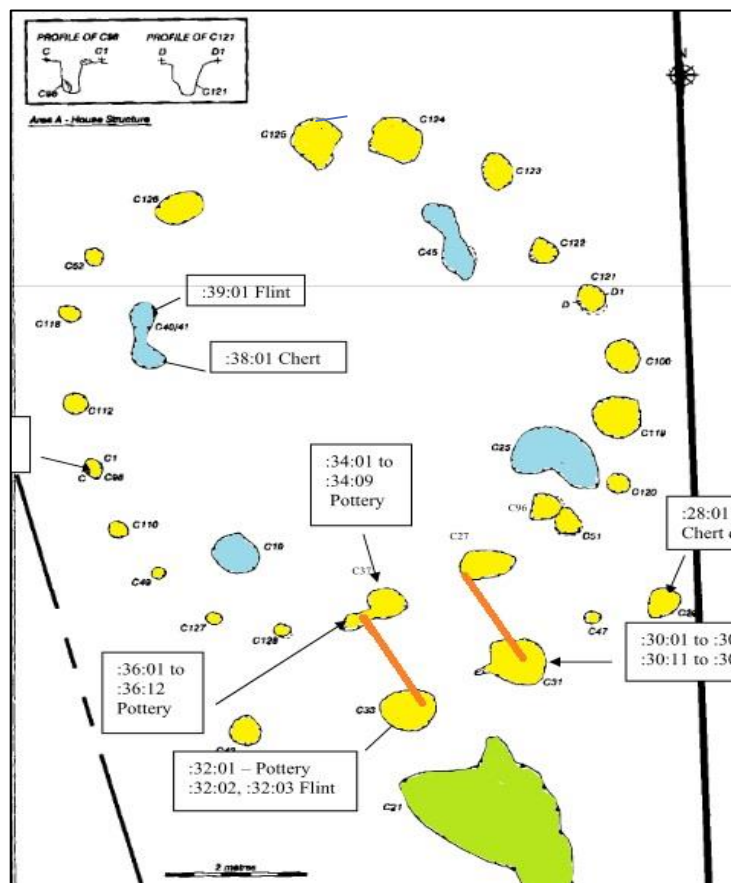


Figure 5: Plan of the site in Kilbride (Cotter 2005).



Figure 6: A posthole looks like this when excavating (Taken by Walsh 2019).

4.3 Finds from Kilbride

A small pit at the site in Kilbride yielded some burnt bone and 47 sherds of pottery (Figure 7). Pottery from the site has been identified as Grooved Ware, and radiocarbon dates span the period 3010-2470 cal BC. On that basis the site is interpreted as a Late Neolithic Timber Circle. There were scrapers made from flint which would have been used skinning hides and hammerstones used to grind down the cereals or indeed cremated bone (Figure 8 and Figure 9). When hammerstones and cremated bone are found together it suggests that the hammerstones could also have been used for funerary purposes.



Figure 7: The grooved ware pottery from the site in Kilbride was similar to this image (Taken from Walsh 2019).



Figure 8: Burnt bone from the site in Kilbride (Taken from Cotter 2005).



Figure 9: Scraper from the site in Kilbride (Taken from Cotter 2005).



Figure 10: Hammerstones (Taken by Walsh 2019).

6. Conclusion

The purpose of this study was to highlight that Mayo Abbey has a rich prehistoric past which compares with other well known prehistoric sites in Ireland. This will inform us as the project moves forward to provide an understanding that the origins of the medieval remains in Mayo Abbey have links with the neolithic past. This knowledge will aid the project to present a deeper understanding of the Mayo Abbey landscape assisted by the continued analysis of results from the Lidar Survey. Some of the future proposals that have been mentioned are to undertake a geophysical analysis and archaeological investigations. I am happy to continue supporting the Mayo Abbey Heritage Committee with this project and help in any way that I can.

7. References

Cotter, E. 2005, Archaeological Excavations at Kilbride. Mayo-Galway Gas Pipeline. ACS archaeological services.

Walsh, P. 2019, Archaeological Excavations at Ballycullia, Co Roscommon. N5 road project, Co Roscommon. AMS - archaeological management solutions.

Mitchell F. and Ryan M. (1993), Reading the Irish Landscape. Town House Dublin

Appendix 2:
Mayo-Galway Gas Pipeline, Kilbride Report, 2008

PROJECT DETAILS

Project	Mayo-Galway Gas Pipeline
Client	Bord Gáis Eireann, Gasworks Road, Cork
Site	Kilbride 1
Townland	Kilbride
Parish	Mayo
County	Mayo
Nat. Grid Ref	127637,278879
Location	RDX 79
Licence No.	05E0833
Archaeologist	Eamonn Cotter
Report Type	Final
Report Status	Draft
Project Start Date	June 2005
Report Date	January 2008

ACKNOWLEDGEMENTS

This report has been prepared by Archaeological Consultancy Services Ltd on behalf of Bord Gáis Éireann.

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.

Consulting Engineers – ARUP Consulting Engineers

Bord Gáis Éireann

Project Archaeologist- Rose Cleary

National Monuments, Department of the Environment, Heritage and Local Government

Chief Archaeologist - Brian Duffy

Archaeologist – Martin Reid

Irish Antiquities Division, National Museum Of Ireland

Keeper - Nessa O Connor

Assistant Keeper – Isabella Mulhall

NON-TECHNICAL SUMMARY

Monitoring of topsoil stripping along the route of the Mayo-Galway Bord Gáis pipeline revealed a cluster of archaeological features near the southern end of Kilbride townland in Co Mayo, to the south of RDX (road crossing) 79 (NGR 127637,278879). The site was designated Kilbride 1 and was excavated in advance of pipe installation by Eamonn Cotter of Archaeological Consultancy Services Ltd., on behalf of Bord Gáis Éireann.

The principal feature of the site was a circular structure measuring 8m in diameter. The structure was formed of a ring of 19 postholes, within which four large postholes formed a rectangular pattern 4.6m x 3.6m. The main entrance to the structure faced south and an east/west row of postholes 1.5m to the south seemed designed to form an outer straight façade in front of the entrance. There was no evidence for an internal hearth, but a small area of burnt clay c. 11m to the south of the structure may have been the remains of an external hearth. Other features around that burnt area did not form any coherent pattern, but included a small pit which yielded some burnt bone and 47 sherds of pottery.

Pottery from the site has been identified as Grooved Ware, and radiocarbon dates span the period 3010-2470 cal BC. On that basis the site is interpreted as a Late Neolithic Timber Circle.

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1. INTRODUCTION

This report details the results of the archaeological excavation of a site uncovered during archaeological monitoring of topsoil stripping along the route of the Mayo-Galway gas pipeline, carried out on behalf of Bord Gáis Éireann. The site was located in Kilbride townland, Co Mayo (OS six-inch sheet number 90, NGR 127637,278879; elevation 68.7m OD, see Figures 1–3). It presented initially as a cluster of pits and possible postholes and was designated Kilbride 1. The excavation was conducted by Eamonn Cotter of Archaeological Consultancy Services Ltd., between 4 July and 20 July 2005 under licence number 05E0833 issued by Department of Environment, Heritage and Local Government.

2. THE PROPOSED DEVELOPMENT

Bord Gáis Éireann (BGE) proposes to develop a gas pipeline from the northwest of County Mayo to the south of County Galway. This will form part of a series of developments, the Corrib Natural Gas Field Development and the Pipeline to the West, which will provide an additional source of natural gas and connect the West of Ireland to the natural gas grid. The Pipeline to the West project is the construction of a gas pipeline from Dublin to Galway and continuing onwards to Ennis and Limerick.

The proposed pipeline from the Bellanaboy Bridge Terminal to Craughwell will be approximately 150km long, 660mm (26”) in diameter, and buried underground throughout its length. The pipeline will be constructed in high strength steel and will operate at 85barg. There will be six block valve stations along the route, which will allow the pipeline to be isolated into sections and will facilitate off-takes for the provision of low-pressure gas supplies to towns along the route.

The Mayo-Galway gas pipeline project was initiated by Enterprise Energy Ireland Ltd as part of the Corrib Natural Gas Field Development. Initial feasibility studies and route selection were undertaken by Enterprise. In late 2000 Enterprise signed a contract with BGE in which it was agreed that BGE would take over the project, undertake the detailed design and manage the construction of the pipeline from the Corrib reception terminal at Bellanaboy Bridge to Craughwell.

3. THE RECEIVING ENVIRONMENT

3.1 Archaeological and Historical Background

The pipeline will be approximately 150km in length, passing through mainly agricultural farmland with areas of boggy marginal land. The region crossed by the pipeline has a dense concentration of archaeological features and finds spanning the Mesolithic to Post Medieval periods.

Mesolithic

The earliest settlers in Ireland are thought to have arrived around 7,500BC, during the Mesolithic period. These people were hunter-gatherers whose existence was based almost entirely on a foraging economy. Settlement sites associated with this culture are rare as they tended not to produce the kinds of permanent structures which later cultures would build and one of the only Mesolithic settlements identified in Ireland to date is a hut site at Mount Sandel in County Derry. The main indicators of Mesolithic activity in Ireland, therefore, take the form of flint scatters and shell middens etc., which have been identified at several locations, especially along the coasts and river valleys. Given the nature of the Irish landscape at the time, covered as it was in dense primeval forests, the Mesolithic people were not in a position to venture very far inland. Instead, they remained largely confined to the coasts and river valleys where they would fish for their survival, only making expeditions into the thick forests for roots, berries and in pursuit of the wild animals that roamed there. Mesolithic evidence in Galway and Mayo consists mainly of sporadic stray finds, for example a single Bann flake from the Late Mesolithic recovered from the shore of Lough Lannagh near Castlebar, Co Mayo, and another (Reg No: 1962:262) found under 6ft of bog in Cloonbar, Co Galway.

Neolithic

The Neolithic period saw the adoption of farming in Ireland, and with it the appearance of more permanent structures in the landscape. The most dramatic evidence of Neolithic farming in Ireland comes from County Mayo. Along the north coast of the county a long-term programme of localised excavation accompanied by large scale systematic probing revealed an extensive network of fields, homesteads and tombs preserved beneath the covering of blanket bog, in an area now known as the Céide Fields. The bog, up to 4m deep, covered long parallel stone walls up to 2km in length and 150-200m apart, forming fields up to seven hectares in area, with evidence for houses and tombs within them.

Megalithic tombs are the best known and most prominent monuments of the Neolithic period in Ireland. The tombs are divided into four classes based on their construction method: court tombs, portal tombs, passage tombs and wedge tombs. There are examples of all classes in Co Mayo, including 22 court tombs located within a 40-mile radius centred on Ballycastle, North Mayo.

Court tombs are so called because of the court-like area in front of the tomb entrance which gave access to the tomb gallery. This court is usually defined by a façade of large upright stones (or orthostats) or by a dry-stone wall. In shape, courts are semi-circular to u-shaped and open or circular/oval and fully enclosed. The gallery, which consists of a series of roofed compartments, opens off the inner end of the court. Burials were inserted into these compartments or chambers. A large mound or cairn usually surrounded the gallery although this feature rarely survives well. Excavations at Ballyglass showed that a court tomb had been built on the site of a large rectangular wooden house

dated to c.3160 BC and there can be no doubt that this area had considerable settlement in the Neolithic (Mitchell & Ryan 2001).

Several court tombs are located close to the gas pipeline route in North Mayo. The impressive tomb at Carrowkilleen (RMP MA 037:001), the largest monument of its class in Mayo, is located 150m east of the pipeline. In the townland of Eskeragh, a court tomb was identified as part of a complex of monuments (RMP MA 028:003) including pre-bog walls, a standing stone, a stone row and an enclosure. Another, at Ballyduffy (RMP MA 047:008) is located 30m east of the pipeline, and one is located approximately 2Km north of the Kilbride site in Shinganagh townland (RMP MA091-007).

There are around 500 wedge tombs in Ireland, of which around 30 are found in Mayo. The examples found in the Mayo-Sligo region are comparable with those found along the western coast of France. Several are located close to the gas pipeline route, again in North Mayo. One, in the townland of Largan Beg, (RMP MA 027-020) is located 200m west of the pipeline; one at Carrowgrave South (RMP MA 037:021) is located 150m east of the pipeline; one at Srahyconigaun (RMP MA 037:102) is located 50m west of the gas pipeline.

There are seven known portal tombs in Mayo and one identified passage tomb at Carrowreagh. The remains of some other megalithic tombs are so badly damaged that they cannot be accurately identified and are recorded as unclassified megalithic tombs.

Bronze Age

The Bronze Age commenced in Ireland sometime around 2500BC with the introduction of metalworking, at first using copper and later bronze. In Co Mayo, between 1700BC and 1300BC, there was renewed settlement with pastoral farming on the sites of the older fields at Céide. By this time they had acquired extensive bog cover so there may have been a brief halt in the growth of the bog or local pressure on the land may have required the bringing of some marginal areas into production. At Belderg Beg, a house, 10m in diameter with a dry-stone wall and postholes, produced saddle querns and rubbers; a charred block of wood within the house was dated to c.1400BC. Nearby there were further stone walls; these started on mineral soil but continued on out into the blanket bog, which surrounded the site where they rested on peat. Oak stakes built into the wall extended down into the peat and where the wall ended, a line of stakes continued into the bog; the stakes were dated to about the same time (Mitchell & Ryan 2001). A similar settlement was uncovered at Carrownaglogh, where a stone field enclosure of around 2.2ha displayed traces of a round house and cultivated ridges of lazy-bed type all covered by layers of blanket bog (Mitchell & Ryan 2001).

Another important indication of Bronze Age settlement and activity in Co Mayo was the construction of bog roads. The record of trackway construction dates back to at least 3500 BC in Ireland. There were episodes of relative dryness when trees re-colonized bogs and when man returned, as in Mayo, to re-use the fields that had previously been abandoned. Track-ways may have been built both in the wet

and dry periods to connect substantial areas of dry land. These track-ways represent a considerable investment of time and resources and were clearly important to the communities they served.

Palaeobotanical evidence suggests a change in climate. In the Late Bronze Age, when the climate appears to have become wetter, and land that had been suitable for agriculture in Neolithic times may have no longer have supported agricultural production. The woodland cover of the landscape was ever depleted through the development of agriculture and the increasing need for charcoal for smelting. The Bronze Age landscape would have seen large-scale changes throughout the period. The overall distribution of settlement had increased. Larger field systems developed with organised field boundaries and linear track-ways linking settlements.

A variety of burial practices are known from the Bronze Age. Burials in cists, box-like structures made of stone slabs, are common in this period, a practise carried over from the Neolithic period. Cists are frequently found under large circular mounds (cairns) of stone and earth, but can also be found under level ground with no surface indication of their presence. The burials can be either cremated or unburnt and decorated pottery, either food vessels or urns, is generally found with them. Cist graves, have been found in substantial numbers throughout Ireland and well over six hundred have come to light up to 2001 (Mitchell & Ryan 2001). A cemetery mound at Corrower, southeast of Ballina, Co Mayo, consisted of a low circular mound some 13m in diameter and was found to contain nine graves. Eight burials survived and all of these were cremated, with five accompanied by one or more bowls. A majority were unprotected, perhaps placed in small pits; four, however, were in cists. One cist, slightly off-centre, seems to have been the principal grave; this was a small polygonal structure with capstone and paved floor. Three bowls stood mouth upwards on this floor; they and the cist were filled with fine sand through which were mixed the cremated bones of at least five persons (Waddell 1998, 143).

A cist (RMP GA 042-070) and two cairns (RMP GA 042-075 & 093) are located in North Galway, in the townland of Cave and in close proximity to the gas pipeline route. In North Mayo, a cist burial (RMP MA027-003) was located c.50m from the gas pipeline in the townland of Sheskin.

Standing stones are another common Bronze Age monument found throughout the country, though they are particularly common in the southwest. They can vary in height from one to seven metres, and can occur in isolation or in groups forming linear alignments, some of which appear to be aligned with celestial events. They may have functioned as territorial boundary markers and as grave markers, and excavations at several have revealed cist burials at the base (O'Kelly 1989, 228-9). The dating of standing stones appears problematic. They are associated with the Bronze Age but their construction and uses may indeed range from the Late Neolithic into the Early and Late Bronze Age. It is difficult today to fully establish the full original significance of the stones, because individual standing stones may once have been part of a more complex group and, individually or as a group, would have formed

part of the overall structure of the human landscape of the Bronze Age, a landscape which included other burial and settlement sites which are today invisible.

The RMP files list three standing stone sites close to the gas pipeline route. The three (MA090-03312, MA090-124 and MA090-125) are located close together in the neighbouring townlands of Carrowjames and Curry located to the west of Balla in Co. Mayo, c. 4Km west of the gas pipeline route.

The burnt mound or *fulacht fiadh* is one of the most common pre-historic monuments in the country. At present over 4000 have been recorded, and this number will undoubtedly increase with further field survey. Internationally, burnt mounds are known from Scandinavia, Wales and Scotland, the Orkney and Shetland Islands and parts of Cumbria (Buckley 1990, 9). On the ground the classic *fulacht fiadh* is a relatively low grassy mound of crescent or U-shaped plan. They are usually, though not exclusively, close to water, often a stream, lake, river or marsh. A recent research programme of radiocarbon dating of burnt mounds has dated the large majority of the sites to a well-defined period within the Bronze Age, c.2400-3600 BP (Brindley and Lanting 1997, 55-6). Approximately 300 of these sites are known in Co Mayo, many having been excavated in conjunction with modern development projects. Four were discovered close together on the route of the Ballinrobe Sewerage and Sewage Disposal Scheme. One, (Clareen, Site No 42) contained up to 200 animal bones, derived principally from the butchery of two cattle (Walsh, 1994). Another four were identified and excavated as part of the Westport Main Drainage and Waste Water Disposal, one of which (Gortaroe 1) contained seven bones and a hammerstone (Gillespie, 2002). One was excavated at Carrowntreila Co Mayo as part of the N26 Ballina to Bohola (stage 1) Road Scheme. The site consisted of a fire pit, a possible well and two troughs with a group of 98 stake holes clustered between the two troughs (NRA brochure).

Iron Age

The Iron Age remains the most elusive period of Irish archaeology, particularly in respect of the 'ordinary' farming communities of the period.

The best known forms of Iron Age settlement are crannógs and hillforts. Crannógs are lake dwelling, located either on the lakeshore or on natural or artificial islands within the lake. Excavations have shown that they originated in the Late Bronze Age and were periodically inhabited and abandoned in the Iron Age. A further phase of crannóg construction took place in the Early Medieval period. The most important site of the period is Lough Gara in Co. Sligo, where a drop in water levels in 1952 exposed nearly 400 crannógs (Raftery 1994, 32). Excavations at one of these, at Rathinaun, revealed a sequence of occupation, abandonment and re-occupation ranging from the Late Bronze Age to the Early Medieval period (ibid.).

Dry-land sites in the form of domestic huts are also known from the period and have been excavated at Scrabo Hill in Co. Down and at Curraghatoor, Co. Tipperary (Ó Kelly 1989, 309).

A number of crannógs are located in close proximity to the gas pipeline in Co Mayo. Two (RMP MA 119-045 & -046) are situated in Carras Lough c.50m from the pipeline, three (RMP MA 090-019, -021 & -046) are situated within Cuilmore Lough, c.100m E of the pipeline in the townlands of Tully More and Tully Beg. There is a possible crannóg (RMP MA 079-057) in a lough in the townland of Lakeland Lower, approximately 50m south of the gas pipeline. Within the townland of Kilknock, a crannóg (RMP MA 079-042) is located in the centre of Lough Nabó. Another (RMP MA 079-101) is located in the townland of Ballinvoash c.50m to the south of the gas pipeline. Two are located in the vicinity of Smuttanagh townland, one at Tully Beg (MA090-019) and one at Brownhall Demesne (MA090-046).

Early Medieval

The classic monument of the Early Medieval period is the ringfort, of which about 30,000 examples have been identified. The mean density for Ireland as a whole is 0.55 ringforts per km² but this varies greatly from region to region. Central Mayo is a zone of medium density (Stout 2000). Ringforts appear as a circular area defined by banks and external ditches and excavation often reveals the remains of dwelling houses within their interior. Many of the ringforts listed within the RMP files appear to fit into the average size associated with these monuments of around 30-40m in diameter. The banks are generally constructed of earth except in stony areas where they may be constructed of stone. In some areas of Co. Mayo walls were constructed of stone due to shallow soils and the widespread abundance of limestone. Those with earthen banks are sometimes referred to, as 'raths' while those with stone banks are known as 'cashels'. A single bank encloses most ringforts, but it is also quite common for them to have two (a 'bivallate' ringfort) or even three ('trivallate') banks.

A large percentage of the sites that are classified as sub rectilinear enclosures appear to be possible variations of ringforts, and it seems likely that a high percentage of ringforts and other types of enclosure would have had rectangular enclosures associated with them. It may be that these rectangular enclosures associated were for agricultural purposes. Within different locations around Ireland different methods appear to have been used to form such enclosures. Some are built of stone, whereas others have earthen banks and fosses, depending on the local geology (Mitchell & Ryan 1997).

There are a large number of ringforts and enclosures located close to the gas pipeline route. When the archaeological inventory of Co Mayo is complete and all the sites are visited it will provide a more accurate account of the various sites labelled simply 'enclosure' at present. A number of ringforts and enclosures have been excavated in recent times as part of road construction. One (SMR 38:4) was excavated in Carrowkeel before road realignment. Excavation demonstrated that the ringfort overlay an earlier ditched enclosure (Zajac, 2002). Another, at Castlegar, Claremorris (SMR 101:26) was excavated as part of Knock-Claremorris Bypass. The excavation uncovered a V shaped fosse averaging

1.8m in width and 2m in depth. The site also held a souterrain and a cobbled path leading up to the souterrain entrance (Zajac 1999).

Enclosures in the vicinity of the Kilbride site are recorded at Fahy Beg (RMP MA090-099) c. 1.2Km to the north-west, Knockaunakill (RMP MA091-018) c. 1.5Km to the north-east, and Cullentragh (RMP MA100-036), c. 1.2Km to the south-west.

Historically of course the primary influence on this period was the arrival of Christianity, which left its mark on the archaeology of the period in the form of numerous churches and ecclesiastical sites. The Early Ecclesiastical sites could be regarded as the ecclesiastical equivalent of the secular ringfort, being of similar construction, though frequently much larger. Many ecclesiastical enclosures survive as abandoned, isolated monuments, but it is likely that many others survive unseen beneath later accretions on sites which have continued in uses as churches and graveyards down to the present. The earliest churches were of timber and have now disappeared, many replaced by Medieval and Late Medieval stone churches. Indeed practically every parish retains traces of Medieval ecclesiastical origins.

Archaeological remains of this period are recorded in Mayo Parks townland (RMP MA090-100), c. 1.2Km north-west of Kilbride.

The Middle Ages

The Anglo-Norman invasion of Ireland, begun in 1171, wrought huge changes in the archaeological landscape of the country, most visibly in the construction of stone castles, churches and abbeys. The first determined effort to control Connacht began in 1224 (Otway-Ruthven 1980, 76) and the incastellation of the province began in earnest in 1231, though in 1233 a resurgent Irish destroyed several castles. A more determined effort by the Normans in 1235 completed the conquest and de Burgo built a castle at Loughrea which became his principal stronghold in Connacht. However all of Mayo and Sligo, and large parts of Galway were granted to men who held lands elsewhere, and in general the native Irish chiefs of the area must have been relatively undisturbed (ibid., 96-99).

Because of the limited nature of Norman control of the area medieval monuments are perhaps not as numerous as in other parts of the country, though many are to be found. At Gweeshadan townland a church and castle (RMP MO90-043, and -10201) are located in close proximity, a pattern frequently found in Norman settlements. Another castle (RMP MO90-055) is located 1.5Km to the south at Doonnamona, and yet another (RMP MO90-8201) 1.5Km to the southeast at Cloghanlucas.

A castle site (RMP MA091-019) is located in Knockaunakill townland c. 1.2Km north-west of the Kilbride site.

Moated sites, the defended farmsteads of the early fourteenth century are known at the appropriately named townland of Moat (MA090-023), and at Knockadorraghy, 5Km to the southeast, where three (RMP MO90-9701, -9703, and -131) are located in close proximity.

Late Medieval and Modern Period

During the fifteenth and sixteenth centuries, the tower house (a relatively plain structure of three or more storeys in height) became the principal dwelling type for many of the wealthy landowning class in Ireland, both of Gaelic and Anglo-Irish origin. The tower house can be seen as a compromise between the needs of domestic comforts and military/defensive requirements in a turbulent political environment where central authority had all but collapsed in large areas of the country. By the seventeenth century the overwhelming majority of the 3,000 castles in Ireland would have been tower houses (Barry 1988). Over 200 are known from Co. Galway (Sweetman 1999, 163) and 100-200 from Co. Mayo (Leask 1986, 159).

In the late 16th and 17th centuries, the old pattern of land occupation in Ireland was radically disrupted by the turmoil of war and political change. Many of the existing hereditary landowners were dispossessed in favour of new men loyal to the crown. A new influx of tenants and small landowners was introduced to Connacht as landowners in other parts of the country were dispossessed and forced to transplant there. Despite the upheavals the general trend was towards increasing centralization of authority and extension of government rule. In that climate the military requirements of the tower house became obsolete and they were gradually replaced by the more comfortable, domestic-orientated ‘fortified house’ such as Lough Mask Castle, Co. Mayo, and Glinsk, Co. Galway, and subsequently by the ‘country house’, an early example of which was Eyrecourt, Co. Galway, built sometime after 1660 (Craig 1989, 145).

3.2 The Landscape

The townland of Kilbride is located in an area known as ‘The Plains of Mayo’. This is a large expanse of generally low-lying limestone land dotted with eskers, drumlins and small lakes created by retreating ice sheets. The site itself was located on a plateau near the summit of one of these small north-south eskers, with extensive views to the west and north-west, towards a distant horizon dominated by Croagh Patrick.

Land use in the area is mainly grassland supporting cattle and sheep.

4 EXCAVATION RESULTS

4.1 Excavation methodology

Topsoil stripping was carried out by machine equipped with a grading bucket. All potential archaeological features exposed were carefully cleaned and recorded (by plan, photographs, levels, feature sheets etc.) and excavated by hand. Each feature (cut feature, fill, layer, deposit, spread, built

feature etc) was assigned a Context number. All Contexts were numbered sequentially from 1 to infinity within each site; i.e. C12 represents feature 12. Where appropriate, soil samples and charcoal samples were taken in an effort to obtain a date and function for the various features. All finds were numbered according to the requirements of the National Museum of Ireland from 1 to infinity according to licence number and context number; i.e. 05E0833:12:4 represents find number 4 within context number 12 in Kilbride, which was excavated under licence number 05E0833.

4.2 Stratigraphic Report

When topsoil was removed in this area a large number of archaeological features was noted, in four concentrations (Fig. 2, Areas A-D). Within these the area of greatest interest was the northern end of Area A

Area A

The principal feature of the site was located in this area (Fig. 6 and Plate 1). It comprised a circular structure defined by three settings or groups of postholes, as follows:

Group 1 – **C35, C37, C128, C127, C49, C110, C98, C112, C118, C52, C126, C125, C124, C123, C122, C121, C100, C119, C120, C51, C96** and **C27**. These 22 postholes formed a circle approximately 8m in diameter. The postholes varied in size. Those around the western side were generally smaller, with an average diameter and depth of 0.35m and 0.5m respectively, while those around the eastern and northern sides had an average diameter and depth of 0.5m and 0.55m respectively. Three postholes on the northern side of the structure (C124, C125 and C126) were wider and shallower than average, at c. 0.6 and 0.4 respectively. The spacing between these postholes was also wider than average.

The very close spacing of some of the postholes suggests that not all were original and it is likely that the structure originally comprised of a ring of 19 postholes, with C37, C96 and C124, being inserted as replacements or supports.

Group 2 – **C19, C25, C40, C41, and C45**. This group comprised a setting of postholes forming a rectangle measuring 4.6m E-W x 3.6m N-S within the circle described above. C19 and C25 were single postholes forming the south-western and south-eastern corners respectively, C40/41 was a pair of conjoined postholes forming the north-western corner and C45 was a pair of conjoined postholes forming the north-eastern corner. These were all substantial postholes averaging 0.6m in diameter and 0.5m deep.

Group 3 – **C29, C47, C31, C33, and C43**. This group comprises a line of postholes running east-west and located one metre south of the circle of postholes. Two at the centre of the line, C31 and C33 are much larger than the others and, together with C27 and C35 appear to form an elaboration of the entrance to the structure.

Together these three groups represent a circular structure with a square setting of substantial post within the circle and an elaborate entrance with straight façade on the south side. The structure is interpreted as a Late Neolithic timber circle.

Group 4 – **C03, C05, C08, C11, C13, C14, C17, C20, C21, C23, C56, C59, C61, C65, C78, C102, C104, C106, C108, C129, C130**. This was a disparate group of features located directly south of the timber circle. They formed no coherent pattern and their relationship with the timber circle is uncertain, though dates and pottery from some of these features indicate they are clearly contemporary with the circle and related to it.

C21 and **C23** were two conjoined features located c. 0.5m south of the timber circle (Plate 2). **C21** was a sub-circular pit measuring 1.8m x 1.6m and 0.2m deep. Its fill, **C20**, was a dark brown silty clay with some charcoal flecks. **C23**, located 0.8m to the south, was another circular pit c. 0.7m in diameter and 0.2m deep. Its fill, **C22** was almost identical to the fill of **C21**. Burnt clay along the western side and the base of **C23** indicated *in situ* burning had taken place in the pit. A sherd of Late Neolithic Grooved Ware pottery was recovered from the fill (see Appendix 3 below for details). Both pits, **C21** and **C23**, were joined by a trench c. 0.5m wide and 0.2m deep and continuing to the south of **C23**, giving the appearance of a single linear feature 4.7m long, distended near the southern end (**C23**) and widening significantly at the northern end (**C21**).

A similar feature was excavated approximately 8m to the south. Here, **C05** and **C11** together formed a linear trench aligned north-south (Plate 5). The northern half of the trench, **C11**, was 2.3m long x 1.06m wide and 0.3m-0.4m deep. At the southern end of **C11** the feature narrowed abruptly to 0.7m and continued (**C05**) for a further 3.6m, its depth ranging from 0.05m-0.15m. The two features were separated by a narrow band of redeposited natural.

The function of these two features (**C21/C23** and **C05/C11**) is uncertain. What is clear however is that, though they are c. 8m apart, they are both set on the same linear alignment, an alignment which continues to the entrance to the timber circle, and it may well be that they formed some type of ceremonial approach to that structure.

A pit, **C102**, (Plate 4) was located slightly north of halfway between the two linear features described above and formed part of the same alignment. **C102** was a D-shaped pit measuring 0.35m x 0.46m and 0.32m deep. Its fill, a light brown silty clay, also included fragments of burnt bone, ten sherds of Grooved Ware pottery (Appendix 3) and 15 flint artefacts (Appendix 6).

Approximately 2.5m north-west of **C102** another isolated pit, **C59**, was excavated (Plate 3). This pit measured 1.1m x 0.96m and 0.25m deep. It contained three fills: **C71**, a yellow clay mixed with charcoal-rich silt at the base of the pit, **C58**, a dark brown clayey silt with occasional charcoal flecks, and the upper fill, **C57**, a mid-brown silty clay with frequent charcoal flecks. The upper fill, **C57**, contained concentrations of charcoal and burnt bone within it. **C58** also contained fragments of burnt

bone, and both C57 and C58 contained pottery and flint artefacts. In all a total of 47 sherds of pottery and 10 flint artefacts were recovered from this pit (see Appendices 3 and 6, respectively).

Some 2.5m south of C58 another isolated feature, **C56**, was excavated. This was a shallow oval feature measuring 0.3m x 0.18m x 0.06m deep. Compacted charcoal and burning on the base of the pit indicated it was a hearth. Fragments of hazelnut shell were found among the charcoal. Two fragments of flint debitage were recovered from the pit.

Area B

Area B was a cluster of six features (C62-64, C68 and C70-73) located c. 20 south-west of Area A (Fig. 5 and Plate 6). Four of these **C64**, **C62/63**, **C72/73** and **C70**, appear to have formed a single structure. **C64** was a sub-circular feature measuring 0.36m x 0.29m x 0.31m deep. Its base was circular and 0.16m in diameter. **C62/63** was a pair of conjoined postholes located 1.1m south-west of C64 - C62 was 0.26m x 0.22m x 0.34m deep; C63 was 0.3m in diameter and 0.39m deep. **C72/73** was another pair of conjoined postholes, located 1.6m south-west of C62/63 - C72 measured 0.3m x 0.46m x 0.55m deep and C73 was 0.3m in diameter and 0.43m deep. **C70** was located 1.5m south of C72/73. It measured 0.43m x 0.36m x 0.32m deep.

With the exception of C72 and C73 the diameter/depth ratio of these features seemed generally greater than might be expected for postholes. Nevertheless they were regularly spaced and did form a slight arc, suggesting they represent some type of open-ended structure or screen. As no other features were found in the vicinity it is not certain what function such a screen might have served. However, dating evidence from C70 (see Section 4.4 below) shows clearly they were contemporary with the timber circle.

One other feature in this area, **C68**, was an isolated posthole 5m to the north of the above features. It measured 0.4m x 0.5m x 0.6m deep. One piece of struck flint was recovered from its fill.

Area C

Area C was a group of seven features (C79, C80, C81, C83, C85, C86 and C88) located c. 40m north-west of the timber circle, (Figs. 4 and 8a). These were a random scatter of pits which did not form any coherent pattern. The largest, C86, measured 0.9m x 0.8m x 0.3m deep and was filled with a charcoal-rich silty clay. It produced one sherd of Grooved Ware pottery (see Appendix 3). The occurrence of this pottery indicates that this one pit at least is contemporary with the timber circle and it is likely the other features in Area C are also, though their function is unknown, as is their relationship to each other and to the timber circle.

Area D

Area was a group of three features (90, C91 and C93) located c. 90m north of Area A (Figs. 4 and 8b and Plate 7). Two of these, C90 and C93, could not be fully excavated as they continued eastwards

outside the limit of the pipeline wayleave. **C90** was a linear ditch which extended 4.1m from the baulk, at which point it terminated. The ditch was, on average, 0.95m wide and 0.43m deep. Its fill was a dark brown/grey silty clay with frequent charcoal inclusions. Numerous large stones were also present in the fill.

There was no evidence to link these features with the timber circle and it is not known if they were contemporary with it or represent some later, perhaps modern, agricultural activity.

4.3 Artefactual evidence

A total of 148 artefacts were recovered from the site, including 97 sherds of pottery, 50 flint artefacts and 1 stone object, a water-rolled cobble which had been used as a hammerstone.

The pottery has been identified as Grooved Ware (see Appendix 3 for full details), a type found in Late Neolithic contexts in Ireland. Almost half of the pottery, 48 sherds, was found in a single pit, C59, located 6.5m south-west of the entrance to the timber circle. Given the concentration of pottery in this pit it is likely that it had some special significance on the site, though what that significance was is unclear.

In addition to C59, pottery was found in three other features external to the timber circle. These were: one sherd from C23, 2m to the north-east of C59, 10 sherds from C102, 3m to the east of C59, and one sherd from C86, located in Area C c.40m north-west of the timber circle. The remaining 37 sherds were mainly concentrated on the entrance to the timber circle: 10 sherds from C31, the outer right-hand posthole, 21 sherds in C35/37 a double posthole forming the inner left-hand side of the entrance, 1 sherd from C33, the outer left-hand side. In addition 5 sherds were recovered from C96 one of the ring of structural postholes along the western side of the circle.

Fifty-six lithics were recovered during the excavation, comprising flint and chert pieces. As with the pottery, there was a notable concentration of these in pits to the south of the timber circle, including 10 from C59 and 15 from C102. Within the timber circle itself individual pieces were found in C40 and C41, the double posthole forming the north-west corner of the rectangular structure within the circle, and others were found in three of the postholes forming the linear external façade to the circle: 5 in C29, 3 in C31 and 2 in C33. Individual pieces were found in other pits to the south, and one from C86 in Area C. These artefacts are more fully discussed in Appendix 6.

4.4 Environmental evidence

Table 1 Results of soil sample flotation					
Sample	Context	Soil Weight Pre-sieve	Residue Weight	Flot Weight	Content
S18	C39, fill of posthole within timber circle.	3.25kg	350g	37g	Charcoal
S11	C24, fill of posthole within timber circle.	3.55kg	417g	2g	Charcoal
S22	C55, fill of possible hearth to	2.5kg	126g	48g	Charcoal

	south of timber circle.				
S7	C26, fill of posthole, part of timber circle.	3kg	476g	8g	Charcoal, cremated bone
S28	C69, fill of posthole in Area B.	2.5kg	217g	4g	Charcoal
S24	C58, fill of pit to south of timber circle.	24kg	4.37kg	160g	Charcoal
S30	C86, fill of pit in Area C.	6.25kg	598g	12g	Charcoal
S20	C44, fill of posthole within timber circle.	2.13kg	378g	2g	Charcoal
S16	C30A, upper fill of posthole, part of entrance to timber circle.	2.8kg	383g	13g	Charcoal
S23	C57, upper fill of C59, pit to south of timber circle	2.2kg	348g	19g	Charcoal, cremated bone
S34	C95, posthole, part of timber circle.	2kg	345g	20g	Charcoal, cremated bone
S35	C99/100, posthole, part of timber circle.	3kg	385g	43g	Charcoal
S36	C101, fill of pit to south of timber circle.	2.9kg	402g	5g	Charcoal
S37	C103, fill of isolated pit to south of timber circle.	3.3kg	575g	68g	Charcoal

Table 2 Charcoal identification		
Context/Sample no.	Context type	Species and Weight
C24:S11	Fill of C25, structural posthole, part of Late Neolithic Structure	Oak (2g) & Alder (6.1g)
C26:S7	Fill of C27, structural posthole, part of Late Neolithic Structure	Tiny pieces of oak (8g)
C39:S18	Fill of C40, structural posthole, part of Late Neolithic Structure	Tiny pieces of oak (37g)
C44:S20	Fill of structural posthole, part of Late Neolithic Structure	Oak (2g)
C55:S22	Fill of C56, hearth to south of Late Neolithic Structure	All alder (48g)
C58:S24	Middle fill of C59, pit to south of Late Neolithic Structure	All Hazel (160g)
C69:S28	Fill of C70, one of a group of postholes in Area B	Oak (3.8g) & Alder (0.2g)
C86:S30	Fill of pit, one of an isolated group of features in Area C	Oak, alder and blackthorn & Seeds and grasses

As can be seen from Table 1 charcoal was the principal environmental material retrieved from the soil samples. A range of species was identified, including oak, alder, hazel and blackthorn (see full report Appendix 4).

The variety of species indicates different natural environment in the vicinity of the site. Oak charcoal was found in several of the timber circle postholes, indicating the presence of oak woodland in the area, and the use of oak in construction. The presence of hazel and blackthorn indicates a more open, scrubby environment, possibly in woodland clearings and margins, while the presence of alder suggests some wetland in the vicinity. This variety reflects the landscape of the area. The site itself is located on a drumlin ridge on high, dry ground, where species like hazel and oak would have thrived, while alder would have been common in the low-lying wet land to the north, west and east.

Interestingly, the relatively substantial quantity of charcoal retrieved from one pit, C59, was found to be entirely of hazel, suggesting the pit was lined with hazel wattle. This pit appears to have had a special significance on the site, as it produced 47 sherds of pottery and 11 flint artefacts.

4.5 Dating evidence

Radiocarbon Dating

Four charcoal samples, taken from three different areas of the site, were submitted for radiocarbon dating. The results are presented in Table 3 below (full details in Appendix 5).

Table 3: Kilbride Radiocarbon dates				
Lab code	Sample material	Years BP	13C/12C Ratio	Calibrated dates 2 sigma
Beta - 217655	Oak charcoal from C44, fill of structural posthole, (part of timber circle).	4210 +/- 40 BP	-25.2 o/oo	Cal BC 2900 to 2670
Beta - 217656	Hazel charcoal from C58, middle fill of pit to south of timber circle.	4080 +/- 60 BP	-26.1 o/oo	Cal BC 2870 to 2470
Beta - 217657	Alder charcoal from C69, fill of one of a group of postholes in Area B	4310 +/- 40 BP	-26.2 o/oo	Cal BC 3010 to 2880

Dates were obtained from charcoal samples from different areas of the site, including a structural posthole within the timber circle, the pit C59 to the south of the circle, and one of a setting of postholes in Area B to the south-west of the circle. As can be seen from Table 3 above, all three dates are broadly contemporary, placing the site in the Late Neolithic.

Pottery

The pottery has been identified as Grooved Ware, a type found in around fifteen sites in Ireland and associated with timber circles on 6 of those sites (see Appendix 3 below for discussion).

The radiocarbon dates from Kilbride tie in closely with dates obtained from other Grooved Ware sites.

The combination of radiocarbon dates and the recovery of Grooved Ware pottery place the site firmly in the Late Neolithic, c. 3000-2500 BC. Radiocarbon dates were obtained from Areas A and B of the site and one sherd of Grooved Ware pottery was recovered from a pit in Area C, indicating that all

three areas were broadly contemporary.

5. DISCUSSION

Timber circles- the archaeological context for Kilbride

The site at Kilbride is identified as a Late Neolithic timber circle, a site type of which only six or so have been excavated in the country to date. One of the first to be excavated was that at Knowth, Co. Meath (Eogan and Roche 1994, 322-30), which bears a striking resemblance to the Kilbride site. At Knowth the structure was located close to the passage tombs, but stratigraphically later than them (ibid., 322). The structure measured 6.7m x 6.28m internally, with an entrance to the east. Like Kilbride it comprised a rectangular structure represented by four corner postholes, enclosed by a circular structure, and, like Kilbride, it had an external setting of postholes outside the entrance, though at Knowth the setting followed the curve of the circle, whereas at Kilbride they were almost straight. Around 400 sherds of Grooved Ware pottery were recovered, all from the fill of the post-pits (ibid., 326).

At Ballynahatty, Co. Down, a timber circle was found within a much larger enclosure and formed part of an extensive ceremonial landscape which includes the Giant's Ring, an earthen banked enclosure some 200m in diameter and numerous burials (Hartwell 1994, 14). Here the structure (referred to as BNH6) comprised two concentric rings of postholes with an entrance to the south-east. The structure measured c. 10m internally. A rectangular setting of four postholes was located within the inner circle, as at Kilbride and Knowth, but within that setting was a smaller rectangle of 14 postholes, a feature not found on the other sites. However the excavator identified two separate phases of construction in this smaller structure and assigned the larger four-posthole setting and the circle to two further separate construction phases (ibid., 12).

The remaining known sites yielded similar evidence:

- At Balgatheran, Co. Louth Structure C comprised a setting of nine postholes forming an oval enclosure measuring 6.5m x 5.7m, which enclosed a rectangular setting of four postholes (Ó Drisceóil 2003, 257). The entrance was to the east-south-east and a number of external postholes suggest it had been elaborated into a porch
- at Rathmullen, Co. Meath Site 15/16, comprised a setting of twenty postholes forming a circle some 7m in diameter with an entrance to the south-east enclosing a rectangular setting of four postholes (Stafford 2003, 330);
- at Bettystown, Co. Meath 27 post-pits formed a circular structure 7.6m x 6.5m externally, with a porch entrance to the south-east;
- at Inch/Ballyrenan, Co. Down a circular feature c. 15m in diameter comprised of at least one ring (and possibly two concentric rings) of postholes is thought to have been a timber circle (McQuillan 2000, 47).

A number of features are common to most of the excavated timber circles. Of the six sites for which entrance orientations are known all except one are to the south-east, the exception being Knowth.

Of the seven excavated sites four are located in the vicinity of other ceremonial/burial sites. At Knowth the timber circle is close to the passage tombs, which were present before it was constructed (Eogan and Roche 1994, 322). At Ballynahatty the timber circle is just one of an extensive range of monuments of the Neolithic and Bronze Age, including a passage grave, an embanked enclosure two flat cemeteries, a standing stone and a multiple cist cairn. At the Bettystown timber circle a Bronze Age flat cemetery was located close by and at Inch/Ballyrenan two ring-ditches were excavated nearby, one of which contained several cremated burials.

Although the regular occurrence of Grooved Ware pottery on timber circle sites can be said to represent a 'separate and culturally different' phase of Irish prehistory (ibid. 1994, 329) their association with earlier, contemporary and later burial sites suggests that they were part of a long tradition of ceremonial/burial usage of certain locations, spanning many centuries.

While there were numerous individual pits and postholes outside the timber circle at Kilbride, there was no evidence of any other nearby structure or burial. However, it must be borne in mind that only a narrow corridor of c. 25m wide was made available for excavation and, as can be seen from Fig. 4, the timber circle itself was located only centimetres from the eastern baulk, so that other unknown features may exist beyond the reach of the excavation.

A common topographical location is shared by at least six of the seven excavated sites, in that all except Inch/Ballyrenan are located on or near the summit of a ridge overlooking surrounding low-lying land. The excavator of Ballynahatty suggested the area was a ceremonial centre, isolated and 'set apart from farming activities' (Hartwell 1991, 15). This suggestion is supported by pollen analysis undertaken in a nearby lake which showed that cereals were not grown in the area in antiquity (ibid., 15). While Ballynahatty cannot be regarded as typical of timber circle sites given the extent and nature of other monuments in the vicinity, and interpretations which hold true there should not necessarily be extended to other sites, some similar evidence was found in the Kilbride area. As part of a recent multidisciplinary study of the Mayo Abbey area pollen cores were obtained from Lough Fark, a small lake located 1Km north of the timber circle site (Fuller 2002, 20-23). Analysis of the cores showed no significant Neolithic land clearance in the area and only limited agricultural activity. This could be interpreted as evidence that settlement and agricultural activities contemporary with the timber circle were located at some distance from it and that the ridge at Kilbride was indeed a separate, ceremonial area.

The Kilbride timber circle

The interpretation of the site at Kilbride as a Late Neolithic timber circle is based on the radiocarbon dates and the presence of Grooved Ware pottery, a type also found on these sites elsewhere. As noted

above the site is likely to have performed a ceremonial/ritual function and to have existed in a landscape away from the focus of contemporary settlement and farming activities.

The morphology of the Kilbride site is virtually identical to other similar sites, though on a more diminutive scale than some in regard to the size of the posts used. In the Knowth example, for instance, the entrance postholes were up to 1.32m in diameter and 1.3m deep, while those forming the rest of the circle were 0.5m-0.8m in diameter and 0.66m-1.18m deep (Eogan and Roche 1994, 323), and at Ballynahatty the postholes of the inner ring were 1.8-2m deep. Postholes on the other excavated sites appear to have been less massive, however, and Knowth and Ballynahatty may have been exceptions rather than the norm. The postholes at Kilbride ranged from 0.35m to 0.5m in diameter and c. 0.5m deep, with those at the entrance and the four internal ones being at the larger end of the scale.

The features to the south of the timber circle are difficult to interpret. The pit C59 was clearly a significant feature given that it contained 47 sherds or almost half of all the pottery recovered on site, as well as flint and some cremated bone. The two elongated pits, C22/23 and C5/11 are equally problematical. It is notable, however, that they form a linear alignment with the entrance to the timber circle, an alignment which also includes the pit C102, which produced 10 sherds of pottery and 13 flint pieces (see Fig. 5). It may be that these features together represent some form of ceremonial approach to the circle, an alignment which given its south-easterly orientation, may have focused on the mid-winter rising sun.

The spacing of the structural postholes of the circle is not uniform and it is notable (see Fig. 6) that postholes 125 and 126 are further apart than is the norm. The location of this wider gap directly opposite the entrance suggests it deliberate, but its function is uncertain. It is unlikely that it was another entrance as the postholes are shallower than those at the entrance, and indeed did not seem capable of supporting a tall post. It may be that these were quite short posts supporting a horizontal timber. Could this have been the precursor of the recumbent stone circle of a later period, in which the tallest stones formed the entrance and a low 'recumbent' stone was set directly opposite it?

There appears to have been little or no discussion among archaeologists as to whether these structures were roofed or open. Indeed the name 'timber circle' implies an unroofed structure. One excavator has suggested that they were mortuary structures and that the four-post rectangular structure may have carried a platform on which bodies were left to decay (Hartwell 1994, 13). It is, however, entirely possible that the structures were roofed, with the inner posts forming a rectangular superstructure acting as main support for the roof and the circle of posts carrying the ends of the rafters and the wall. Whether roofed or unroofed however the weight of evidence clearly suggests that these structures were ceremonial in nature.

6. CONCLUSION

Archaeological monitoring of the topsoil stripping in Kilbride townland along the route of the Mayo-Galway Bord Gáis pipeline revealed a cluster of archaeological features near the southern end of the townland. The site was designated Kilbride 1 and was excavated in July 2005 by Eamonn Cotter under licence number 05E0833. Resolution of the site revealed the remains of a Late Neolithic timber circle, comprised of a circle of postholes c. 8m in diameter with an entrance to the south-east. The entrance had an external porch, flanked by other postholes which formed a straight façade outside the entrance. The circle enclosed a setting of four postholes which formed a rectangle measuring 4.6m x 3.6m. A cluster of features to the south of the circle may have formed part of a ceremonial approach to the entrance. Ninety-seven sherds of Grooved Ware pottery were recovered during the excavation. Radiocarbon dates from the site span the period 3010-2470 Cal BC (2 Sigma calibration).

The site is interpreted as a Late Neolithic timber circle and it closely resembles six other examples excavated in the country to date. They are believed to have been ritual/ceremonial sites, possibly mortuary structures where bodies were placed to decay.

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Signed:



Eamonn Cotter

January 2008

APPENDIX 1 – List of Recorded Contexts

Context No.	Area	Description	Interpretation
1	All		Topsoil
2	A	Silty clay.	Fill of pit C3
3	A	Circular pit near S end of Area A	Unclear
4	A	Dark brown silty clay.	Fill of C5
5	A	Linear cut, 3.6m x 0.7 x 0.1m deep	With C11 forms linear trench, possibly related to approach to timber circle.
6	A	Dark grey silty clay	Upper fill of pit C8
7	A	Greyish silty clay	Lower fill of pit C8
8	A	Oval pit 0.64m x 0.41m x 0.3m deep.	One of several pits to S of timber circle. Function unknown
9	A	Dark brown silty clay.	Fill of pit C78
10	A	Dark grey silty clay with frequent charcoal	Fill of cut C11
11	A	Linear cut 2.3m x 1.06 x 0.4m deep	Continuation of C05. Function uncertain
12	A	Dark brown/black silty clay.	Fill of C13
13	A	Sub-circular pit, 0.44m x 0.4m x 0.16m deep.	Pit near C11 at southern end of Area A. Function uncertain.
14	A		Shallow linear furrow
15	A		Non-archaeological feature
16	A	Grey/black clayey silt	Fill of C17
17		Rectangular cut 1.8m x 0.76m x 0.58m deep.	Uncertain. May have been posthole c. 0.5m diameter and 0.4m deep, cut into disturbed area.
18	A		Fill of posthole C19
19	A	Sub-circular cut, 0.72m x 0.6m x 0.48m deep	Posthole at SW corner of rectangular structure within timber circle
20	A	Dark brown silty clay	Fill of C21, linear pit to S of timber circle.
21	A	Sub-circular; 1.6m x 1.8m x 0.2m.	Linear pit to S of timber circle. Function uncertain.
22	A	Grey/brown silty clay.	Fill of C23.
23	A	Linear, sub-rectangular; 4.7m x 0.7m x 0.2m	Linear feature cut by C21. Function uncertain.
24	A	Dark grey clayey silt.	Fill of C25
25	A	Oval, 0.95m x 0.67m x 0.62m.	Posthole forming SE corner of rectangular structure within timber circle.
26	A	Grey/black clayey silt.	Fill of C27
27	A	Oval, 0.73m x 0.42m x 0.53m.	Posthole on E side of entrance to timber circle.

28	A	Grey/brown silty clay.	Fill of C29.
29	A	Sub-circular, 0.47m x 0.59m x 0.32m.	Posthole. Most easterly of a line of postholes to S of timber circle.
30	A	Grey/black silty clay	Fill of C31
31	A	Sub-circular, 0.7m x 0.9m x 0.42m.	Posthole. One of a line of postholes to S of timber circle.
32	A	Grey/black clayey silt.	Fill of C33
33	A	Sub-circular cut, 0.66m x 0.8m x 0.4m.	One of a line of postholes to S of timber circle.
34	A	Grey/brown silty clay.	Fill of C35.
35	A	Sub-circular cut, 0.56m x 0.6m x 0.3m.	Posthole on W side of entrance to timber circle.
36	A	Dark brown silty clay.	Fill of C37.
37	A	Oval cut, 0.36m x 0.3m x 0.32m.	Posthole immediately adjacent to C35.
38	A	Light grey silty clay.	Fill of C41.
39	A	Light grey silty clay.	Fill of C40.
40	A	Sub-circular cut, 0.4m x 0.4m x 0.54m.	One of two conjoined postholes (C40, C41) forming NW corner of rectangular structure within timber circle.
41	A	Sub-circular cut, 0.5m x 0.62m x 0.48m.	One of two conjoined postholes (C40, C41) forming NW corner of rectangular structure within timber circle.
42	A	Grey/brown silty clay	Fill of C43
43	A	Sub-circular cut, 0.45m x 0.56m x 0.32m deep.	Posthole. Most westerly of a line of postholes to S of timber circle.
44	A	Dark brown silty clay	Fill of C45
45	A	2 sub-circular cuts linked by narrow trench. One was 0.47m x 0.52m x 0.47m deep, the other 0.36m x 0.57m x 0.36m deep.	A pair of conjoined postholes forming the NE corner of the rectangular structure within the timber circle.
46	A	Light brown silty clay	Fill of C47
47	A	Sub-circular cut, 0.2m x 0.22m x 0.14m deep.	Possible posthole, one of a row to S of timber circle.
48	A	Dark brown clayey silt.	Fill of C49
49	A	Circular cut, 0.2m diam., 0.42m deep.	One of the postholes forming the timber circle.
50	A	Dark brown silty clay.	Fill of C50
51	A	Sub-circular cut	One of the postholes forming the timber circle.
52	A	Dark brown clayey silt.	One of the postholes forming the timber circle.
53	A	No information	Fill of C54
54	A	Same as C126	One of the postholes forming the timber circle.
55	A	Compacted charcoal	Fill of C56

56	A	Oval depression 0.3m x 0.18m x 0.06m deep	Small hearth to S of timber circle.
57	A	Brown silty clay; frequent charcoal, some burnt bone and pottery	Upper fill of pit, C59
58	A	Dark brown clayey silt, some charcoal, burnt bone and pottery.	Second fill of C59
59	A	Sub-circular cut, 1.1m x 0.96m x 0.25m deep.	Pit to S of timber circle containing numerous sherds of pottery and some burnt bone.
60	A	Dark brown silty clay.	Fill of C61.
61	A	Sub-circular cut, 0.36m x 0.4m x 0.28m deep.	Isolated posthole to SW of timber circle.
62	B	Oval cut, 0.26m x 0.22m x 0.34m deep	One of two conjoined postholes (C62, C63) which form part of a curving line of postholes. Function uncertain.
63	B	Circular cut, 0.3m diam., 0.39m deep	One of two conjoined postholes (C62, C63) which form part of a curving line of postholes. Function uncertain.
64	B	Sub-circular cut, 0.36m x 0.29m x 0.31m deep	Pit or poss posthole forming a curving line along with 62, 63, 70, 72 & 73.
65	A	Oval cut, 0.42m x 0.53m x 0.48m deep	Isolated posthole to SW of timber circle.
66	A	Linear cut, NW/SE; 0.6m wide, 0.17m deep.	Furrow.
67	B	Dark brown silty clay	Fill of C68
68	B	Sub-circular cut, 0.5m x 0.4m x 0.6m deep	Isolated pit.
69	B	Light brown silty clay	Fill of C70
70	B	Sub-circular cut, 0.43m x 0.36m x 0.32m deep	Posthole forming a curving line along with 62, 63, 64, 72 & 73.
71	A	Black silt with clay inclusions	Lowest fill of pit, C59
72	B	Oval cut, 0.3m x 0.46m x 0.55m deep	One of 2 conjoined postholes (with 73) which form part of curving line along with 62, 63, 64, 70, 72 & 73
73	B	Circular cut, 0.3m diam., 0.43m deep	One of 2 conjoined postholes (with 73) which form part of curving line along with 62, 63, 64, 70, 72 & 73
74	A	Grey/brown silty clay	Fill of C75
75	A	Oval cut, 0.41m x 0.55m x 0.27m deep.	Isolated pit at southern end of Area A
76	A	Grey/brown silty clay	Fill of C77
77	A	Oval cut 0.35m x 0.3m x 0.43m deep	Isolated posthole at southern end of Area A.
78	A	Linear cut, 1m x 0.44m wide x 0.3m deep	Pit to south of timber circle. Function uncertain.

79	C	Sub-circular cut, 0.36m x 0.32m x 0.22m deep	Pit. One of a cluster of features to NW of timber circle. Function uncertain.
80	C		Small pit to S of C79. Similar dimensions. Function uncertain.
81	C	Circular cut, 0.46m diam., 0.14m deep	Pit. One of a cluster of features to NW of timber circle. Function uncertain.
82	C	Dark brown silty clay	Fill of C83
83	C	Oval cut, 0.48m x 0.3m x 0.21m deep	Pit. One of a cluster of features to NW of timber circle. Function uncertain.
84	C	Grey/brown silty clay	Fill of C85
85	C	Circular cut, 0.28m diam., 0.36m deep	Poss. Posthole. One of a cluster of features to NW of timber circle. Function uncertain.
86	C	Dark brown silty clay fil. Oval cut, 0.8m x 0.4m x 0.3m deep.	Pit. One of a cluster of features to NW of timber circle. Function uncertain.
87	C		NON-ARCHAEOLOGICAL.
88	C	Circular cut, 0.28m diam., 0.26m deep	Poss. Posthole. One of a cluster of features to NW of timber circle. Function uncertain.
89	C		NON-ARCHAEOLOGICAL.
90	D	Linear cut, 0.95m wide, 0.43m deep, extends for 4.1m from baulk	Linear ditch extending outside limit of excavation. Frequent ash and charcoal inclusions in fill. Function uncertain.
91	D	Linear cut, 2.58m x 0.8m x 0.32m	Linear pit. Function uncertain. Possibly result of tree clearance.
92	D		NON-ARCHAEOLOGICAL.
93	D		NON-ARCHAEOLOGICAL.
94	D		NON-ARCHAEOLOGICAL.
95	A	Mid-brown silty clay	Fill of C96
96	A	Oval cut, 0.42m x 0.4m x 0.27m deep	Pit adjacent to posthole C51, one of the structural postholes for the timber circle. C96 may have held a supporting post.
97	A	Dark brown silty sand.	Fill of C98
98	A	Circular cut, 0.4m diam., 0.54m deep.	One of the structural postholes forming the timber circle.
99	A	Light brown clayey silt	Fill of C100
100	A	Circular cut, 0.5m diam., 0.52m deep	One of the structural postholes forming the timber circle.
101	A	Light brown silty clay	Fill of C102
102	A	D-shaped cut, 0.35m x 0.46m x 0.32m deep.	Isolated pit to S of timber circle
103	A	Light grey silty sand, frequent charcoal.	Fill of C104.
104	A	Sub-circular cut, 0.8m diam., 0.13m deep	Isolated pit near southern end of Area A.
105	A	Light brown silty clay	Fill of C106
106	A	Sub-circular cut, 0.22m x 0.16m x 0.33m deep.	Isolated posthole

107	A	Mid-brown silty clay	Fill of C108
108	A	Oval cut, 0.28m x 0.25m x 0.57m deep	Isolated posthole
109	A	Dark brown silty clay	Fill of C110
110	A	Circular cut, 0.32m diam., 0.3m deep	One of the structural postholes forming the timber circle.
111	A	Dark brown silty clay.	Fill of C112.
112	A	Circular cut, 0.4m diam., 0.3m deep.	One of the structural postholes forming the timber circle.
113	A		Features transferred to different excavation licence number
114	A		
115	A		
116	A		
117	A	Dark brown silty clay	Fill of C118
118	A	Oval cut, 0.26m x 0.35m x 0.44m deep.	One of the structural postholes forming the timber circle.
119	A		One of the structural postholes forming the timber circle.
120	A		One of the structural postholes forming the timber circle.
121	A		One of the structural postholes forming the timber circle.
122	A		One of the structural postholes forming the timber circle.
123	A		One of the structural postholes forming the timber circle.
124	A		One of the structural postholes forming the timber circle.
125	A		One of the structural postholes forming the timber circle.
126	A		One of the structural postholes forming the timber circle.
127	A		One of the structural postholes forming the timber circle.
128	A		One of the structural postholes forming the timber circle.
129	A		Pit/posthole near S end of Area A.
130	A		Isolated pit/posthole in Area A.
131	A		Possible posthole, one of a cluster of features to S of timber circle.

Appendix 2 – Location of recovered artefacts

The following three figures show the locations of the artefacts retrieved from the site

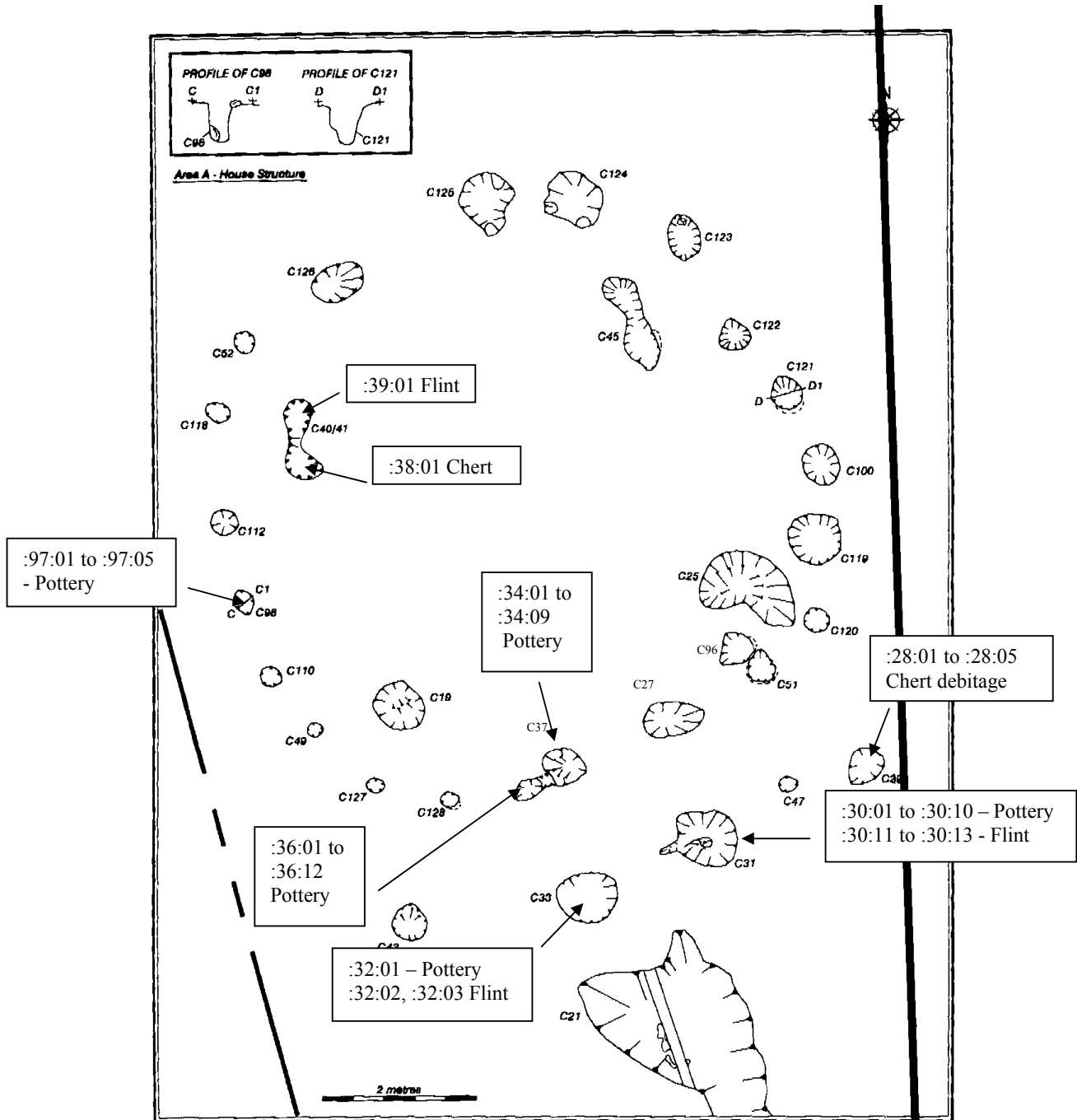


Fig. A Artefact contexts within the timber circle

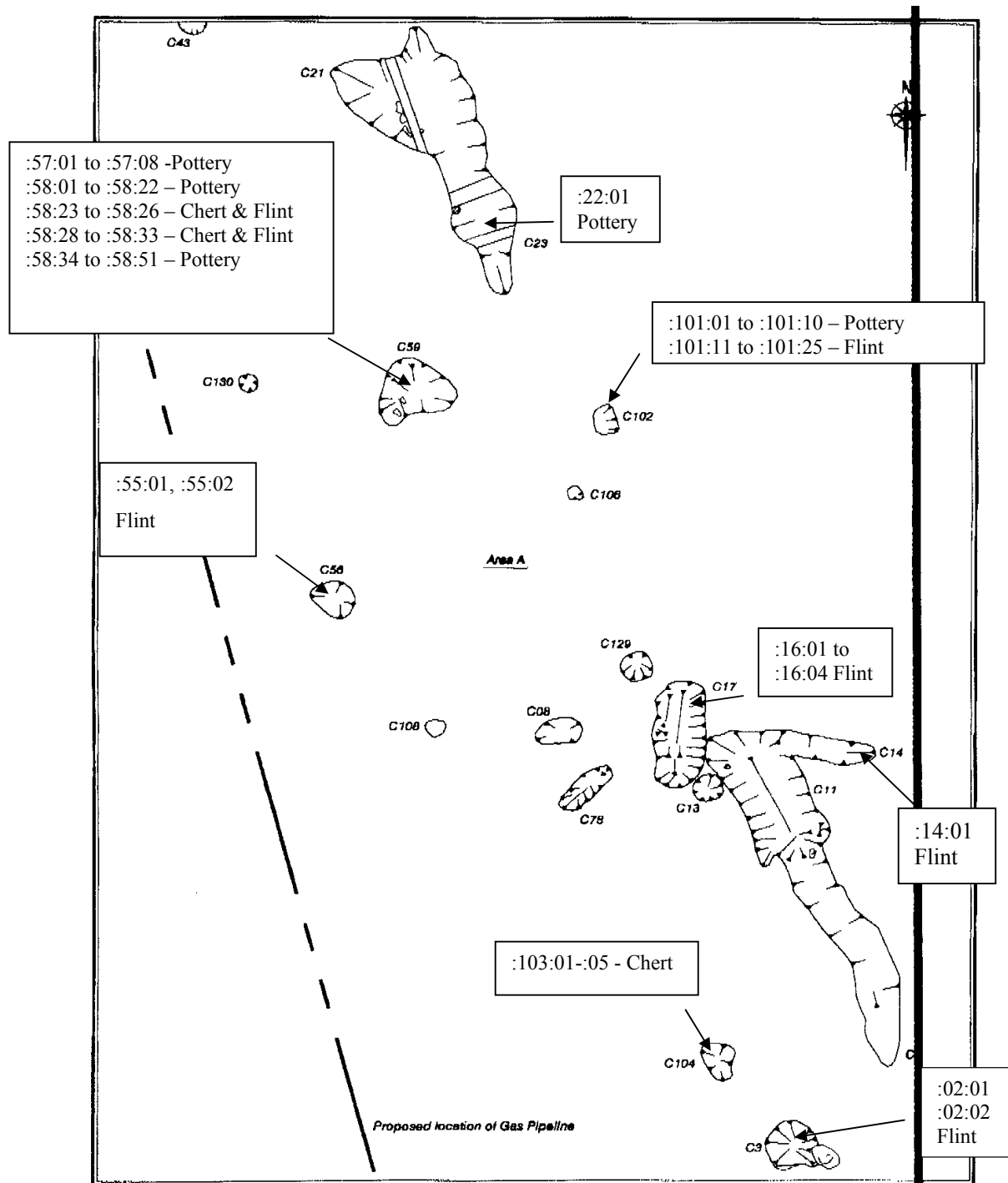


Fig. B Artefact contexts in the area to south of the timber circle

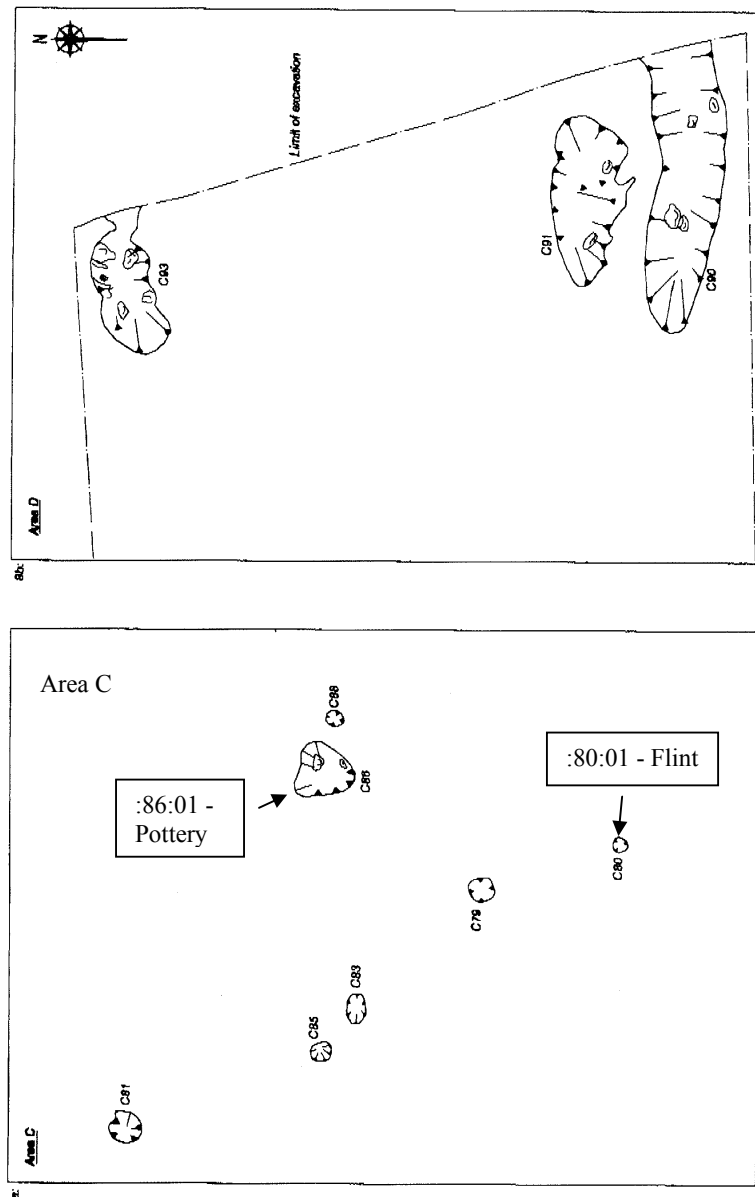


Fig. C Artefact contexts in Area C

APPENDIX 3 – Pottery identification**Kilbride, Co. Mayo 05E0833**

Helen Roche and Eoin Grogan

Grooved Ware Assemblage

Ninety-seven sherds of Grooved Ware were found during the excavation at Kilbride. These consisted of four rimsherds, five base-angle sherds, a base fragment, thirty bodysherds and fifty-seven fragments representing up to fifteen vessels (see Catalogue below). The identifications were based on the fabric matrix, featured sherds and decoration. The bulk of the sherds were uncovered in Area A with thirty-seven sherds (vessels 1-7) coming from within the pits forming the timber circle (Contexts 30, 32, 34, 36, 97), fifty-nine sherds (vessels 8-14) from within the pits immediately south of the entrance to the circle (Contexts 22, 57, 58, 101) and a single sherd (vessel 15), probably a base fragment, found within a pit in Area C (Context 86).

Based on the classification by Roche (1995, 14-23) Grooved Ware in Ireland can be divided into three styles. *Style 1* consists of fine thin-walled, mainly decorated vessels, *Style 2* are coarse thick-walled, largely undecorated vessels and *Style 3* consists of fine or coarse vessels which have overall external decoration. The Kilbride assemblage belongs to the coarser end of *Style 1* with the walls measuring from 6.1mm up to 13.8mm in thickness. *Style 1* Grooved Ware is generally of a very high quality with thin well fired walls representing some of the finest and most accomplished examples of pottery in Irish prehistory. Most examples are decorated with either grooved or twisted cord horizontal lines that are confined to the area immediately below the rim. Such decoration is mainly present on the interior surface but examples with decoration on the exterior surface or indeed on both surfaces are known (Eogan and Roche 1997, fig. 28). The Kilbride assemblage represents a poor quality coarser version of *Style 1* and is somewhat similar to Grooved Ware from the timber circle at Bettystown and a group of pits at Fourknocks, both in Co. Meath (J. Eogan 1999; King 1999, 157-198). The generally brittle and friable nature of the fabric indicates that the Kilbride potters were either not accomplished in the production of Grooved Ware or were possibly not familiar with its particular production and firing techniques.

Similar to other known Grooved Ware vessels the examples from Kilbride were coil built, as sherds from vessel 1 exhibit coil breaks. The evidence from the few featured sherds and the curvature of some of the bodysherds show that the vessels were flat-based and mainly barrel-shaped, with the body splaying out gently from the base and then curving in towards the rim. Three of the surviving rimsherds were rounded and slightly in-turned (vessels 1, 11, 14) and the fourth was flat (vessel 10). The surfaces of many of the sherds were weathered indicating that they had been exposed for some time before deposition but there were also examples showing that exterior surfaces were smoothed before firing (vessels 1, 2, 5, 6, 7, 11, 13). The colour of the fabric ranged mainly from orange to brown, sometimes with grey cores. Only three examples of decoration were present (vessels 1, 12, 14) and, consistent with known examples of Grooved Ware, this is confined to the area immediately below the rim on both exterior and interior surfaces (Eogan and Roche 1997, 148-161; 1999, 98-111). Six irregularly spaced and placed horizontal to oblique grooves are present on the exterior surface just below the rim of vessel 10 and two deeply impressed grooves are present on the interior surface just below the rim. This is unusual for Grooved Ware found in Ireland as generally decoration is carefully fashioned and placed. However, similar more carelessly decorated Grooved Ware was found on the sites at Balfarg and Balfarg/Balbirnie in Scotland (Mercer 1981; Barclay and Russell-White 1993). Decoration conforming more closely to known Irish Grooved Ware examples was present on vessels 12 and 14, in the form of part of a horizontal groove on the exterior surface of the bodysherd (vessel 12), which indicates that it is from just below the rim; and two irregularly spaced horizontal grooves on the interior surface just below the rim of vessel 14. Carbonised matter, which is a common feature on Grooved Ware from other Irish sites, was present on the interior surfaces of vessels 4, 6, 7, 8, 12 and 14, on the exterior surface of vessel 13 and on both surfaces of vessels 2, 10 and 11, indicating that they had been used for cooking at some stage in their history of use.

Discussion

Grooved Ware has been an established Late Neolithic pottery type in Britain since Stuart Piggott's reappraisal of the pottery assemblage from Clacton, on the coast of Essex (Piggott in Warren *et al.* 1936, 191). However, in Ireland it is a relatively new addition to the Late Neolithic pottery assemblage, despite Seán P. Ó Ríordáin's reference to it in his Grange, Co. Limerick, publication (1951, 62-63). Because of recent research (Roche 1995; Brindley 1999, 23-35) and the excavation of new sites that have produced large assemblages of Grooved Ware, it is now an established additional phase in Irish prehistory, dating to c. 2882-2459 cal.

BC (Eogan and Roche 1997, 219). The dates 2900-2850 and 2820-2670 cal. BC obtained from Kilbride fit in perfectly to this period. Although still not plentiful and with a notable concentration in the north-eastern part of the country over fifteen sites have now been identified: six of these are timber circles (Fig. 1), which obviously represent sites where activity of a ritual or ceremonial nature was carried out. The Kilbride timber circle and associated assemblage is one of the latest additions to the growing number of Grooved Ware sites in Ireland. Its presence in Co. Mayo is especially significant in representing the first Grooved Ware associated timber circle in this region. Coincidentally, another recent excavation in Co. Mayo at Lowpark on the Charlestown bypass produced 1500 sherds of Grooved Ware from a single pit (information from Richard Gillespie). A timber circle was not apparently identified but the presence of one cannot be dismissed. The Kilbride site is also important for our understanding of Grooved Ware sites in Ireland in that it represents one of the few Grooved Ware sites where Beaker pottery is not present, another example being at Bettystown, Co. Meath (J. Eogan 1999). This is an important factor as in the past Grooved Ware has often been regarded as representing an aspect of Beaker assemblages rather than representing an autonomous phase.

The Kilbride timber circle is similar in plan to those from Knowth, Co. Meath, Whitewell, Co. Westmeath, and Ballynahatty, Co. Down (Eogan and Roche 1997, fig. 21; Phelan 2002, 514; Hartwell 1998, 32-44), with their well defined entrances and internal square settings of four large post-pits. Although few of the Kilbride timber circle pits contained pottery it is interesting to note that the location of the pits that did contain sherds correspond somewhat with those recorded from both the Knowth and Bettystown timber circles in Co. Meath (Eogan and Roche 1997, 101-222; fig. 40; Roche 2000). A similar feature was also observed Whitewell, Co. Westmeath. At these three sites concentrations of sherds were especially prominent within the post-holes that formed the entrance. The deliberate placing of finds in the entrance area has also been observed on British Grooved Ware sites; for example, at the Wyke Down henge in Dorset it was noted that this area produced pottery with the most complex decoration (Cleal in Barrett, Bradley and Hall 1991, 141-142).

The concentration of pits containing Grooved Ware immediately south of the entrance to the timber circle is also interesting. The similarity of the pottery to that from the circle points towards the contemporaneity of both areas and the positioning of the external pits might represent a ceremonial approach leading to the circle entrance. Although it is difficult to

establish a direct relationship between the pottery uncovered in Area A and the single sherd found in Area C (86:1), the sherd is similar in form to the Grooved Ware assemblage and it can be suggested that both areas form part of this overall Grooved Ware complex.

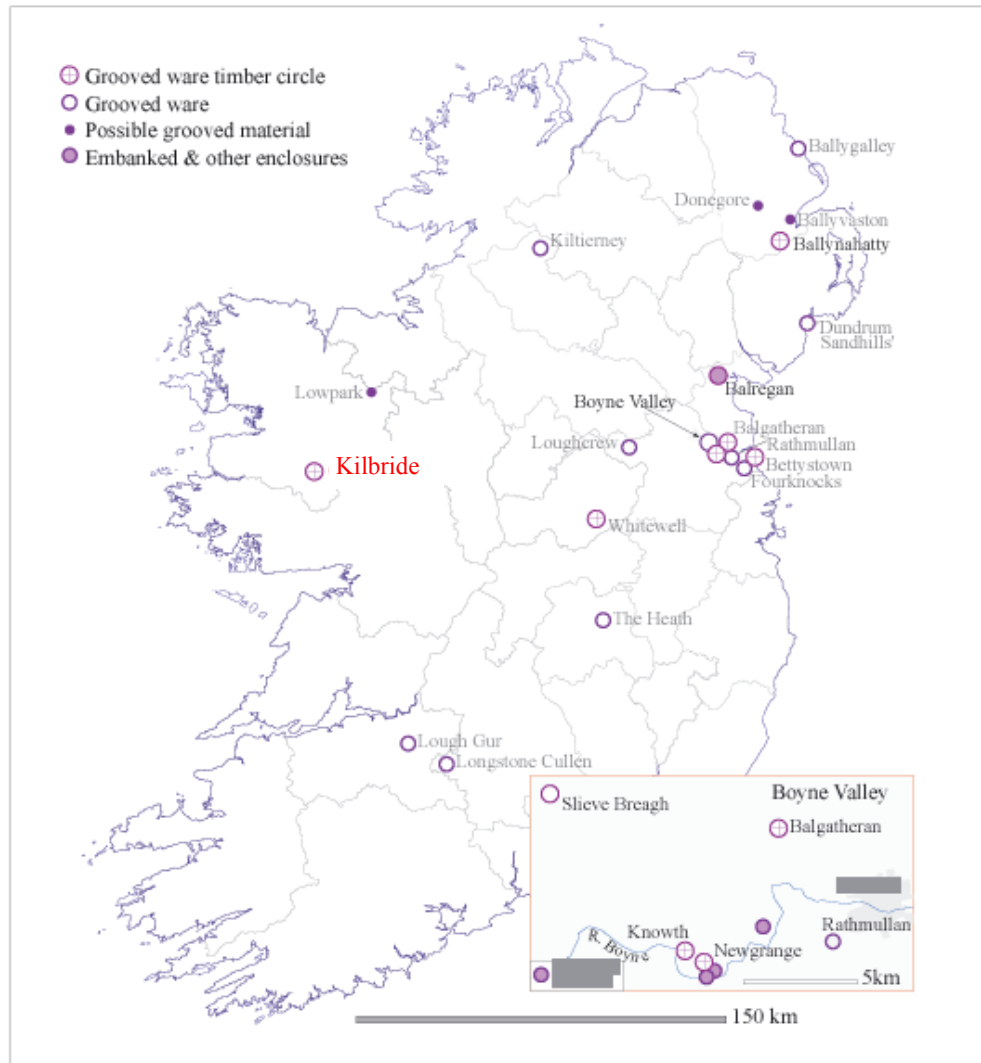


Fig. 1. Distribution of Grooved Ware sites in Ireland (inset: the Boyne Valley).

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Catalogue

Vessels from timber circle:

Vessel 1. Rimsherd 30:8 and four bodysherds 30:5, 9, 7, 10.

Slightly in-turned rounded rim. Thick-walled reasonably compact fabric with a moderate content of inclusions ($\leq 2.4\text{mm}$). The sherds are weathered but the surviving areas of the exterior surface are smooth. Sherds 5 and 9 have coil breaks. Colour: orange/grey/orange-grey. Thickness: 10.4-12.2mm.

Vessel 2. Two base-angle fragments **30:1**, 2 and two fragments **30:3**, 4.

Thin-walled poor quality crumbly fabric with a low content of inclusions ($\leq 3.2\text{mm}$). The sherds are weathered but the surviving surfaces show that the exterior surface had been smoothed. Traces of carbonised matter are present on the exterior and interior surfaces. Colour: orange throughout. Thickness: 7.2-8.0mm.

Vessel 3. Base-angle fragment **30:6**.

Poor quality friable fabric with a low content of coarsely crushed inclusions ($\leq 4.0\text{mm}$). The exterior surface has been smoothed, the interior surface is missing. Colour: Buff with a grey core. Thickness: 9.0mm.

Vessel 4. Bodysherd **32:1**.

Thin-walled compact fabric with a low content of inclusions ($\leq 2.4\text{mm}$). The exterior surface is smooth and traces of carbonised matter are present on the interior surface. Colour: orange/orange/black. Thickness: 6.1mm.

Vessel 5. Nine bodysherds **34:1**, 2, 3, **36:1-6** and twelve fragments **34:4-9**, **36:7-12**.

Thick-walled fabric, slightly sandy in texture with a moderate content of inclusions ($\leq 4.6\text{mm}$). All sherds show evidence for weathering but surviving areas of the exterior surface show that the fabric had been smoothed. It is possible that more than one vessel is present but the fabric is too similar to be certain. Colour: mainly orange throughout. Thickness: 10.2-12.0mm.

Vessel 6. Three bodysherds **97:1-3**.

Thin-walled brittle fabric with a moderate content of inclusions ($\leq 2.6\text{mm}$). The sherds are weathered but surviving areas of the exterior surface show that it had been smoothed. Carbonised matter is present on the interior surface. Colour: orange/grey/black. Thickness: 6.2-7.0mm.

Vessel 7. Two bodysherds **97:4**, 5.

Hard compact, good quality fabric with a moderate content of inclusions ($\leq 3.0\text{mm}$). The sherds are slightly weathered but the exterior surface is smooth. Carbonised matter is present on the interior surface. Colour: dark orange/dark orange/black. Thickness: 8.9mm.

From pits south of timber circle:

Vessel 8. Base-angle sherd 22:1.

Thick-walled but good quality fabric with moderate content of inclusions ($\leq 2.2\text{mm}$). The exterior surface has been smoothed but inclusions protrude through areas of the interior of the base. Traces of carbonised matter are present on the interior surface. The base is unusually constructed as the base and body are moulded as a unit. Colour: orange/grey/orange.

Thickness: 11.7mm.

Vessel 9. One bodysherd 57:1 and seven fragments 57:2-8.

Thick-walled friable, slightly pasty-textured fabric with a high content of inclusions (≤ 4.9).

The surface of the sherds are weathered and uneven. Colour: orange/grey-brown/orange.

Thickness: 12.2-13.8mm.

Vessel 10. Rimsherd 58:22, base-angle sherd 58:35, two bodysherds 58:1,2 and twenty three fragments 58:3-12, 38-50.

Slightly in-turned rounded rim and the body splays outwards from the base. Hard, friable fabric poor quality fabric with a high content of inclusions ($\leq 8.0\text{mm}$). The fabric is weathered and the surfaces are uneven and inclusions protrude through the surface. Decoration consists of up to six irregularly spaced and placed horizontal to oblique grooves, on the exterior surface just below the rim. Two deeply impressed grooves are present on the interior surface just below the rim. Traces of carbonised matter are present on both surfaces. Colour: orange/grey-brown/orange. Thickness: 8.7-12.8mm.

Vessel 11. Rim fragment 58:13, four bodysherds 58:14-16, 37 and five fragments 58:17-21.

Flat rim with thick-walled hard friable fabric with a high content of inclusions ($\leq 8.9\text{mm}$). The weathered sherds have uneven surfaces but were originally of good quality and the exterior surfaces had been smoothed. Slight traces of carbonised matter are present on both surfaces. Colour: orange/grey-brown/orange. Thickness: 10.8-11.9mm.

Vessel 12. Bodysherd 58:34.

Thick-walled poor quality friable fabric with a high content of inclusions ($\leq 5.4\text{mm}$). The sherd is weathered and the surfaces are uneven. Part of a horizontal groove is present on the exterior surface (which is probably close to the rim). Slight traces of carbonised matter are present on the interior surface. Colour: orange throughout. Thickness: 11.8mm.

Vessel 13. Bodysherd **58:51**.

Compact good quality fabric with a moderate content of inclusions ($\leq 2.6\text{mm}$). The sherd is slightly weathered but the exterior surface had been smoothed. Slight traces of carbonised matter are present on the exterior surface. Colour: orange/grey/orange. Thickness: 8.9mm.

Vessel 14. Rim **101:1**, a bodysherd **101:2** and eight fragments **101:3-10**.

Slightly in-turned rounded rim with two irregularly spaced horizontal grooves on the interior surface just below the rim. Thin-walled compact good quality fabric with a moderate content of inclusions ($\leq 4.3\text{mm}$). The sherds are slightly weathered but the exterior surface had been smoothed. Traces of carbonised matter are present on the interior surface. Colour: orange/brown/orange-black. Thickness: 6.9-8.1mm.

From pit north-west of timber circle:

Vessel 15. Probable base fragment **86:1**.

Good quality compact fabric with a low to moderate content of inclusions ($\leq 2.0\text{mm}$). The surfaces are smooth. Colour: orange throughout. Thickness: 13.1mm.

Appendix 4 - Charcoal identification

SPECIES IDENTIFICATION OF CHARCOAL SAMPLES FROM KILBRIDE, CO. MAYO (05E0833)

ELLEN OCARROLL

SEPTEMBER 2006

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1. INTRODUCTION
2. Methods
3. Results
4. Discussion
5. Conclusions
7. References

1. Introduction

Ten charcoal samples from a series of excavated features in Kilbride townland, Co. Mayo were submitted for analysis. The principal feature of the site was a circular structure measuring 8m in diameter, interpreted as a Late Neolithic timber circle. The structure was formed of a ring of 19 postholes. Within this circle four large postholes formed a rectangular pattern. Samples of charcoal from these four postholes (**C24, 26, 39 & 44**) were submitted for identification and analysis. One oak sample from **C44** was then radiocarbon dated to Cal BC 2900 to 2850 & Cal BC 2820 to 2670 or the Late Neolithic. The entrance to the structure faced south and had a protruding external porch. There was no evidence for an internal hearth, but a small area of burnt clay c. 11m to the south of the house was also sampled and analysed (**C55**). It may have been the remains of an external hearth. Other features around the burnt area did not form any coherent pattern, but included a small pit (**C58**) which yielded some burnt bone and 47 sherds of pottery. Charcoal was also analysed and dated from this pit and yielded a date of Cal BC 2870 to 2470. Other samples analysed included the fill of a posthole (**C69**) in Area B and fill of a pit (**C86**) in Area C.

The charcoal was sent for species identification prior to ^{14}C dating, and also to obtain an indication of the range of tree species which grew in the area, as well as the utilization of these species for various functions. Wood used for fuel at pre-historic sites would generally have been sourced 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.

2. 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 so as a clean section of the wood can be obtained. This charcoal is then identified to species under an Olympus SZ3060 x 80-zoom stereomicroscope. 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. All samples were suitable for species identification.

3. RESULTS

Table 1: Results from charcoal identifications at Kilbride/Gortaphuntaun

Context/Sample no.	Context type	Date	Species and Weight	Comment
05E833:C24:S11	Fill of C25, structural posthole, part of Late Neolithic Structure	Undated	Oak (2g) & Alder (6.1g)	Alder suitable for conventional dating
05E833:C26:S7	Fill of C27, structural posthole, part of Late Neolithic Structure	Undated	Tiny pieces of oak (8g)	Not suitable if you want a tight date range
05E833:C39:S18	Fill of C40, structural posthole, part of Late Neolithic Structure	Undated	Tiny pieces of oak (37g)	Not suitable if you want a tight date range
05E833:C44:S20	Fill of structural posthole, part of Late Neolithic Structure	Cal BC 2900 to 2850 & Cal BC 2820 to 2670	Oak (2g)	Not suitable if you want a tight date range
05E833:C55:S22	Fill of C56, hearth to south of Late Neolithic Structure	Undated	All alder (48g)	Bagged 6 g for conventional dating
05E833:C58:S24	Middle fill of C59, pit to south of Late Neolithic Structure	Cal BC 2870 to 2470	All Hazel (160g)	Bagged 6 g for conventional dating
05E833:C69:S28	Fill of C70, one of a group of postholes in Area B	Cal BC 3010 to 2880	Oak (3.8g) & Alder (0.2g)	Alder suitable for AMS date
05E833:C86:S30	Fill of pit, one of an isolated group of features in Area C	Undated	Oak, alder and blackthorn & Seeds and grasses	1g of alder and blackthorn bagged separately for AMS dating

Table 2: Species represented in the identified samples

Botanical name	Species	Weight
<i>Quercus sp</i>	Oak	57.8g
<i>Corylus avellana</i>	Hazel	160g
<i>Alnus glutinosa</i>	Alder	55.3g
<i>Prunus spinosa</i>	Blackthorn	1g

4. Discussion

There are four species types present in the charcoal remains. The range of species identified from the excavated features analysed includes large (oak) and smaller (hazel and alder) trees and some scrub (blackthorn).

Oak (*Quercus sp.*) was identified from all the structural postholes associated with the Late Neolithic timber circle (**C24, 26, 39, & 44**). It was also identified from the posthole **C69** in Area B and the undated pit in Area C (**C86**). It is not surprising that oak was selected for use in this Late Neolithic Structure as throughout all periods of prehistory and history oak has been used for structural timbers. Analysis of timber excavated from a similar type timber circle at Bettystown in Co. Meath (98E0072) produced similar results. All of the charcoal identified from the post pipes at Bettystown was shown to be of oak (O Carroll, unpublished report). The use of oak timber is possibly related to the timbers unique properties of great durability and strength.

The oak identified suggests that there was a supply of oak in the surrounding environment at Kilbride in the Late Neolithic Period. Pollen research conducted at various sites throughout Ireland has shown that oak along with elm woodlands were prevalent in the earlier periods to be replaced by ash in the woodland clearings created by the first farmers (Hall & Pilcher 2001, 35). Oak has been identified from several excavated Neolithic houses throughout Ireland.

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 could have been selected from mixed woodlands nearby.

A large amount of hazel (*Corylus avellana*) was identified from the fill of the pre-historic pit (**C58**). The amount of hazel charcoal may indicate that this pit was lined with hazel wattle.

Hazel was very common up to the end of the 17th century and was used for the manufacture of many wooden structures such as wattle walls, posts, trackways and baskets. McCracken (1971, 19) points out that “it was once widespread to a degree that is hard to imagine today”. With the

introduction of brick, steel and slate the crafts associated with hazel became obsolete, and today the woods that supplied hazel have diminished rapidly. Hazel is normally only about 3-5m in height and is often found as an understory tree in deciduous woods dominated by oak. It also occurs as pure copses on shallow soils over limestone as in The Burren in Co. Clare and survives for 30 to 50 years. Its main advantage is seen in the production of long flexible straight rods through the process known as coppicing.

Alder (*Alnus glutinosa*) was identified from the fill of the pre-historic hearth **C56**, a posthole **C69**, and a pit **C86**. Alder wood produces good charcoal and was used in the making of gunpowder in the Post Medieval period (Edlin).

Alder is a widespread native tree and occurs in wet habitats along streams and riverbanks. Alder also grows regularly on fen peat. It is an easily worked and split timber and does not tear when worked. Alder is commonly identified from wood remains associated with wet/boggy areas.

Blackthorn (*Prunus spinosa*) was identified from the pre-historic pit (**C86**). Blackthorn is a very durable wood and is as strong as oak. It is a thorny shrub found in woods and scrub on all soil types. In a woodland situation it is more likely to occur in clearings and at the woodland edges. The collection of blackthorn was probably the selection of scrub from nearby to the site in hedgerows and open clearings.

5. CONCLUSIONS

Four species were identified from the sites and features investigated. Oak was selected for certain structural requirements within the Late Neolithic Period. Oak was particularly prevalent in the post material identified from the Neolithic timber circle. This compares to other Late Neolithic timber circles analysed particularly from an excavated example at Bettystown, Co. Meath where all the timber posts were identified as oak (O Carroll, unpublished report). Pollen research conducted at various sites throughout Ireland has shown that oak along with elm woodlands were prevalent in the earlier periods to be replaced by ash in the woodland clearings created by the first farmers (Hall & Pilcher 2001, 35). The majority of Neolithic houses have also been shown to be constructed of oak. Oak has been identified from slot trenches associated with an early Neolithic house in Ballynagilly, Co. Tyrone (Hall & Pilcher 2001, 29), Kilgobbin, Co. Dublin (03E0306) and Monanny, Co. Monaghan (03E0888). Later Bronze Age round houses at Clonfinlough Co. Offaly was largely constructed of ash and hazel (IAWU, Transactions 2).

The large amount of hazel identified from the pre-historic pit **C58** may have been used as wattling or posts within the pit as hazel is generally associated with such activities.

Alder is generally associated with a wetland environment. Its property as an excellent charcoal was obviously exploited in the Early Medieval charcoal production pit. It is difficult to attribute a function to the alder charcoal identified from the pre-historic features but the wood may have simply being collected from nearby as kindling for the fires.

The local environment of the sites is mainly indicative of a dryland environment in the Late Neolithic Period. The oak and hazel would have grown in drier conditions preferring free-draining soils and nutrient-rich clays. A small amount of alder was also present in a posthole and pit which suggests a waterlogged environment in the area.

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APPENDIX 5 - Radiocarbon Dating Results

Sample Data	Measured Radiocarbon Age	¹³ C/ ¹² C Ratio	Conventional Radiocarbon Age(*)
Beta - 217655 BP SAMPLE : 05E833C44S20 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2900 to 2850 (Cal BP 4850 to 4800) AND Cal BC 2820 to 2670 (Cal BP 4770 to 4620)	4210 +/- 40 BP	-25.2 o/oo	4210 +/- 40
Beta - 217656 BP SAMPLE : 05E833C58S24 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2870 to 2470 (Cal BP 4820 to 4420)	4090 +/- 60 BP	-26.1 o/oo	4080 +/- 60
Beta - 217657 BP SAMPLE : 05E833C69S28 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 3010 to 2880 (Cal BP 4960 to 4830)	4330 +/- 40 BP	-26.2 o/oo	4310 +/- 40

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.2;lab. mult=1)

Laboratory number: **Beta-217655**

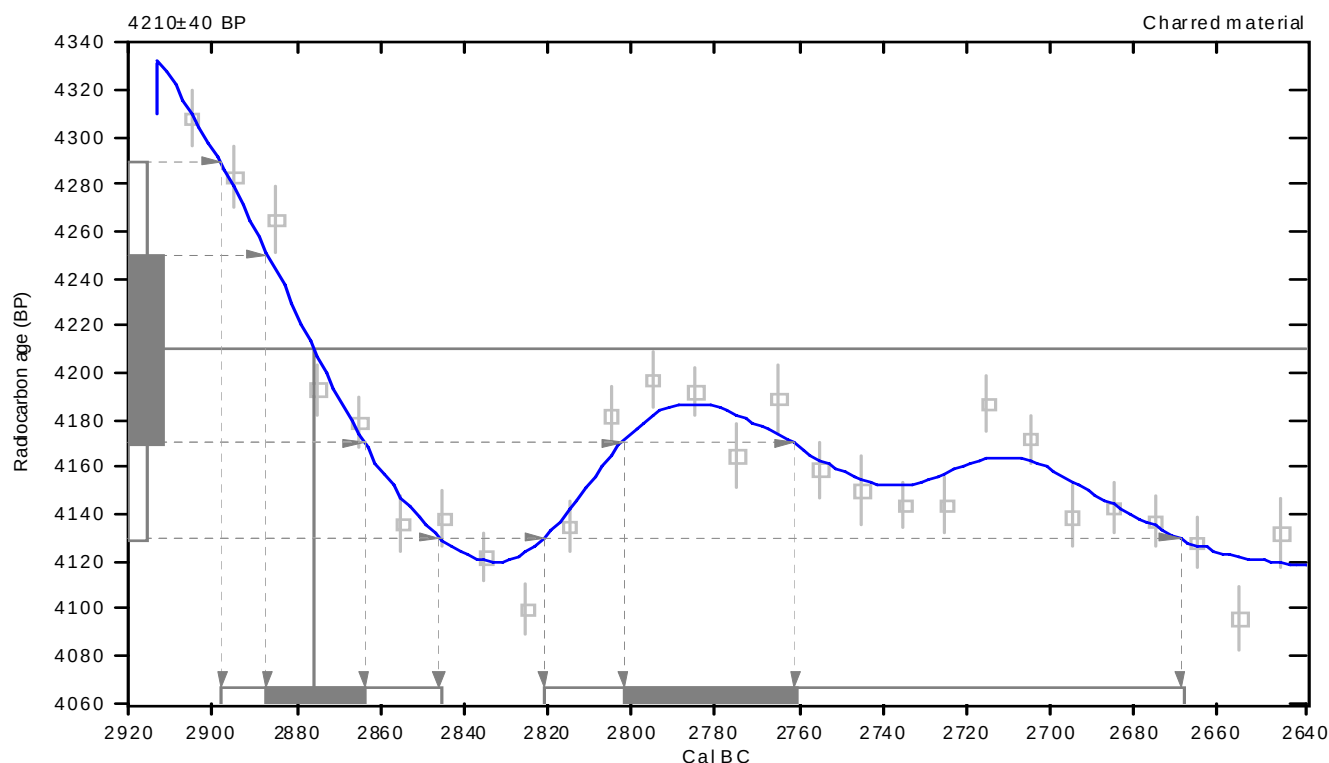
Conventional radiocarbon age: **4210±40 BP**

2 Sigma calibrated results: **Cal BC 2900 to 2850 (Cal BP 4850 to 4800) and**
(95% probability) Cal BC 2820 to 2670 (Cal BP 4770 to 4620)

Intercept data

Intercept of radiocarbon age
 with calibration curve: **Cal BC 2880 (Cal BP 4830)**

1 Sigma calibrated results: **Cal BC 2890 to 2860 (Cal BP 4840 to 4810) and**
(68% probability) Cal BC 2800 to 2760 (Cal BP 4750 to 4710)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, *Radiocarbon* 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, *Radiocarbon* 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.1;lab. mult=1)

Laboratory number: Beta-217656

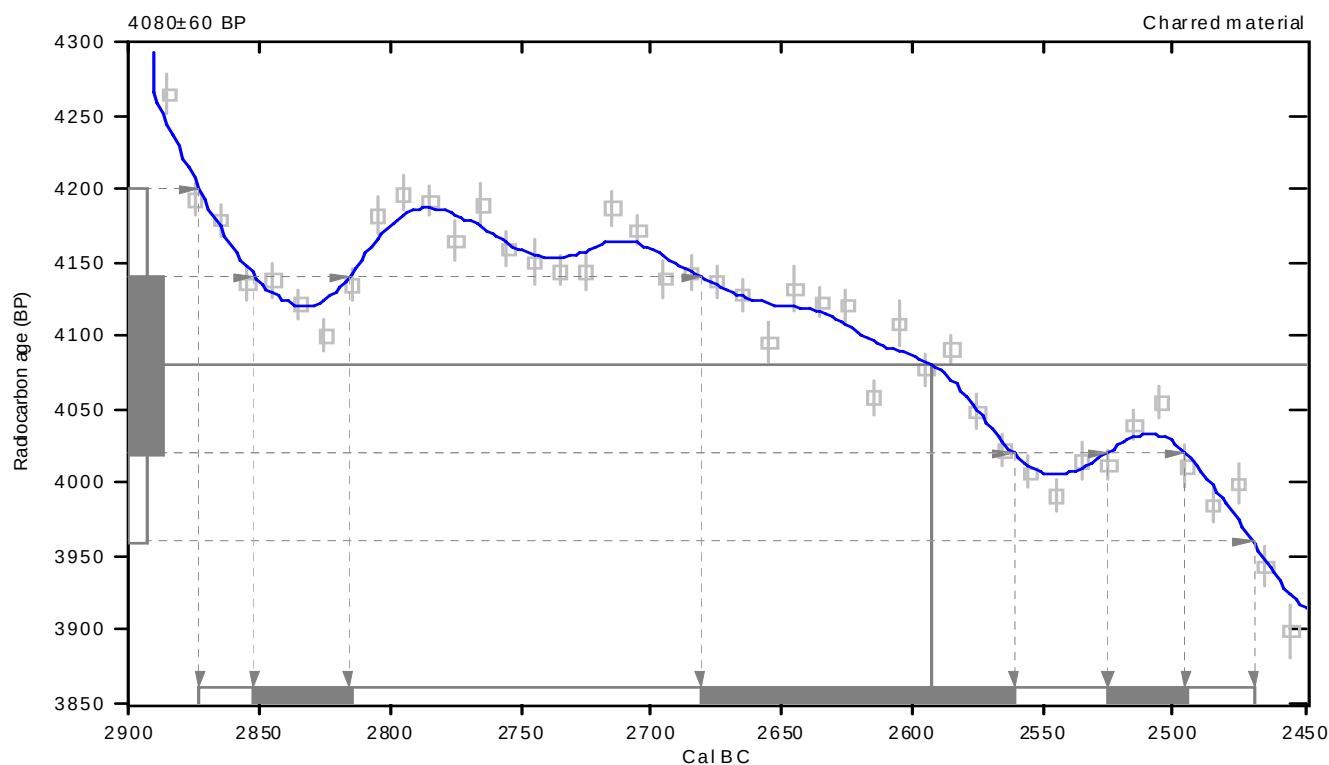
Conventional radiocarbon age: 4080±60 BP

2 Sigma calibrated result: Cal BC 2870 to 2470 (Cal BP 4820 to 4420)
(95% probability)

Intercept data

Intercept of radiocarbon age
 with calibration curve: Cal BC 2590 (Cal BP 4540)

1 Sigma calibrated results: Cal BC 2850 to 2820 (Cal BP 4800 to 4770) and
 (68% probability) Cal BC 2680 to 2560 (Cal BP 4630 to 4510) and
 Cal BC 2520 to 2500 (Cal BP 4480 to 4440)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2;lab. mult=1)

Laboratory number: Beta-217657

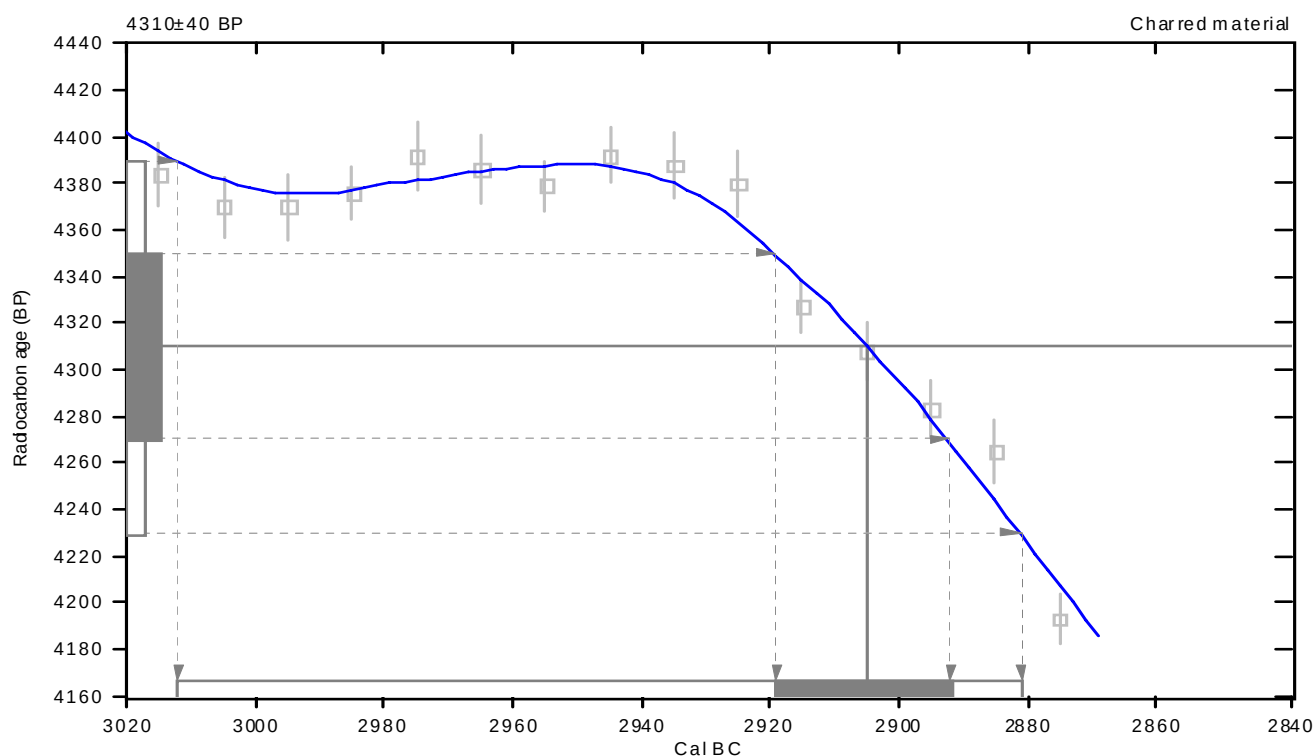
Conventional radiocarbon age: 4310±40 BP

2 Sigma calibrated result: Cal BC 3010 to 2880 (Cal BP 4960 to 4830)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 2900 (Cal BP 4860)

1 Sigma calibrated result: Cal BC 2920 to 2890 (Cal BP 4870 to 4840)
(68% probability)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

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Mathematics

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APPENDIX 6 – The Lithics Report

MAYO GALWAY BORD GAIS
CHIPPED AND WORKED STONE ASSEMBLAGE

ANALYSIS, CATALOGUES AND REPORTS

Kilbride (05E0833)
Barreel 1 (06E0807)
Caltragh 1 (05E0584)
Grallagh 1 (05E0740)

DR EIMÉAR NELIS MA PHD MIAI

MAY 2007

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Introduction

A programme of archaeological excavation at the Mayo-Galway Bord Gais project, resulted in the recovery of chipped, worked and unworked stone artefacts from a total of four sites, namely: Kilbride (05E0833); Barreel 1 (06E0807); Caltragh 1 (05E0584); Grallagh 1 (05E0740). For each site assemblage, a similar analytical methodology has been applied (see Methodology below). In the report which follows, the analysis for each site assemblage is presented in a separate section; within these, the assemblages are quantified and presented in catalogue form, and the composition of the assemblage is discussed in detail. Subsequently, the distribution of the assemblages is presented, and the assemblages are discussed in their broader analytical context.

Methodology

All recovered artefacts have been presented for analysis, and have been studied visually and catalogued, and subject to statistical analysis based on the following attributes: contextual information (including context/feature/sample number etc), basic condition, extent of abrasion, material, colour, cortex, basic character and detailed classification, platform and termination type (where relevant for chipped stone), detail of working (where relevant), length (L), breadth (B), thickness (T), fragment size (given in mm) and mass (g). The criteria upon which these attributes have been selected, and the analytical methodology deployed, are presented in further detail elsewhere (Nelis 2003).

Section 1: Kilbride (05E0833)

Introduction

Excavations at Kilbride (05E0833) uncovered a series of archaeological deposits; these yielded an assemblage of 57 worked and unworked pieces of flint and chert (Table 1.1).

Analysis and discussion

Unique No	Context	Material	Condition	Cortex	Character	Classification	Frag size (mm)	Length (mm)	Breadth (mm)	Thickness (mm)	Mass (g)
05E0833:1:1	1	Flint	Fresh	Secondary	Flakes	Bipolar complete	-	27	14	3	1.56
05E0833:1:2	1	Flint	Patinated	Tertiary	Flakes	Bipolar complete	-	25	18	7	3.28
05E0833:1:3	1	Flint	Fresh	Secondary	Flakes	Bipolar complete	-	22	19	8	3.87
05E0833:1:4	1	Flint	Patinated	Tertiary	Modified	Scraper	-	48	35	9	18.52
05E0833:2:1	2	Flint	Fresh	Tertiary	Flakes	Platform shatter proximal	21	-	18	5	1.68
05E0833:2:2	2	Flint	Fresh	Tertiary	Flakes	Bipolar complete	-	28	18	7	1.48
05E0833:14:1	14	Flint	Fresh	Tertiary	Flakes	Platform shatter medial	50	-	39	8	13.29
05E0833:16:1	16	Flint	Fresh	Tertiary	Flakes	Platform blade shatter prox	32	-	26	12	9.54
05E0833:16:2	16	Flint	Patinated	Tertiary	Flakes	Platform shatter proximal	14	-	15	3	0.38
05E0833:16:3	16	Flint	Fresh	Tertiary	Flakes	Bipolar shatter proximal	15	-	18	3	0.67
05E0833:16:4	16	Flint	Burnt	Tertiary	Flakes	Indeterminate flake shatter	26	-	14	2	0.83
05E0833:28:1	28	Chert	Abraded	Secondary	Flakes	Platform core trimming	-	20	20	6	1.73
05E0833:28:2	28	Chert	Abraded	Secondary	Flakes	Platform complete	-	25	18	6	2.14
05E0833:28:3	28	Chert	Fresh	Tertiary	Flakes	Bipolar shatter medial	25	-	12	2	0.89
05E0833:28:4	28	Chert	Fresh	Secondary	Flakes	Platform complete pressure	-	17	14	3	0.35
05E0833:28:5	28	Chert	Fresh	Tertiary	Flakes	Platform shatter distal pressure	10	-	14	2	0.21
05E0833:30:1	30A	Flint	Patinated	Tertiary	Flakes	Platform blade complete	-	60	28	14	16.33
05E0833:30:12	30	Flint	Patinated	Secondary	Modified	Utilised	-	42	25	6	7.14
05E0833:30:13	30	Flint	Fresh	Tertiary	Flakes	Indeterminate flake shatter	19	-	5	3	0.59
05E0833:32:2	32	Flint	Fresh	Tertiary	Modified	Scraper	-	52	28	6	8.66
05E0833:32:3	32	Chert	Burnt	Tertiary	Modified	Scraper	28	-	24	7	5.17
05E0833:38:7	38	Chert	Fresh	Tertiary	Flakes	Bipolar shatter distal	28	-	21	6	3.39
05E0833:39:1	39	Flint	Fresh	Secondary	Modified	Scraper	-	31	31	9	6.53
05E0833:55:1	55	Flint	Fresh	Secondary	Flakes	Bipolar blade complete	-	20	9	3	0.54
05E0833:55:2	55	Flint	Fresh	Tertiary	Flakes	Platform complete pressure	-	12	13	1	0.28
05E0833:58:23	58	Chert	Fresh	Tertiary	Flakes	Bipolar shatter distal	22	-	25	5	3.61
05E0833:58:24	58	Chert	Fresh	Tertiary	Flakes	Bipolar shatter distal	28	-	20	7	4.91
05E0833:58:25	58	Flint	Burnt	Tertiary	Flakes	Indeterminate flake shatter	18	-	17	5	0.82
05E0833:58:26	58	Flint	Fresh	Primary	Unworked	Thermal flake	-	52	47	23	47.21

05E0833:58:28	58	Chert	Fresh	Tertiary	Flakes	Bipolar complete	-	24	22	6	2.87
05E0833:58:29	58	Chert	Fresh	Tertiary	Flakes	Bipolar complete	-	37	29	7	5.36
05E0833:58:30	58	Chert	Burnt	Tertiary	Flakes	Platform complete core trimming	-	15	20	10	2.20
05E0833:58:31	58	Chert	Burnt	Tertiary	Flakes	Platform complete core trimming	-	14	20	4	0.38
05E0833:58:32	58	Chert	Burnt	Tertiary	Flakes	Platform complete blade	-	28	14	2	.74
05E0833:58:33	58	Chert	Burnt	Tertiary	Flakes	Platform complete core trimming	-	15	24	5	0.93
05E0833:67:7	67	Flint	Fresh	Tertiary	Flakes	Platform shatter distal	31	-	35	10	8.39
05E0833:80:1	80	Flint	Fresh	Tertiary	Flakes	Platform shatter distal	15	-	8	2	0.36
05E0833:103:52a	103	Chert	Fresh	Tertiary	Flakes	Platform shatter distal	8	-	10	1	0.05
05E0833:103:52b	103	Chert	Fresh	Tertiary	Flakes	Platform complete	-	8	5	2	0.12
05E0833:103:52c	103	Chert	Fresh	Tertiary	Flakes	Platform shatter distal	8	-	5	1	0.40
05E0833:103:52d	103	Chert	Fresh	Tertiary	Flakes	Platform complete pressure	-	10	12	2	0.21
05E0833:103:52e	103	Chert	Fresh	Tertiary	Flakes	Platform complete core trimming	-	21	13	4	0.86
05E0833:101:11	101	Flint	Fresh	Tertiary	Flakes	Platform complete	-	30	25	4	3.42
05E0833:101:12	101	Flint	Fresh	Primary	Flakes	Indeterminate flake shatter	35	-	25	7	6.87
05E0833:101:13	101	Flint	Fresh	Tertiary	Flakes	Platform complete	-	23	15	2	0.84
05E0833:101:14	101	Flint	Fresh	Tertiary	Unworked	Thermal flake	-	18	15	5	0.89
05E0833:101:15	101	Flint	Fresh	Tertiary	Angular shatter	Bipolar	-	25	16	6	1.94
05E0833:101:16	101	Flint	Fresh	Tertiary	Flakes	Platform complete blade	-	20	9	2	0.27
05E0833:101:17	101	Flint	Fresh	Tertiary	Flakes	Platform complete core trimming	-	17	16	5	1.38
05E0833:101:18	101	Flint	Fresh	Secondary	Flakes	Platform shatter blade distal	20	-	10	2	0.38
05E0833:101:19	101	Flint	Fresh	Tertiary	Flakes	Indeterminate flake shatter	15	-	10	1	0.23
05E0833:101:20	101	Flint	Fresh	Tertiary	Flakes	Platform complete pressure	-	13	13	2	0.31
05E0833:101:21	101	Flint	Fresh	Tertiary	Flakes	Platform complete pressure	-	12	12	3	0.61
05E0833:101:22	101	Flint	Fresh	Tertiary	Flakes	Platform complete	-	15	14	7	1.01
05E0833:101:23	101	Flint	Fresh	Secondary	Flakes	Bipolar complete	-	17	12	6	0.86
05E0833:101:24	101	Flint	Fresh	Tertiary	Angular shatter	Angular shatter	-	17	10	3	0.41
05E0833:101:25	101	Flint	Fresh	Tertiary	Flakes	Bipolar shatter proximal	11	-	15	4	0.39

Table 1.1: Kilbride (05E0833): showing basic attributes of artefacts.

An assemblage of 57 worked and unworked pieces of flint and chert were recovered from a total of 15 deposits at Kilbride. Flint accounted for the majority of artefacts (37/57 pieces) with the remainder being chert (20/57 pieces) (Table 1.2). Of the total assemblage, only two unworked pieces were recovered, both of which were flint. Most of the remainder of the assemblage were primary knapping debitage, specifically comprised of flake debitage (48/57 pieces: 29 flint, 19 chert) and angular shatter (2/57 pieces: 2 flint); no cores (from which such a debitage assemblage would have been reduced)

were recovered. A number of modified tools were also found (5/57 pieces: 4 flint, 1 chert), accounting for approximately one in ten artefacts.

Type Material	Unworked	Core	Flake Debitage	Angular shatter	Modified	TOTAL
Flint	2	-	29	2	4	37
Chert	-	-	19	-	1	20
TOTAL	2	-	48	2	5	57

Table 1.2: Kilbride (05E0833): showing assemblage composition and material.

Unworked

Two unworked flint artefacts were recovered, both of which were thermally produced flakes which occur as a result of weathering; one was found in C58, and the other piece in C101.

Flake Debitage

The assemblage was mainly comprised of flake debitage (48/57 pieces); the majority of these were flint (29 pieces), but a significant quantity of chert flake debitage was also found (19 pieces). Both platform and bipolar reduction techniques were present; the former being more commonly found (platform: 34/48 pieces: 21 flint, 13 chert; bipolar: 14/48 pieces: 8 flint, 6 chert).

Flint flake debitage was found in most contexts, but chert flake debitage had a more limited distribution, being concentrated in a small number of features, namely C58 (8 pieces), C28 (5 pieces), C103 (5 pieces), C38 (1 pieces). It was also notable that the distribution of flint and chert was almost always mutually exclusive: that is, the features which yielded chert debitage did not contain flint; the only exception to this was C58, which yielded a single piece of flint as well as eight pieces of chert.

Platform and bipolar techniques were evident on both flint and chert, and in both cases platform techniques were more common; however, bipolar technology represented a significant minority, ranging from approximately one-quarter of the flint flake debitage (8/29 pieces; <28%), to almost one third of flake debitage (6/19 chert pieces; <32%). For both flint and chert, platform and bipolar techniques were present in most contexts. In any given context, the trend was for platform reduction techniques to dominate (34/48 pieces), with bipolar examples constituting the remaining minority (14/48 pieces). The exceptions to this pattern were found in C1 and C38, where the single pieces of flake debitage that were found there were produced through bipolar methods, and in C2, C55 and C58, where platform and bipolar techniques were found in similar quantities.

The majority of the flake debitage was in a complete condition, retaining their striking platform and termination in full (27/49 pieces). Of these, most were platform derived (19 pieces), with the remainder being bipolar (8 pieces). Complete flakes and blades ranged in length from just 8 to 60mm, with over 75% having a length of 25mm or less. It is notable that platform derived flakes and blades tend to be smaller than the bipolar examples: the majority of platform debitage has a maximum length of just 21mm or less (13/19 pieces), whereas most of the bipolar debitage has a maximum length of 24mm or more (5/8 pieces).

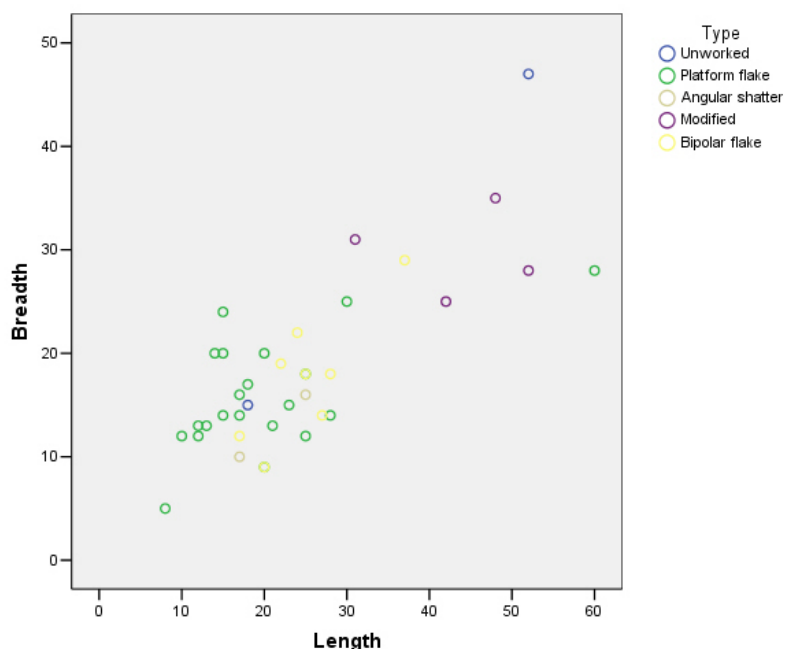


Fig 1.1: Kilbride (05E0833): Length by breadth (mm) of complete flint and chert artefacts.

Platforms and terminations

The most commonly found terminations on complete flakes and blades were feathered, indicating the free-moving dissipation of forces through the flint or chert during the removal of the flake (11 platform, 4 bipolar); most of the remaining pieces had hinged terminations (6 platform, 1 bipolar), which are usually unintended by the knapper and suggestive of inaccurate strikes and/or imperfections within the raw material. A small number of plunging or overshoot terminations occurred (2 platform), again indicative of inaccurate knapping, usually occurring as the result of an over-use and misdirection of force. The splintering characteristic of bipolar reduction methods were in evidence on all of the platforms, and the remaining terminations, of the completed bipolar flakes and blades.

Of the complete platform debitage, the type of platforms indicated that most were produced through percussion flaking (13/19 pieces). Within this group small planar platforms were commonly found (10 pieces), with an additional planar platform also exhibiting some limited edge preparation (1 piece); such platforms are quite easily produced and point to simplistic reduction techniques which would probably have allowed a limited degree of control during the knapping process. The remaining percussion flaked platform debitage carried more complex platforms, which were faceted by pressure flaking (2 pieces); such preparation indicates an effort to exercise greater control during the knapping

process and therefore have more command of the outcome of knapping and the type of flakes produced.

A number of small platform flakes were produced through pressure flaking techniques rather than percussion flaking; these commonly had punctiform (or pointed) platforms and prominent bulbs of percussion, indicating that such flakes were produced when immense pressure was applied at a particular point, rather than the less specific application of a percussive strike at a slightly larger area. Whereas hammers are often used in percussion methods, small hard, pointed tools are mainly used in pressure flaking: the former, then, is often a more generalised approach to knapping, while the latter is more targeted and specific; these reduction techniques are therefore quite different and distinctive. Small pressure flakes tend to occur as the result of (a) the fine trimming or preparation of a core during the primary knapping phase, or (b) the result of the production of tools. At Kilbride, no cores were recovered and therefore it is not possible to conclude whether or not they could have derived from the cores which yielded the remaining flake debitage assemblage; however, the remaining flake debitage assemblage hints at the use of simplistic techniques which are incongruous with the use of pressure flaking during the core preparation process, a technique which would be indicative of complexity in the core reduction techniques. It is therefore unlikely that the small scale pressure debitage within the assemblage resulted from primary knapping, and more likely that it resulted from the secondary modification of tools.

Angular shatter

Two pieces of flint angular shatter were found, both of which were recovered from C101. Both were in a fresh condition, and measured 17mm and 25mm in maximum length respectively. It is probable that these are unspecific debitage resulting from the knapping process.

Modified tools

A total of five modified tools were recovered, of which four were flint and one was chert (05E0833:32:3). Single examples were found in C1, C30, and C39, and two modified tools were found in C32. Four of the five modified tools were scrapers (05E0833:1:4; 05E0833:39:1; 05E0833:32:2; 05E0833:32:3) with the remaining piece being a utilised cutting tool (05E0833:30:12).

Only one of the four scrapers was finely and extensively worked (05E0833:1:4; Plate 1), and was found in topsoil (C1). This piece may have been formed on the distal fragment of a large flake, and

has been retouched along all edges with a rounded scraping edge, the left lateral being more steeply retouched than the right. One small notch in the distal scraping edge may be the result of post-depositional edge damage. Its proximal end is missing and some dorsal trimming seems to have occurred after the breakage; it is therefore possible that the proximal break was part of the original morphology of the piece. Scrapers are difficult to date since their simple forms were replicated for millennia and the recovery of this piece from topsoil does little to clarify its chronological context. Its fine production and careful morphology might hint at an origin during the Neolithic period, but this is by no means conclusive.

From C32, a less meticulously worked scraper was found (05E0833:32:2; Plate 2). This was a long blade scraper with a minimally retouched, small scraping edge at its narrow distal end. In addition, some possible use-wear was noted along the right lateral, and this area therefore may also have been used for cutting (although it may be as a result of hafting). The tool seems to have been subject to some post-depositional edge damage, and so its original scraping edge is not fully apparent. In addition, a burnt chert fragment of a possible scraper was found in C32 (05E0833:32:3; Plate 3). It seems to be minimally utilised scraper, formed on the distal fragment of a flake, and appears to have some use-wear at its distal end.

An unusual but finely produced scraper was found in C39 (05E0833:39:1; Plate 4a and 4b). This was formed on an irregular plunging flake derived from a multi-faceted core: the flake bears a fine proximal end with a punctiform platform, and has a flaring distal end which carries cortex; the scraping edge has been formed on the left edge of the distal end and therefore the functional axis of the scraper (Plate 4b) differs from the main axis of the original flake (Plate 4a). On most scrapers, the functional axis of the tool is similar to the main axis of the original flake and it seems that the distal end of flakes was generally preferred as the functional edge in the production of scrapers. When alternative edges are used, it can indicate that other more suitable flakes were not available, and the potential of the available flakes was being maximised. By altering the orientation of the flake in this case, the scraper functioned with a narrow, well formed, steep nosed scraping edge, flaring towards the hafted area of the tool. In having a narrow, small scraping edge, this piece is similar to 05E0833:32:2. Such scrapers do not have a particularly distinct chronological context in an Irish context, but the similarity of a number of pieces within the assemblage may point to a common functionality of scrapers at the site.

The remaining modified tool found at Kilbride is an irregular flake, which bears use-wear along its left lateral edge (05E0833:30:12); it is possible that this straight edge would have provided an opportunistic cutting edge, which was then utilised without further retouch.

Distribution

The flint and chert artefacts recovered from Kilbride were retrieved from a total of 15 deposits. For the most part, each deposit contained a small scatter of artefacts. Flake debitage, which dominated the assemblage, was found in most contexts. The majority of finds were found in Group 4 features, which were comprised of a spread of pits to the south of the timber circle (39/57 pieces); these mainly consisted of flake debitage, and also included the only angular shatter and unworked artefacts within the assemblage. The bulk of the remaining artefacts were recovered from Group 3 features, which constituted a linear arrangement of postholes to the south of the circle (10/57 artefacts); again, these were mainly comprised of flake debitage, but also included three of the five modified tools found at the site. Two artefacts were recovered from Group 2 features, the rectangular structure within the timber circle; these include a piece of flake debitage and one of the scrapers. It is of interest that no lithic artefacts were found in Group 1 features – the 22 pits which form the timber circle.

Context No	Description	Unworked	Core	Flake Debitage	Angular shatter	Modified	TOTAL
1	Topsoil	-	-	3	-	1	4
38	Group 2: Fill of posthole C41	-	-	1	-	-	1
39	Group 2: Fill of posthole C40	-	-	-	-	1	1
28	Group 3: Fill of posthole C29	-	-	5	-	-	5
30	Group 3: Fill of posthole C31	-	-	1	-	1	2
30A	Group 3: -	-	-	1	-	-	1
32	Group 3: Fill of posthole C33	-	-	-	-	2	2
16	Group 4: Fill of rectangular cut C17	-	-	4	-	-	4
2	Group 4: Fill of pit C3	-	-	2	-	-	2
14	Group 4: Shallow linear furrow	-	-	1	-	-	1
55	Group 4: Fill of hearth C56	-	-	2	-	-	2
58	Group 4: Fill of pit C59	1	-	9	-	-	10
101	Group 4: Fill of pit C102	1	-	12	2	-	15

103	Group 4: Fill of pit C104	-	-	5	-	-	5
67	Area B: Fill of pit C68	-	-	1	-	-	1
80	Area C: Pit	-	-	1	-	-	1
	Total	2	-	48	2	5	57

Table 1.3: Kilbride (05E0833): showing assemblage composition and distribution.

The distribution of the lithic assemblage echoes that of the ceramic assemblage, with the majority of the pottery (Grooved ware) being found in Group 3 and Group 4 features; similarly, the pottery assemblage does not seem to have been recovered from any Group 1 or Group 2 features, ie, those which form the timber circle and rectangular structure.

In general, most features yielded small quantities of chipped stone artefacts; only Group 4 pits C58 (10 pieces) and C101 (15 pieces) digressed from this pattern (Table 1.3). C101, the fill of pit C102, yielded a concentration of artefacts (15 pieces), all of which are fresh flint. They are mainly comprised of flake debitage (12 pieces), but also contain the only angular shatter recovered from the site (2 pieces) and an unworked thermal flake. The flake debitage from C101 is mainly comprised of platform flake debitage (10 pieces), including shatter (3 pieces), regular flakes (2 pieces) and blades (1 piece), a core trimming flake, and small scale flakes resulting from secondary working (3 pieces).

C58, the fill of pit C59, also yielded a concentration of artefacts (10 pieces), most of which were chert (8/10 pieces). A single unworked piece of flint was found, with the remainder being flake debitage (8 chert, 1 flint), of which many had been subject to burning (5 pieces: 4 chert, 1 flint). The flake debitage found in C58 was constituted of both platform and bipolar derived examples in similar quantities (5 platform, 4 bipolar). It is notable that all of the platform flake debitage, but none of the bipolar pieces, had been burnt. Despite their condition, most of the platform flake debitage was complete (3 flakes, 1 blade) with only one shattered piece being found (1 indeterminate burnt flake shatter); the bipolar debitage also contained broken examples (2 complete, 2 shattered). The knapping stage of the majority of flake debitage could not be determined, but where it could be inferred, a small number of flakes may have been related to core trimming (3 platform, 1 bipolar). In terms of size, all of the artefacts could be described as medium scale, with complete examples measuring from 14 to 37mm in length, and most measuring less than 24mm (4/6 complete).

The modified tools were mainly found in Group 3 postholes (C30 and C32), with the remaining pieces being found in topsoil (C1), and the Group 2 posthole C40 (fill C39). The Group 3 modified tools include scrapers (05E0833:32:2; 05E0833:32:3) and a utilised cutting tool (05E0833:30:12); the artefacts found in C39 and C1 were also scrapers.

Assemblage summary and discussion

An assemblage of 57 worked and unworked pieces of flint and chert were found during excavations at Kilbride, derived from a total of 15 contexts. The majority were flint rather than chert, and the assemblage was dominated by primary knapping debitage, most commonly in the form of flake debitage; small numbers of unworked pieces, angular shatter and modified tools were also found, but the assemblage did not include any cores. The flake debitage assemblage was mainly comprised of platform derived material, although bipolar reduction techniques were also strongly represented, accounting for almost one-third of the flake debitage.

A few distributional patterns were discernable. Most chert artefacts were concentrated in a small number of features (C58, C28, C103, C38) spanning Groups 2, 3 and 4, and most contexts tended to yield flint or chert, but not both, pointing to a preference (perhaps dictated by access to raw material rather than simple choice) of one or other material at various stages. This selection did not extend to the reduction techniques applied to the materials: most contexts yielded evidence for both platform and bipolar reduction methods, with the latter tending to be represented in the minority. Analysis of the platforms indicated that a simple percussion knapping technique, deploying only minimal platform preparation, was most commonly found. The assemblage also included a component of pressure flake debitage, which probably occurred as a result of secondary knapping (that is, the debitage resulting from the production of tools, rather than the initial reduction of cores and production of flakes). Such debitage points to the in situ production of tools in the vicinity of the archaeological activity, but a lack of cores suggests that the primary knapping of raw material may have occurred elsewhere, or alternatively that the cores were systematically removed from the area and disposed of elsewhere.

The small assemblage of modified tools offers little insight into the chronological context of the archaeological activity at Kilbride: while the function of scrapers and utilised cutting tools may be inferred, these tool types are poor chronological indicators and are found with variable morphology throughout most of Irish prehistory. The production and use of medium scale scrapers, both finely worked and minimally worked examples alike, are commonly found throughout the Neolithic period; likewise, the utilised tool and the flake debitage assemblage, comprised of both bipolar and platform

derived material, can also span the entire Neolithic period. In lieu of an assemblage of cores or more chronologically diagnostic artefact types, which might help to clarify the chronological context of the assemblage, a broad date range for the Irish Neolithic period is undoubtedly likely, but the difficulty with attempting to narrow the chronological framework is that it would require the identification of distinctive artefact types relating to the Late Neolithic and Final Neolithic/Grooved ware periods. One possible contender is the thumbnail scraper: it is possible (but not yet clearly established) that these artefact types appear in Ireland during the Final Neolithic/Grooved ware period; if this is indeed an accurate assessment of the introduction of thumbnail scrapers in Ireland, then it is not reflected by the Kilbride evidence, because no thumbnail scrapers were found. This is also particularly intriguing given the lack of Beaker pottery at Kilbride: in most cases, Beaker pottery accompanies Grooved ware material, and likewise in such assemblages thumbnail scrapers tend to be found. The unusual lack of Beaker pottery at Kilbride is accompanied by an apparently unusual lack of thumbnail scrapers. It is tempting to suggest that this negative evidence may have implications for our understanding of the emergence of thumbnail scrapers in an Irish context: it may be that they are in fact associated with the arrival of Beaker pottery rather than Grooved ware. The difficulty, however, is that the Kilbride lithic assemblage contains less than 60 artefacts, of which only 5 are modified tools: with such a limited assemblage, it is inappropriate to infer an island-wide trend; not only because it is only one site of a type which is itself unusual, but also because the function of timber circles and the imperatives behind tool production and deposition are likely to be ritualistic and consequently unique, therefore the particular function of timber circles will dictate the composition and distribution of the assemblage. At Ballynahatty timber circle, a large assemblage of over 5000 artefacts contained over 200 modified tools (Nelis 2003, 721-770). Despite the vast scale of the assemblage found at Ballynahatty, the composition was similar to that at Kilbride, being mainly comprised of platform and bipolar flake debitage, and with the modified tool assemblage being dominated by scrapers and minimally retouched cutting tools. Although the assemblage at Ballynahatty was unsurprisingly more variable than the assemblage found at Kilbride, its general composition was similar and few formal tool types, such as knives or projectiles, were found at Ballynahatty (with none being found at Kilbride); similarly, Knowth yielded scrapers and cutting tools for the most part (Dillon 1997), as has Balgatheran timber circle, Co Louth (Nelis forthcoming). The main difference between the composition of the Kilbride assemblage and that at Ballynahatty was the presence of numerous wedge tools at Ballynahatty, which were interpreted as being used for splitting wood or bone; it is also notable that within an assemblage of over 60 scrapers found at Ballynahatty, only one could be described as a thumbnail scraper (ibid). Other similarities between Ballynahatty and Knowth were drawn, with evidence for structured deposition being discernable at both sites, with both sites being interpreted as having been deconstructed and closed in a formal, ritualised manner (for further discussion on Ballynahatty see Hartwell 1998, Hartwell 2002, Gormley 2004): at Ballynahatty, the majority of the assemblage was found within postholes forming Ballynahatty 6 (ie the circular

structure within which lay the possible excarnation platform: ?comparable with Groups 1 and 2 at Kilbride) and at the entrance chamber and façade. At Knowth both the quantity and mass of lithics were carefully structured during deposition, but this does not seem to have been undertaken at Kilbride, with only a small element of the assemblage being recovered from the timber circle, rectangular structure and façade. Given the evidence for structural deposition and the closure of the monuments elsewhere within the Late Neolithic timber circle tradition in Ireland, it would be intriguing to find evidence for similar behaviour at sites such as Kilbride.

Section 2: Barreel 1 (06E0807)

Introduction

At Barreel 1 (05E0807) were excavated a number of archaeological features, including a field system with associated Medieval furrows, and a number of Medieval corn-drying kilns, preceded by a Bronze Age structure. C27 was a Medieval field boundary, which yielded a single stone artefact.

Analysis and Discussion

A single chipped stone artefact was recovered from Barreel 1 (06E0807:27:1). This was a small pressure flake, measuring just 8mm in length; this piece is a product of secondary technology, and is the small scale debitage resulting from the production of a modified tool. It is not accompanied by associated debitage, and given its Medieval context, it is probable that it has been residually redeposited into this feature, having been produced at some period during prehistory. Given its small scale and isolated recovery, nothing further can be said regarding its chronological or technical context.

Unique No	Context	Material	Condition	Cortex	Character	Classification	Frag size (mm)	Length (mm)	Breadth (mm)	Thickness (mm)	Mass (g)
05E0807:27:1	27	Flint	Patinated	Tertiary	Flake	Platform complete pressure	-	8	10	2	.18

Table 2.1: Barreel 1 (05E0807): showing basic attributes of the flint artefact.

Section 3: Caltragh 1 (05E0584)

Introduction

Caltragh 1 (05E0584) was a Late Neolithic/Early Bronze Age house site, consisting of a hearth and a number of postholes. C23 was an oval pit feature, covered by the sealing layer C10.

Analysis and Discussion

From C23 was recovered a single chipped stone artefact: this is the distal fragment of a chert blade, the dorsal face of which bears the scars of thermal damage (Table 3.1); the dorsal face also, however, exhibits evidence of multiple flake scars, which indicates that the blade was the result of a process of complex and intensive knapping of the core. However, in such isolation, little further can be said on this piece, and it is not chronologically diagnostic.

Unique No	Context	Material	Condition	Cortex	Character	Classification	Frag size (mm)	Length (mm)	Breadth (mm)	Thickness (mm)	Mass (g)
05E0584:23:1	23	Chert	Fresh	Tertiary	Flake	Platform shatter distal	42	-	25	9	6.61

Table 3.1: Caltragh 1 (05E0584): showing basic attributes of the flint artefact.

Section 4: Grallagh 1 (05E0740)

Introduction

At Grallagh 1 (05E0740), a fulacht spread dating to the Late Bronze Age, and a field boundary, were excavated. C9 was a pit, which yielded a single chert artefact.

Analysis and Discussion

In C9, a large roundish flake was found. This piece carries some edge damage and possible retouch, and it may be a minimally retouched scraper; however, the scraping profile is poor and if the tool was used as such, its function would have been limited by its poor execution. If this piece was indeed used as a scraper, its minimally worked form indicates that it would have been an opportunistically produced tool, and as such little further comment on its context of production and use. With regard to chronological context, it could have been produced at any period during Prehistory, including the Late Bronze Age, and could be contemporary with the activity at the fulacht.

Unique No	Context	Material	Condition	Cortex	Character	Classification	Frag size (mm)	Length (mm)	Breadth (mm)	Thickness (mm)	Mass (g)
05E0740:9:1	9	Chert	Abraded	Secondary	Modified	Possible scraper	-	41	38	11	21.79

Table 4.1: Grallagh 1 (05E0740): showing basic composition of assemblage.

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Plates



Plate 1: Kilbride (05E0833:1:4): Scraper.



Plate 2: Kilbride (05E0833:32:2): Scraper.



Plate 3: Kilbride (05E0833:32:3): Scraper.



Plate 4: Kilbride (05E0833:39:1): Scraper: (left): striking axis of flake; (right): functional axis of scraper.



Plate 5: Grallagh 1 (05E0740:9:1): Scraper.

Palaeoecology Research Services

**Technical report: Burnt bone from
excavations at Kilbride 1, County Mayo,
Republic of Ireland (licence no: 05E0833)**

PRS 2008/02

**Technical report: Burnt bone from excavations at Kilbride 1, County Mayo,
Republic of Ireland, (licence no: 05E0833)**

by

Deborah Jaques

Summary

A small collection of burnt vertebrate remains recovered from four deposits encountered during excavations at Kilbride, County Mayo, Republic of Ireland, was submitted for examination. The remains of a late Neolithic timber circle were encountered, together with a number of external features which may represent a ceremonial approach.

The burnt bone assemblages were poorly preserved and too small to be of interpretative value. None of the fragments were identifiable, although the appearance and texture of the remains was more consistent with animal than human bone.

KEYWORDS: KILBRIDE; COUNTY MAYO; REPUBLIC OF IRELAND; TECHNICAL REPORT; LATE NEOLITHIC; BURNT BONE

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10 January 2008

Technical report: Burnt bone from excavations at Kilbride 1, County Mayo, Republic of Ireland, (licence no: 05E0833)

Introduction

Archaeological excavations were undertaken at Kilbride, County Mayo, Republic of Ireland, (NGR 127637 278879), in July 2005 by Archaeological Consultancy Services Ltd (ACS), as part of works associated with the Mayo–Galway Bord Gáis pipeline project.

Monitoring of topsoil stripping along the route of the pipeline revealed a group of archaeological features. The excavation uncovered evidence (in the form of 19 postholes) for a late Neolithic timber circle, within which was a setting of four postholes forming a rectangle. A number of features, including a possible hearth, were encountered to the south of the circle and these may have formed a ceremonial approach.

A small quantity of burnt bone recovered both by hand-collection and from the processing of a single sediment sample, was submitted to PRS for analysis.

Methods

The sediment sample was processed by ACS prior to delivery to PRS, and the bone recovered was submitted for analysis, together with the vertebrate material hand-collected during the excavation.

The mesh sizes employed for processing of the sediment sample were 4 mm, with an overflow into a 3.35 mm sieve stacked on top of one of 500 microns. Only those components of the residue that were submitted to PRS are reported here.

Records were made of the vertebrate remains concerning the state of preservation, colour of the fragments, and the appearance of broken surfaces ('angularity').

Fragments were identified to species or species group using the PRS modern comparative reference collection. The bones, which could not be identified to species, were described as the 'unidentified' fraction. Within this fraction fragments were grouped into one of two categories: medium-sized mammal (assumed to be caprovid, pig or small cervid) and totally unidentifiable.

Results

Material from four deposits from this site produced burnt bone. The remains were recovered from Contexts 58, 95, 103 and Area B 'clean back' by hand-collection, whilst additional material came from a sediment sample from Context 58.

Context 58 [fill of pit 59, located to the south of the timber circle; radiocarbon dated as Cal BC 2870 to 2470 from hazel charcoal]

Bags 1 and 2 (remains recovered by hand-collection)

Hand-collected remains from this context amounted to 23 fragments of burnt bone (4 g) which were damaged by fresh breakage and were somewhat poorly preserved. Most fragments were small (to 27 mm, although many were less than 10 mm in maximum

dimension), with rounded edges and a rather battered appearance. The bones were predominantly white in colour, with some fragments showing areas tinged with blue or black. None of the bones were identifiable.

Sample 24 (24 kg of sediment processed; residue weight 4.37 kg)

Forty-four small (less than 10 mm in maximum dimension) fragments of burnt bone (3 g) were recovered from this sample. Extensive fresh breakage was noted and most fragments were extremely poorly preserved, being rather rounded and eroded in appearance. The fragments were primarily white in colour, with a few showing hints of blue coloration. None of the fragments could be identified to species, although several bones were shaft fragments from medium-sized mammals. There were no fragments which could be identified as human remains.

Context 95 [fill of posthole 96, part of the timber circle]
Bag 3 (remains recovered by hand-collection)

This deposit yielded three fragments of burnt bone (less than 1 g), which were small (to 15 mm in maximum dimension) and white in colour, with evidence of fresh breakage damage. One bone was a probable medium-sized mammal shaft fragment but neither of the other fragments could be identified.

Context 103 [formerly registered as find no. 51]

Three fragments of burnt bone (2 g) were recovered from this deposit, they were white in colour, with a 'chalky' feel and slightly rounded edges. As with the previous deposit, one fragment may represent a medium-sized mammal shaft, whilst the others were unidentifiable.

Area B 'clean back' [formerly registered as find no. 45]

Material from Area B 'clean back' amounted to 16 fragments of burnt bone (less than 1 g), of which all bar one were tiny (less than 5 mm). Fresh breakage damage was extensive. One fragment was identified as a piece of medium-sized mammal rib, but the remaining small 'crumbles' were unidentifiable.

Discussion

The burnt bone fragments submitted for analysis were small, poorly preserved and unidentifiable. Fresh breakage damage was extensive and contributed to the high degree of fragmentation noted throughout.

The bones were mainly white and calcined and in all likelihood had been burnt at temperatures in excess of 800°C, although it has been noted that prolonged burning at lower temperatures can achieve a similar result and that other variables, such as the availability of oxygen, the presence of soft tissue and the position within the fire, can also affect colour change (Walker and Miller 2005).

As the remains could not be identified, the presence of human bones cannot be entirely excluded. The appearance and texture of the bone were more consistent with animal bone than with human remains, however.

Retention and disposal

All of the recovered remains should be retained as part of the physical archive for the site.

Archive

All material is currently stored by Palaeoecology Research Services (Unit 8, Dabble Duck Industrial Estate, Shildon, County Durham), along with paper and electronic records pertaining to the work described here.

Acknowledgements

The author is grateful to ACS for providing the material and the archaeological information.

References

Walker, P. L. and Miller, K. P. (2005). Time, temperature, and oxygen availability: an experimental study of the effects of environmental conditions on the colour and organic content of cremated bone. *American Journal of Physical Anthropology, Supplement* **40**: 222.

Appendix 3:
Leading Edge Erosion and Pollution from Wind Turbine Blades, 2021

08.07.2021

Leading Edge erosion and pollution from wind turbine blades

5 th. Edition - English



Asbjørn Solberg, Bård-Einar Rimereit and
Jan Erik Weinbach

"THE TURBINE GROUP" JULY 2021

Preface

We have put together a report on an under-communicated topic; emissions of microplastics and possible toxic compounds from Wind turbines.

Our estimates for emissions are based on the report "*Rain Erosion Maps for Wind Turbines Based on Geographical Locations: A Case Study in Ireland and Britain*" University of Strathclyde, 2021.¹

It is difficult to find good and impartial sources for the problem of emissions from wind turbine blades. Reports that have been published and research that has been done on the topic are most often carried out by authors who have their most important source of income from wind power, such as reports from www.epoksy-europe.eu. The report from Strathclyde is one of the few reports dealing with the volume of emissions from the turbine blades. Just days after our first edition was released the University of Strathclyde announced "*Aker Offshore Wind, Aker Horizons and Strathclyde to collaborate on accelerating recycling glass fibre products*".²

The University of Strathclyde is one of three universities in Glasgow, Scotland. The university has its roots in Anderson's Institution which was established in 1796, and gained status as a university in 1964. It was ranked 38th out of 126 British universities on the Complete University Guide's list for 2016 and number 33 out of 119 British universities at The Guardians 2016. -list. (Wikipedia)

We have estimated emissions from the leading edge of wind turbine blades by calculating the mass loss from Norwegian wind turbines based on the report from the University of Strathclyde.

Already in 2013, rotor blades from wind turbines accounted for 27% of Europe's consumption of epoxy.³ Depending on production method the epoxy in rotor blades contains as much as approx. 33% Bisphenol A.⁴ Nevertheless, there is remarkably little available information on microplastic emissions from turbine blades. However, there are many reports from the industry that focus on wear and maintenance. This indirectly confirm the issues we describe.

Bisphenol A is on the «Norwegian priority list of dangerous substances». These are chemicals that are considered to pose a serious threat to health and the environment are placed on the Norwegian priority list. The list serves as an important tool for which substances the authorities should work specifically with, and it gives an important signal to the business community that these are substances where it is important to work for reduction in use or emissions.⁵

In the 3rd edition, some references were replaced so that now the reference goes directly to main sources where they previously went via our report. For example, footnotes 2 and 3. In the 4th edition, some typing errors were corrected and an updated calculation of erosion for the Norwegian coast were made.

This edition is in English and we have added facts and information given to us (29. April and 4. May) from the researchers of the Strathclyde rapport. We understand the facts and information to support our estimates and calculations.

We would also like to thank and credit Veronica Metcalfe for solid help with this English edition.

Stavanger, Sogndal and Trondheim and 08.07.21

Bård-Einar Rimereit, Jan Erik Weinbach og Asbjørn Solberg

¹ <https://link.springer.com/article/10.1007%2Fs40735-021-00472-0>

² <https://www.strath.ac.uk/whystrathclyde/news/akeroffshorewindakerhorizonsandstrathclydetocollaborateonrecyclingglassfibreproducts/>

³ https://epoxy-europe.eu/wp-content/uploads/2018/11/Epoxy_Socioeconomic_Study_Main_Findings_August-2017.pdf

⁴ https://www.epoxy-europe.eu/wp-content/uploads/2015/07/epoxy_erc_bpa_whitepapers_wind-energy-2.pdf

⁵ <https://www.miljodirektoratet.no/chemicallist/61?listcasnr=80-05-7>

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Summary

There are examples from both the UK and Denmark that after 5 years you either have to make very large critical, costly repairs such as at London Array Park or demolition / replacement as at Anholt in Denmark. Both locations with wing diameter of 120 meters.

Experiments carried out at the University of Strathclyde show that a rainfall with pure particle-free fresh water of 50 mm pr. month results in a mass loss of 0.037% pr. month and a rainfall of 500 mm pr. month gives a mass loss of 0.199% pr. month. The wear with seawater (3.5% salinity) is 40% greater⁶.

A turbine blade is simply explained as fiberglass mats, epoxy resin and hardener.

Epoxy, in contrast to polyester, contains 33% Bisphenol A which is considered very harmful to health.

The blades of a 4.2 MW turbine for areas with harsh weather have a diameter of 130-140 m and the total weight is just under 60 tonnes, with longer blades they weigh well over 60 tonnes **each**.

We estimate a total weight of 60 tonnes per. turbine.

We estimate the total of exposed leading edge (LE) weight to be 700 kg.

Many places along the Norwegian coast have annual rainfall of approx. 2,500 millimetres.

This gives us the formula for wear and tear: $f(x) = 0.979 \% * (\frac{diameter}{100})^{11,4}$

And an estimated annual emission of microplastics of approx. 62 kg per year per turbine.

And 20 turbines more than 1.2 tonnes each year and 31 tonnes over 25 years.

In Norway there are close to 400 turbines with a wing diameter of 130 meters or more. Estimated total emissions from these 400 turbines are 25 tonnes a year.

Over the course of 25 years, this amounts to an estimated 620 tonnes!

We point out that we have calculated the annual precipitation as rain. If the precipitation consists of a lot of snow, ice and hail, with salt or sand, mass loss from Leading Edge (LE) will increase beyond this.

⁶ <https://link.springer.com/article/10.1007%2Fs40735-021-00472-0>

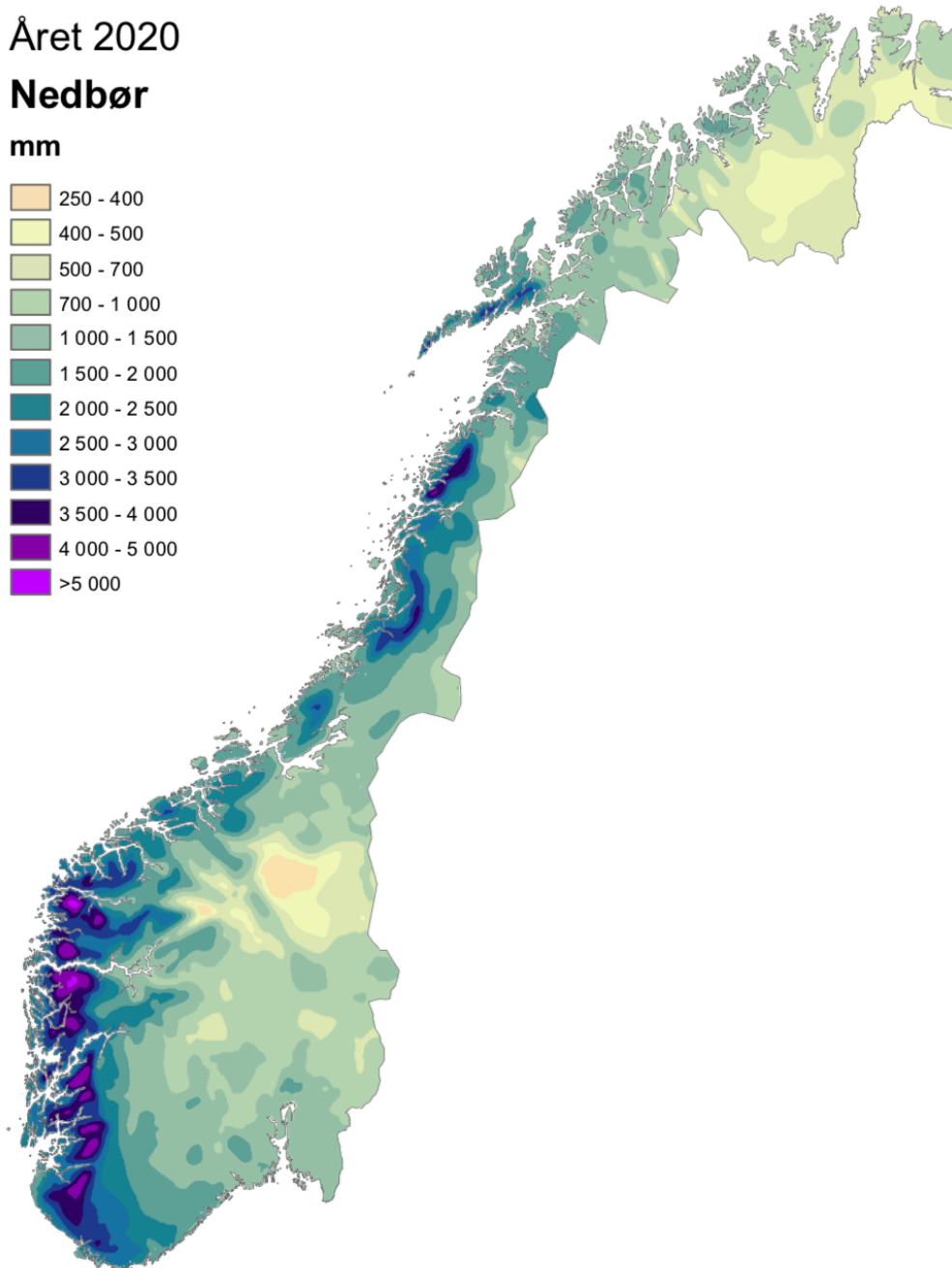
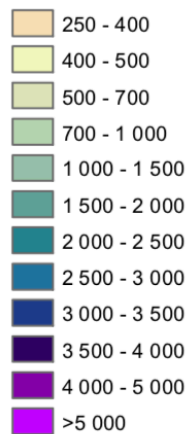


Klimatologisk oversikt

Året 2020

Nedbør

mm



Normalperioden er 1961 - 1990

⁷ <https://www.met.no/publikasjoner/met-info>

Through NORWEA, the wind industry states a total annual emission of max 150 grams pr. turbine⁸.

That is a maximum of 60 kg for 400 turbines.

Our estimates show that emissions can be 41 000 % greater than the figures provided by NORWEA.

It is important to note that the wear on rotor blades is exponential.

Erosion Rate is exponential to Impact Speed or Impact Energy (see figure 4).

New and larger turbines will have far greater mass losses.

The average temperature in many places along the coast is below 4 degrees from November to April, which gives at least 5 months with the risk of icing and hail, in other words periods of higher average mechanical stress and emissions than those found in Scotland.

25 tonnes of annual emissions in the form of micro- and nanoplastics are thus sprinkled over outfields, pastures, soils, water sources and eventually fjords and sea areas.

How much of this will be Bisphenol A is uncertain, **but 1 kilo of bisphenol A is enough to pollute 10 billion litres of water. That's 10 000 000 000 litres.**

Since 2017, the WHO has advised that drinking water should have a maximum of 0.1 micrograms of BPA pr. litre. This is 0.000 000 1 grams per litre of water⁹.

The environmental protection authorities in Norway have statistics on emissions of free Bisphenol A. These statistics are given in grams with emissions. Emissions from the wind industry are not included, and no decision has been made as to whether emissions from the wind industry can be broken down into harmful substances.

⁸ <https://norwea.no/norwea-mener/2021/3/26/faktaark-vindkraft-plast-og-bisfenol-a>

⁹ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L2184&from=EN>

Introduction

Some reports say the coating is polyurethane while "On the Material, Characterization of wind turbine-B_2017" says that the cover layer on the Leading edge is also a specially developed epoxy "*developed for Leading Edge Protection*" (LEP)¹⁰. The same report also explains the mechanisms surrounding damage caused by raindrops, defined as the Water Hammer pressure effect.

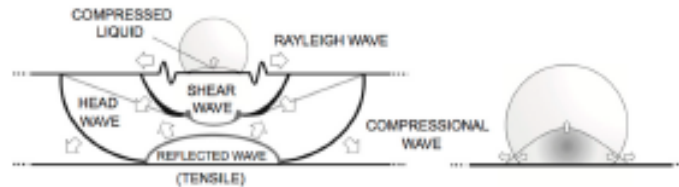


Figure 1 source: On the Material, Characterisation of wind turbine-B_2017

The fact that all objects that move quickly through air, hail and rain wear has been a known problem in the aviation industry since 1940, also in other industries there is a well-known problem with wear caused by flow.

The wind power industry has chosen to neglect and under communicate this in much the same way as the tobacco and sugar industry dealt with health effects.

That there is a wear problem today and that there will be a significantly bigger problem with larger turbines in the future, is confirmed by "On the Material, Characterization of wind turbine-B_2017"¹¹, which says: *Rain erosion protection coatings have been proposed, tested and validated with particular industrial solutions, but the proposed solutions are still not as reliable as the wind energy industry requires. Rain erosion has thus become a scientific challenge for the wind industry since there are no well-defined methodologies to design coatings against rain erosion and it is unclear how to modify their properties depending on the location, weather conditions, etc.*

What we know about the forces and mechanical stresses on wind turbines is that the stresses increase exponentially as the turbines become larger. Offshore wind turbines will wear 40-50% more due to salinity. Offshore wind is more unprofitable than land-based, and it thus requires much larger turbines, which in turn will result in much larger emissions.

Longer rotor blades, give increased speed in the blade tip. The industry is well aware of increased mass loss and thus increased emissions when they increase blade speed, but they believe increased blade wear can be

¹⁰ That there is no bisphenol in the coating is undocumented information in the form of claims from the wind industry, they do not say anything about the coating. But also polyurethane has its environmental challenges with increased cancer risk and allergenic properties.

¹¹ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5666952/>

justified by requiring less investment, e.g. that it requires lower investment costs, i.e. smaller and cheaper gearboxes.

The purpose of the report from Strathclyde is to predict the need for maintenance, but it also quantifies the mass loss in rotor blades. The report from Strathclyde focuses on a test of mass loss on a material sample. The selected measurement for erosion is mass loss as a percentage of the original sample. The ideal loss data would be the mass loss connected with area. Then the mass loss calculations would be easier to predict. But no body publishes data like this, therefore the Strathclyde report is the best available source.

The mass of the test material was measured before the experiment and after each exposure time. This will result in a direct numerical relationship between average monthly rainfall and erosion as a mass loss.

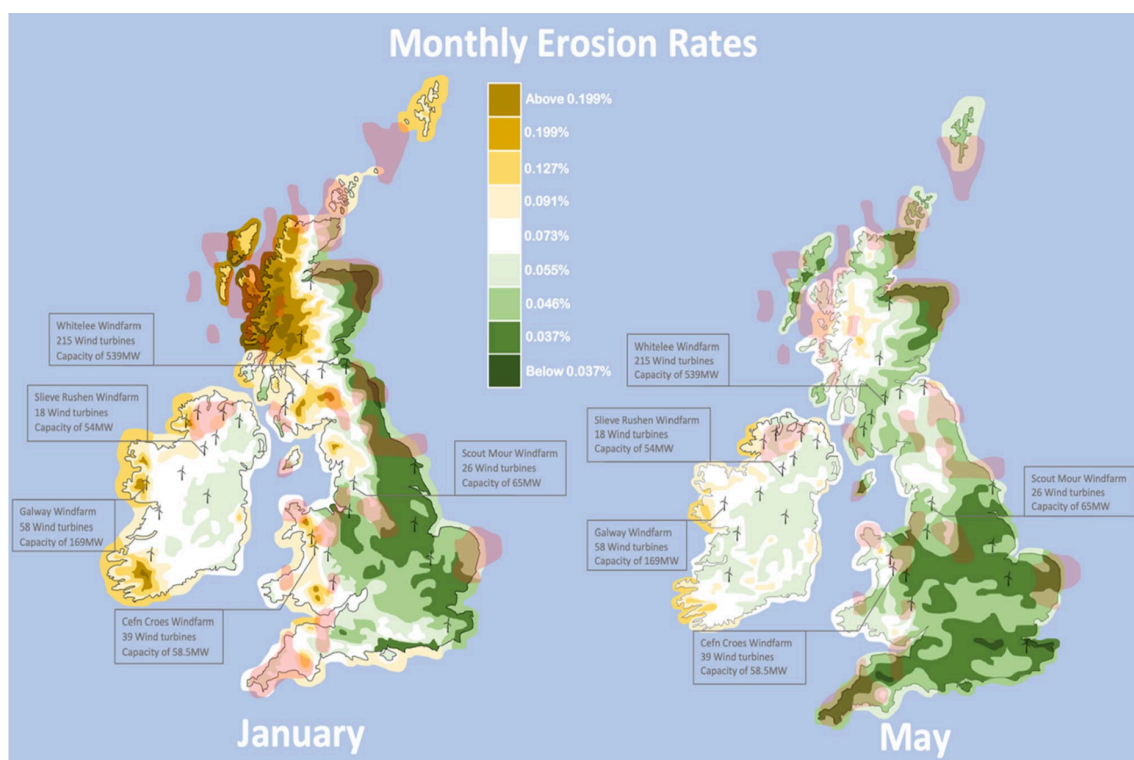


Figure 1. The monthly erosion rates in January and May with overlays of major wind turbine farms and areas of frequent hail. Source: Journal of Bio- and Tribo-Corrosion · March 2021)

The pulp loss mainly consists of two-component epoxy. A turbine wing is largely made of fiberglass reinforced epoxy where epoxy makes up approx. 40% of the pulp and fiberglass make up 60%. In addition, some balsa wood, divinycell (a kind of hard foam) and some other materials are used to create the profile for the wing construction.

Epoxy contains 33% bisphenol A. This amounts to approx. 13 - 15% of the total weight of a rotor blade. In other words, there is a lot of microplastic, **and a large part of this is bisphenol A.**

In this document, we do not consider the state of the emissions of microplastics, or the distribution of inert and harmful substances in the form of free chemicals. To differentiate this is an isolated large scientific work that should be carried out as it is known that all substances are broken down to a greater or lesser degree.

Pollution authorities throughout Europe should jointly launch a major impact assessment. Since we are talking about large emissions from turbine plants, one should also look at how epoxy is broken down in the animals' digestive system with mechanical processing, heat and acid.

“Bisphenols are not covalently bound to the polymeric structure, from which with time, or due to physical and / or chemical factors such as heat and acidity, can be gradually released into the external environment, contaminating water, soil and sediments, and later the rest of the agro-food chain.”¹²

The special thing about emissions from land-based wind turbines in Norway is that they are located higher than water sources and biotopes, and that they will be able to spread the problem over relatively large areas such as outfields and pastures. **In addition, many of these discharges could end up in drinking water sources.**

Loss of bisphenol will apply to those areas of the blade that are not covered by surface treatment, i.e damaged areas, and whether epoxy is used in the surface treatment. Where polyurethane cover layers are used, bisphenol will probably not be released until the cover layer has worn away¹³, but the mass losses are microplastic and it will enter the food chain. Polyurethane contains isocyanates which are known to be both carcinogenic and allergenic.

The bisphenol A (BPA) content of the emissions will increase throughout the period of use and after use, as the materials are uncovered and exposed. In particular, current practice of burying rotor blades in landfills will result in high emissions over a long period of time.

¹² Review article, Environmental Research 151 (2016) Monica Giulivo a,n, Miren Lopez de Alda b,n, Ettore Capri a, Damià Barceló b,c

¹³ That there is no bisphenol in the coating is undocumented information in the form of claims from the wind industry, they do not say anything about the coating but also polyurethane has its environmental challenges with increased cancer risk and allergenic properties.

The experiments performed at the University of Strathclyde in short

The Strathclyde report only looks at rain (no ice, snow or hail), but describes that previous studies show that hail causes both surface damage and micro delamination that results in accelerated and large mass losses due to rain.

Weather data are taken from Ireland and Scotland. Data are collected in January and May, which are the wettest and driest months, respectively.

The test specimens are exposed to a similar load as the average weather for a 20-year period from the weather data.

The speed in the test was 60 m/s, which corresponds to the speed at the end of a 50-meter wing. In other words, the test is relevant for large parts of the turbine blades. The rotor speed increases exponentially beyond the blade wing. For example, turbines with a diameter of 140 meters on the wings have a speed of approx. 80-100 m/s at the tip. The inner part of a turbine blade will wear considerably less than the tip.

The experiment was also repeated with salt water with a view to offshore wind turbines. Salinity was 3.5%, which is equivalent to seawater in the UK and Ireland. The mass loss then increases by 40-50%.

Mass loss also results in increased turbulence and drag, which results in lost efficiency. To counteract lost production, the blade angle is changed, which exposes a larger surface to mechanical wear, which in turn results in increased mass loss.

The University of Strathclyde writes that they have used the same material as on wind turbine blades, but which is not further described, e.g. about which surface treatment has been used in the experiments. It can mean that the figures only apply to open exposed epoxy without surface treatment, even though the text indicates that complete sheets of coating have been used in the experiments. The authors have been contacted but we have not been contacted at the time of writing.

The report says the following about the wear:

“The degradation of the sample should erode in three distinct stages. The first is the initiation period; where the sample is at its smoothest and difficult to penetrate, this is when the turbine blades are brand new and operating at optimal efficiency.

Secondly is steady state erosion; where the sample has been impacted by a critical number of drop-lets to affect the surface roughness of the sample enough to instigate more considerable erosion which continues at a constant rate. It is during this stage that the turbine starts to decline in efficiency.

Lastly the third stage is the final erosion region where the erosion rate decreases, however, this is when the turbine blade is at its most vulnerable and the erosion on the blades can begin to become structural weak points.”

From other reports

Another report “*Sustainable_End-of-Life_Management_of_Wind_Turbine*”¹⁴ acknowledges the problem: *"For erosion protection, a load reducing strategy can be realized as so-called erosion safe control, i.e., reduction of tip speed during heavy rain."* (page 4).

Report Accelerated rain erosion of wind turbine from DTU¹⁵: *"The liquid coating materials contain the same basic compositional components: resin, solvents, pigments and additives."* (page 9).

We have looked at a number of reports and all conclude that erosion due to rain is a major problem. The reports focus mainly on operation and maintenance, not on emissions and environmental damage.

With the increasing size of the turbines, which gives high speed to the blades, it appears that edge tape and similar do not meet goals. Modern and large wind turbines therefore use a layer of polyurethane-based paint/varnish on top of the epoxy gelcoat or epoxy coating as protection.

In addition to Leading Edge Erosion (LEE), several research sources mention pitting and delamination as known problems.

Other comments

There are examples from both the UK and Denmark that after 5 years you either have to make very large critical, costly repairs such as at London Array Park or demolition/replacement and Anholt in Denmark. Both locations with a blade diameter of 120 meters.

The average temperature in many places on the Norwegian coast is below 4 degrees from November to April. This means minimum 5 months with danger of icing and hail. In parts (like Troms and Finnmark) there are more extreme weather conditions. Norway will have higher average mechanical load and emissions than those found in Denmark, England and Scotland.

Leading Edge Erosion (LEE) causes an annual production loss of somewhere between 56 and 75 million euros. A large industry has emerged around the maintenance of rotor blades. That this industry can live off the alleged emissions/mass loss of 0-50 grams (max 150 grams per turbine) is a logical shortcoming which at best appears naive. But our environmental authorities accept this as the truth. For Norway (with 1164 turbines) the total annual maintenance would be max 174 kg.

The maintenance costs for a 500 MW offshore wind turbine plant will be between 2 and 8 million pounds per. year. A quick calculation indicates that it can be up to £80,000 per turbine.

¹⁴ <https://pubmed.ncbi.nlm.nih.gov/33673684/>

¹⁵ https://backend.orbit.dtu.dk/ws/portalfiles/portal/116954840/Shizhong_Zhang_978_87_93054_49_3_fil_fra_trykkeri.pdf

The same source tells that repairs and production losses cause lifetime costs of 1.3 million pounds¹⁶.

This confirms that the industry calculates large emissions from wear from rotor blades.

Several reports show that the maximum speed for today's large turbines is just below 100 m/s, while larger turbines will have speeds up to 110 m/s. The speed cannot increase indefinitely as the flow speed becomes unfavourably high and the efficiency will decrease.

The choice of turbine type in many places confirms that large loads are expected on both the rotor blades and the construction itself.

Wear and emissions can be divided into three phases:

Phase 1 - wear on polyurethane coatings, the Leading-edge protection (LEP), which is not as environmentally critical but it releases microplastics that contain isocyanates and other substances that are carcinogenic and allergenic. Some turbines have epoxy as (LEP) instead of polyurethane.

Phase 2 - wear on Gelcoat- which is an epoxy. This gives emissions but not major mechanical weakening on the turbine blade.

Phase 3 - wear into the glass epoxy layer under the gelcoat. This results in increasing emissions and structural problems on the turbine blades.

Results and conclusion

Disclaimer: The University of Strathclyde report says too little about test criteria and our estimates must therefore be regarded as qualified estimates. Nevertheless, they provide grounds for assuming that there may be a significant problem that clearly needs to be highlighted and taken very seriously. In our estimates we use the results from the University of Strathclyde report.

We have in this report carried out estimates for climate along the Norwegian coast. We have calculated mass

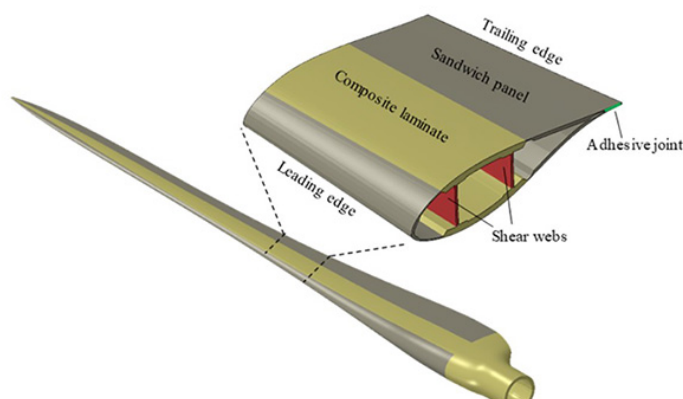


Figure 3 Typical wing profile

Source: <https://www.dtu.dk/english/news/Nyhed?id={CDC59567-A8A1-4ACE-866A-7FD8D559D5FF}>

loss on the leading edge (LE) from 50 meters and beyond on the blade. The estimates show that there are almost certainly large and strongly under communicated emissions from the wind turbine industry. Increased blade diameter gives increased tip speed. With speeds more than 300 km/h = 83 m/s, the encounter with raindrops, hail and ice particles will increase the erosion of the blades.

¹⁶ <https://www.sciencedirect.com/science/article/pii/S1364032119305908>

In our estimate, we have used a Vestas 136 turbine, with a diameter of 136 meters and a total blade weight of approx. 60 tons. We have used 700 kg as exposed Leading edge per turbine. That is little more than 1% of the total blade weight.

After we published our first edition of this report Kieran Pugh, PhD University of Strathclyde, wrote this in an email dialogue with us *“The affected area which the experiments were conducted, which was at the tip on the leading edge, will weigh 50kg max. This is due to the tip only traveling at the speed tested. This is the upper estimate of the combined three blades”*.

In our estimate, we have used 12 kg as weight on LE on the last meter of the blade (the tip). It gives 36 kg for all three blades. It is approx. 40% less than the weight Kieran Pugh states as maximum weight.

Kieran Pugh also states that based on 50 kg the erosion is 0.5735 kg per turbine per year. He specified *“This is also a worst-case scenario involving assumptions like the turbine is operating at maximum operational speed at all times during rain, this means this estimate of mass loss is at the most extreme case and is unlikely to increase.”*

With our formula we get an annual erosion of 0.220 kg with 36 kg LE and 60 m/s. It seems that our estimates are very cautious compared to what Kieran Pugh himself has as erosion at 60 m/s.

In the beginning (phase 1) our estimated emission figures will be set too high, but when there is visible wear and tear, our figures will probably be low (see phases 1, 2 and 3).

When the wear has reached a certain point, it will begin to break down into larger particles and the emissions will accelerate.

We have reviewed a number of reports on maintenance and it is clear that a turbine blade cannot survive 15-20 years in exposed environments without significant maintenance.

Previously, suppliers of maintenance services showed and discussed the jobs together with figures and documentation. In 2021, almost all information will be kept hidden and it is very difficult to find available figures and data. This can be regarded as a confirmation that the emissions are high.

It is worth noting that weight, volume and consequently the emission figures will increase in the 3rd power as a result of increasing size of turbines and salinity in the air will increase this problem by another 40%.

The experiments at Strathclyde show that a rainfall with pure particle-free fresh water of 50 mm per month. results in a mass loss of 0.037% per mnd. and that a rainfall of 500 mm per. mnd. gives a mass loss of 0.199% per. mnd. The wear with seawater (3.5% salinity) is 40% greater.

Many places on the Norwegian coast have annual rainfall of approx. 2,500 millimeters.

This gives us this formula for wear and tear: $f(x) = 0,972 \% * (\frac{diameter}{100})^{11,4}$

We use an estimate of 700 kg as weight on the exposed leading edge. This will give an annual loss of 62 kg per year per turbine.

20 turbines are likely to produce emissions greater than 1.2 t per year and 31 t over 25 years.

We only count the annual rainfall as rain. If there is a season with a lot of ice and hail, the mass losses will increase beyond this.

Climatological overview (NORWAY) rain 2020 ¹⁷

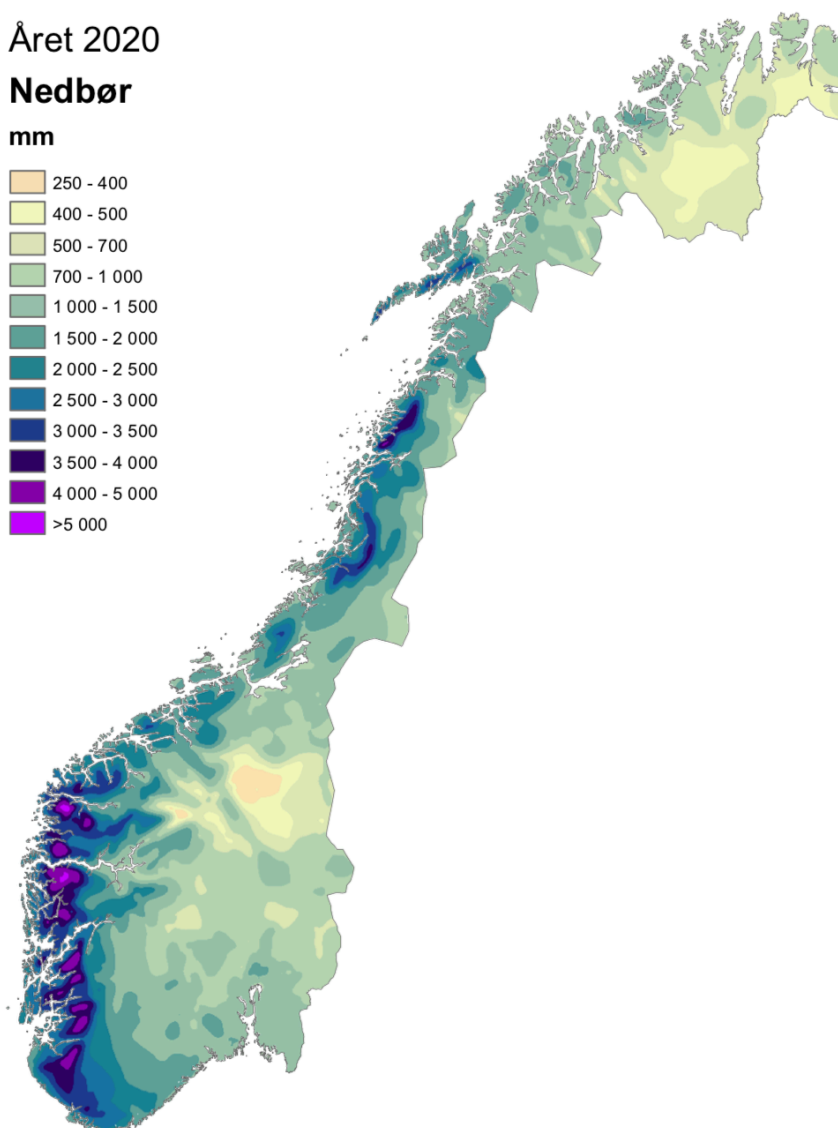
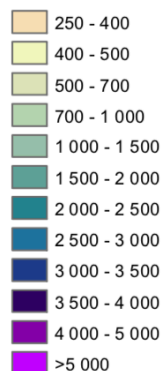


Klimatologisk oversikt

Året 2020

Nedbør

mm



Normalperioden er 1961 - 1990

¹⁷ <https://www.met.no/publikasjoner/met-info>

Conclusion

The report from Strathclyde mentions that hail and harsh weather conditions will increase wear and tear.

Based on the Strathclyde report it is unlikely that erosion with Norwegian winter conditions will be as low as for Scotland and Ireland. 62 kg annual erosion of micro- and nanoplastics is therefore probably a cautious estimate per. turbine.

In Norway, according to NVE, there are close to 400 turbines with a wing diameter of 130 meters or more. An estimate is then that the total emissions from these 400 turbines are approx. 25 tonnes a year.

In the course of 25 years, it amounts to an estimated 620 tonnes!

Through NORWEA, the industry states a total annual emission of a maximum of 150 grams per turbine¹⁸.

This corresponds to a maximum of 60 kg for 400 turbines.

Our estimates show that the emissions can be over 41 000 % greater than what NORWEA states.

Note that the erosion is exponential.

Larger turbines with higher tip speed will have much more erosion.

Erosion Rate is exponential to Impact Speed or Impact Energy (see graph)

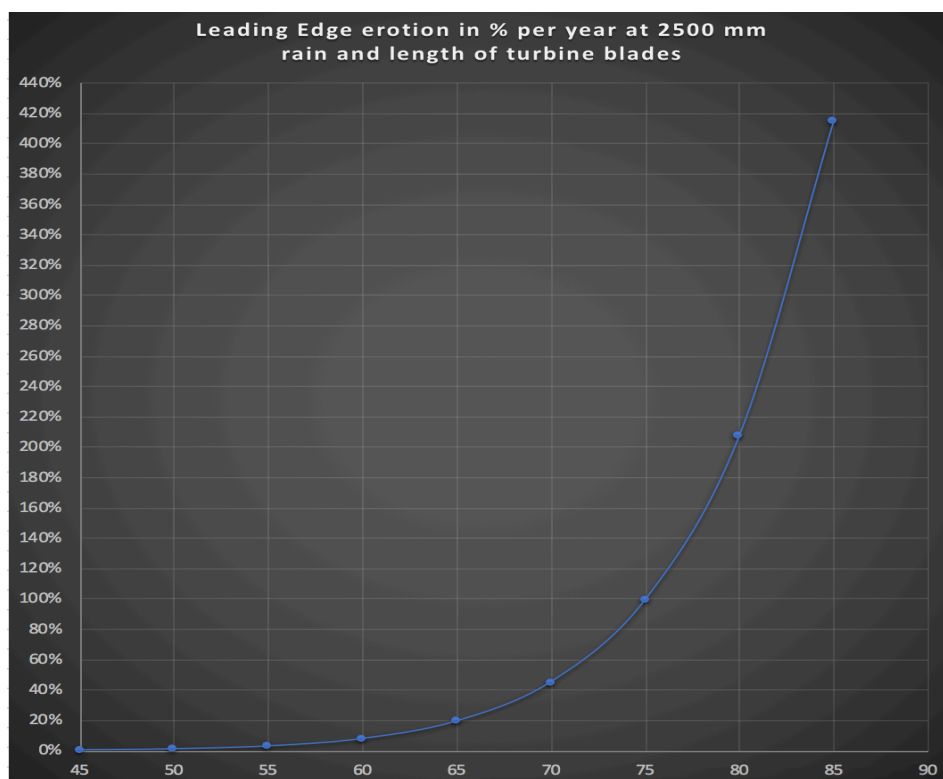


Figure 4. erosion (loss in percent) as a function of precipitation, speed and length of turbine blades

¹⁸ <https://norwea.no/norwea-mener/2021/3/26/faktaark-vindkraft-plast-og-bisfenol-a>

The average temperature in many places on the Norwegian coast is below 4 degrees from November to April. This gives the risk of at least 5 months with of icing and hail and long periods of higher average mechanical stress and emissions than those found in Scotland.

25 tonnes of annual emissions in the form of micro- and nanoplastics, which are sprinkled over outfields, pastures, water sources and eventually sea areas.

How much of this will be epoxy made with Bisphenol A (BPA) is uncertain, but 1 kilo of BPA is enough to pollute 10 billion litres of water. That's 10,000,000,000 litres.

Since 2017, the WHO has advised that drinking water should have a maximum of 0.1 micrograms of BPA per litre. That is the same as 0.0000001 grams per litre of water¹⁹.

Food producers, dairy farms, reindeer slaughterhouse and Norwegian sheep farmers market pure milk and pure meat from Norwegian mountains. Fish and seafood is a major export industry. With large emissions of toxic compounds from the wind turbine industry, this industry will be exposed. Wind turbines can have major ecological, health and economic consequences.

We do not know any wind turbine facilities having applied for or received emission permit.



Figure 5 Photo: A small blade profile - to get an impression of proportions. Own photo, from testing

¹⁹ https://www.nmf.no/wp-content/uploads/2021/02/Green-Warriors-of-Norway-ECHA_REACH-Bisphenol-comments-and-evidence.pdf

Guleslettene wind power plant (Florø in Norway) – an example

Guleslettene which has been in focus due to conflict with the municipal waterworks, has approx. 3575 mm rain per. year. They have Vestas 136 turbines with a diameter of 136 m on the wingspan.

The formula for calculating wear then becomes $f(x) = 1,4 \% * \left(\frac{\text{diameter}}{100}\right)^{11,4}$.

It gives an estimate of 90 kg of emissions of micro- and nanoplastics per turbine and 3,960 kg annual emissions.

Over 25 years the emissions will be 99 tonnes.

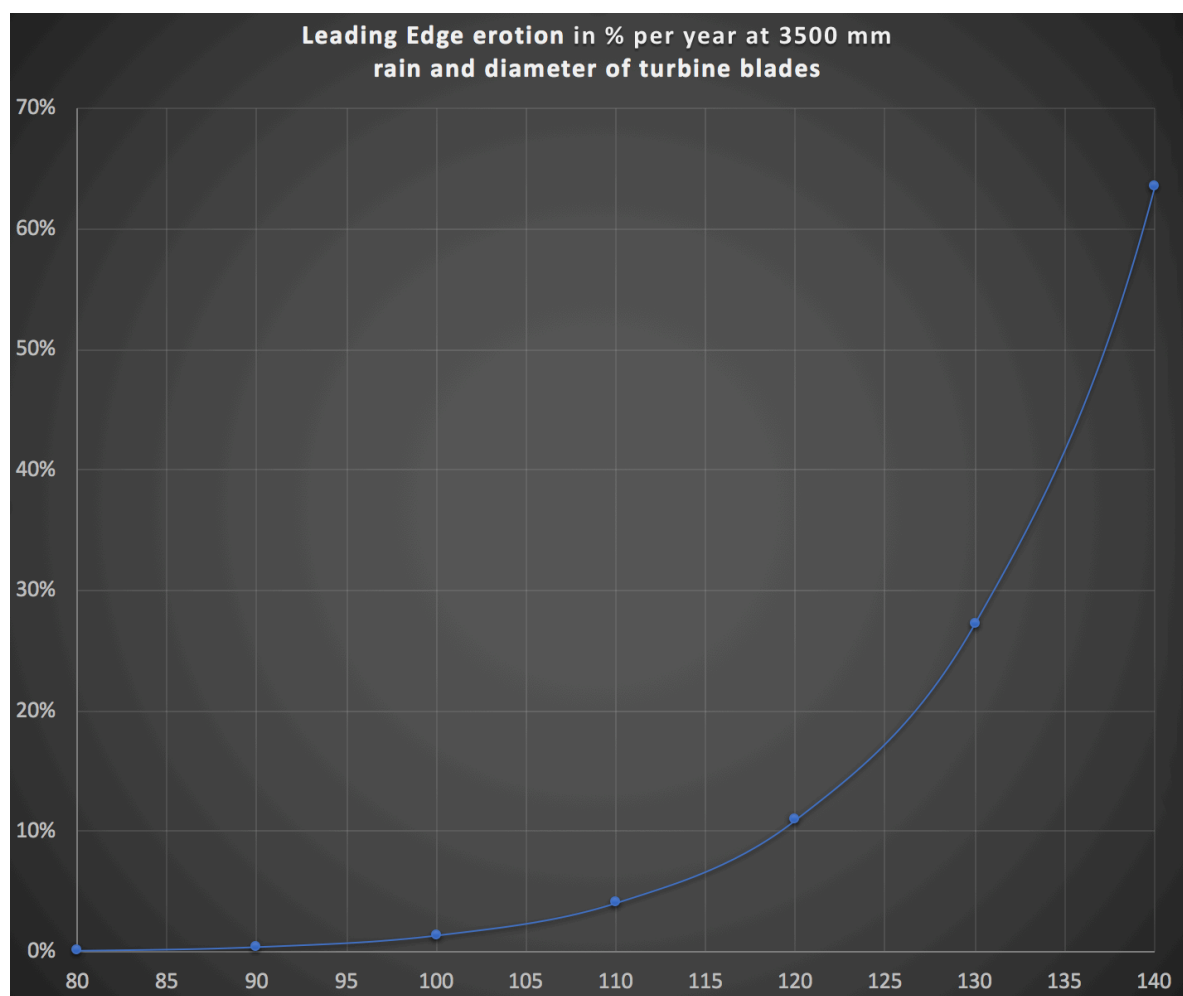


Figure 6. erosion (loss in percent) as a function of precipitation, speed and length of turbine wing

Logical check

In the absence of good published documentation that quantifies mass losses, we have found this one report from Strathclyde.

In the report, *The increasing importance of leading-edge erosion and a review of existing protection solutions from 2019*²⁰, it appears that there are large and known problems with mass loss and that they will increase with offshore wind:

“Blade leading edge erosion has become an important issue for the offshore wind industry.” and it goes on “... greater blade lengths and higher tip speeds, as well as a move to new markets with monsoonal climates, has caused leading edge erosion to progress from an issue that only affects a small number of turbines in the most extreme environments to a major problem that effects entire wind farms.” It also states “..As a result, blades can experience significant erosion within just a few years, which considering their supposed 25-year service life, is a serious problem.”

You can also read about accelerated tests performed at 135 m/s where LEP is worn through in 30 minutes. When we know that offshore turbines get up to 110 m/s, the emissions from offshore wind must be large.

Here is a short quote about Bisphenol A from a blog within the construction industry. The author has many years of experience with environmental classification and is affiliated with Statsbygg. She can't find any good explanations for whether epoxy contains Bisphenol A or not, nor how much. The author writes that she received the following answer from the Norwegian Environment Agency:

“Bisphenol A and Epichlorohydrin = epoxy resin are not currently on the priority list, but it is harmonized classified (a substance that has been adopted in the EU / EEA and included in Annex VI of CLP), among others. a with environmental hazard classification H411 «Toxic, with long-term effect on life in water”²¹.

The Norwegian Environment Agency therefore recommends, based on both the environmental hazard classification and the suspicion that it has endocrine disrupting effects, that it is a good "precautionary principle" that one tries to find other and more environmentally friendly alternatives.

Remember that Bisphenol A amounts to approx. 13 - 15% of casting weight of a turbine blade.

When it comes to wind turbines and the environment, no rules or guidelines have been made that safeguard people's health, pollution and the environment²².

²⁰ <https://doi.org/10.1016/j.rser.2019.109382>

²¹ <https://www.futurebuilt.no/Blogg#!/Blogg/Inneholder-epoxy-stoff-paa-prioritetslisten-Eller-ikke>

²² <https://www.futurebuilt.no/Blogg#!/Blogg/Inneholder-epoxy-stoff-paa-prioritetslisten-Eller-ikke>

Dismantling and demolition

In Norway there are no requirements or guidelines for either disassembly or handling turbine blades after the end of use. The only thing that exists is a requirement that after 12 years of operation, money must be set aside for demolition. That money is set aside presupposes that there is money in the operating company, legally it is the landowner who is responsible for clean-up.

The practice of demolition has been so-called controlled rollover into terrain, it pollutes the terrain a lot and it makes much of what is described as circular economy impossible, especially when it comes to all fiberglass and epoxy. The only reason to roll over in terrain is that it costs approximately only approx. 33% compared to disassembly.

Rotor blades pollute during operation and are an environmental problem after the operation phase, there are no requirements for how this composite waste is to be handled.

When it comes to alternative use, there are currently few or no good methods.

The wind turbine industry has previously dumped some of the waste in Africa through so-called second-hand sales, today most of it is buried all over the world. Often the turbines will remain standing after the end of the operational phase, there is a real danger in Norway as well.



Figure 7 Photo: Bending test of a section on a wing profile. Own photo, from testing

"You can't escape physics and knowledge, no matter how good you are at rhetoric"

"THE TURBINE GROUP" JULY 2021

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