Location, Form and Function in Shetland's Prehistoric Field Systems

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Statement of originality

I hereby confirm that this is an original study conducted independently by the undersigned and that the work contained herein has not been submitted for any other degree. All reference material has been duly acknowledged and cited.

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Date:

Abstract

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Shetland boasts exceptionally well-preserved, but largely overlooked, field systems spanning a period of approximately 4000 years (Neolithic/Bronze Age – Viking/Norse). These have the potential to vastly increase our understanding of past agricultural practices and life styles. This study uses topographical survey, Shape Analysis, GIS, soil survey and micromorphology to answer questions relating to their location, form and function/management, pioneering the use of new tools and testing current models. An holistic landscape approach to the field systems is developed and tested against a multi-period site. Previously unknown types and periods of field systems are identified through survey and shape analysis, tools demonstrated to be valuable in refining the emerging model of field classification. GIS has illuminated pre-, during and post- construction factors influencing boundary form. New insights into location arise from the survey and GIS. Soils work has demonstrated that existing models of soil management over-simplify a complex situation, that thin acidic soils retain cultural information and that accretion was important to the sustainability of these peaty soils. While soils were sustainable over extended periods, the cultural inheritance of managed land appears to be limited. This thesis therefore presents the most holistic and comprehensive understanding of Shetland field systems which has so far been attempted.

For my father, Brian Charles Turner (1926 – 2008) who did not live to see the end of this study but who was nevertheless delighted by it
and my husband, David Marsh, who could have lived without it!

Give to me Lord, a thankful heart
And a discerning mind,
The strength to finish what I start
And act on what I find.

C Micklem (1925-)

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CONTENTS

List of Figures

List of Tables

Chapter 1: Introduction and Aims

It is reasonable to assume that as soon as people began to build houses that were more than temporary shelters, they began to restrict the area from which they could gather resources, in particular food (although this has been questioned by Whittle, 1997). Growing their own food was a way of compensating for this, enabling people to begin to manage and control the resource to some degree. If people were going to the trouble of growing crops, then they would want to ensure success. Barriers which afforded a degree of protection, particularly from passing animals, would have been required almost immediately. Generally speaking, whilst it must exist, evidence of such barriers is hard to find. Nevertheless, these barriers, or boundaries, would have been important in defining ownership rights, territories and a sense of belonging or otherness: an identity for the people or community that erected them. The focus of the present research is to explore what these barriers meant, primarily in terms of farming. It will explore how the sizes and shapes of fields changed over time and why (field form), how people managed the land and how this also changed (field function), what factors influenced the form and function of the field systems and whether inheriting previously worked land was a positive or negative factor.

Understandably, antiquarian and early professional archaeology focused on the excavation of buildings and structures, such as tombs, which were readily identifiable as being the remains of past cultures. However, as early as 1923, Cyril Fox created a series of distribution maps for sites in the fens and uplands of Cambridgeshire and in 1938 Curwen sought to understand prehistoric landscapes by examining the Black Houses and shielings of Lewis in order to gain an understanding of prehistoric interaction with the landscape (Stoddart, 2000). Subsequent work has either focused on England with an emphasis on tools such as Doomsday Books and Enclosure Maps which do not exist for Scotland (eg: Hoskins, 1955; Aston and Rowley, 1974; Roberts 1987) or, more recently has been part of the rise of post-processual, post-modernist, archaeology which focuses on the "socio-symbolic" aspects of landscape (eg: Schama, 1995; Bender, 1993; Tilley, 1994; Ashmore and Knapp, 1999). The development of "Geoarchaeology", the application of tools from the disciplines within Earth Sciences to archaeological problems, presents new ways of understanding archaeological landscapes (as opposed to using structures or site based archaeology). This current research will apply a landscape focused approach to a range of field systems, in order to test and develop new methodologies.

DEFINING FIELD SYSTEMS

A field system is defined in this study as "the land enclosed by boundaries, or identifiably in use at a specific period of time". Those which are examined within this study are associated with structures which are characteristic of a given period. The existence of surviving structures is not a pre-requisite for a field system, but, in the absence of excavation, structures have been employed in order to assist in dating the boundaries and any episodes of land use which are identified.

It was not essential for field systems to have any surviving boundaries. Boundaries may have once been of wood, or of an ephemeral nature, and just not have survived; they could be obscured by later landuse, as at Old Scatness; they may have been defined by natural features, such as breaks of slope at South Nesting Hall. Post-medieval field systems in

Shetland were often not bounded by anything at all, or at best were marked by upright stones or small pits known as "boot holes", although earthworks were created as the result of repeated use of the rigs. The prehistoric field systems, however, are most usually identified from patterns of dykes, clearance cairns and lynchets which may or may not be associated with an extant house site. (A dyke is a positive, rather than negative feature in the Northern Isles). Many of the dykes in Shetland today are drystone, but earlier dykes often combined turf or earth within the stone, and it was not uncommon for the main constituent of certain dykes to be of turf.

THE SIGNIFICANCE OF STUDYING FIELD SYSTEMS

As already stated, field systems became necessary as soon as people began to settle in one place and grow crops in order to supplement their diet. Field systems were fundamental to the success or failure of a settlement, and ultimately to its stability. Without them, a society was dependent on collecting and gathering natural resources, over which they had little authority. Establishing field systems put humans more in control of their environment. While this too would be subject to natural forces, some of these, such as soil fertility, could be assisted; others, like the weather, could still not be controlled. Farming and field systems therefore have an important place in our understanding of how people adapted and manipulated their environment to make it work for them. However, Graeme Whittington identified that "one of the largest gaps in our knowledge of prehistoric Scotland relates to the appearance of the farmed and settled landscape" (Whittington, 1978).

There are numerous questions relating to the farmed landscape which are understood poorly, if at all. For example, how was territory defined and do these definitions change in any given period? If they changed, how and why did they evolve? If territorial boundaries, whether physical or conceptual, continued from one cultural society to the next, such as from the Late Iron Age, did the Vikings adopt Pictish estates wholesale?

During the 1970s and early 1980s instrument survey of exceptionally well preserved tracts of prehistoric landscape began: Dartmoor (Fleming, 1978), Bodmin Moor (Johnson and Rose, 1994), The Lake District (Leech, 1983; Turner, 1987). All these studies focused on the landscape in terms of topography, landuse, technology, demography, social interaction, economic resources and risks. More recently archaeological "landscape studies" have focused on theories of how people may have perceived their surroundings.

The study of the archaeological landscape can therefore be broadly divided primarily into two different approaches, Site Based Archaeology (the archaeology of the built heritage) and Theoretical/ Social Archaeology.

A. Site Based Archaeology (the archaeology of the built heritage)

1. Survey in the immediate vicinity of an excavated site (eg; Kebister, Scord of Brouster field systems) as a tool to assist the interpretation of the site.
2. Constructed landscapes, i.e. the survey of a wider area in order to create a Sites and Monuments Record/Historic Environment Record (SMR/HER) in actuality or in microcosm, interpreting the whole as a number of discrete sites eg: Hunter (1996) Fair Isle; work of RCAHMS (eg: Johnson and Rose, 1994); studies in the Lake District National Park (including Leech, 1983; Turner, 1987)

B. Theoretical/Social Archaeology (concepts after Knapp and Ashmore, 1999:5)

1. Conceptualised landscapes ie: landscapes which are given meaning through localised social practices and experience. They may have powerful religious associations, artistic or other cultural meanings invested in natural features (eg: woods, rivers, and springs) rather than archaeological sites or monuments. Where they do exist, these are generally insignificant.
2. Ideational Landscapes, or "Sacred Landscapes" which relate to the formation of ideas or mental images of things not present to the senses and to culture based on spiritual values or ideas. Bintliff (1996) called these "Landscapes of the mind".

More recently the Site Based approach has begun to expand in order to put one or more sites into an economic / environmental framework. This has resulted in a more integrated approach between the related, but often discrete disciplines of the excavation of structures and environmental archaeology. This approach has been developed at Old Scatness where the two disciplines have become seamlessly interwoven (Dockrill *et al* 2010; Turner, 2004, Turner *et al,* forthcoming).

This study will take a rather different approach to any of these. Whilst it will have more in common with the Site Based approach than with Theoretical Archaeology, the focus of the study will not be the structures but the fields, or landscape, itself. Information will be sought from soils located within the middle of the fields rather than from soils which have a stratigraphic relationship to a structure. This will be referred to as a "Landscape approach".

THE SIGNIFICANCE OF SHETLAND

There are compelling reasons for basing a study of field systems in Shetland. The studies, already referred to above, which have previously taken place to map landscape features have each focused on a single period. Orkney and Wessex boast impressive and unparalleled ritual landscapes dating from the Neolithic period. The archaeology of the Dartmoor Reaves and the cairnfields and boundaries of the Cumbrian Uplands are impressive examples of domestic Neolithic/Bronze Age settlement. However, in every case, the remains of later periods do not survive on anything like an equivalent scale. Shetland is very different in this regard.

Arguably it is easier to examine anthropogenic landscapes in Shetland than in most parts of Northern Europe because the "bits in between" the settlement sites (where archaeological and antiquarian attention has tended to focus) contain visible traces of how the land was used. Cultivation and intensive farming are very limited in Shetland today and, whilst the presence of sheep makes the land more acidic and even less suitable for farming, it is this which has helped to preserve evidence of the past. In Shetland "stone fences" (to borrow a Scandinavian expression) the remains of either stone built dykes or remains of fealie (turf built) dykes, are visible in the modern landscape. In Shetland a "dyke" is a positive feature not a negative one. In other parts of Britain the post and stake hole remains of field systems are far harder to find in the landscape. However, these may have once also formed part of the division of the fields of Shetland and therefore, good as the landscape survival is, it may not reflect the whole story.

Charles Calder (1956) was the first person to appreciate that the extent of the Neolithic/Bronze Age houses was greater than the structures alone; that they were set within enclosures, field boundaries and cairn fields. Alasdair Whittle (1986) mapped the multiple field systems at Scord of Brouster and also Pinhoulland, work which began to demonstrate the importance and extensive nature of the early farming settlements on the West Side of Shetland. Subsequently (1980) Noel Fojut turned his attention to the Iron Age period. Although no Iron Age field boundaries had been recognised in Shetland at the time, Fojut took a geographical and statistical approach to the plethora of brochs in the South Mainland of Shetland, and made calculations which related to the number of people that the available resources within a putative territory could have supported. During the 1980s, Owen and Lowe (1999) mapped a primarily post-medieval landscape in the area surrounding Kebister, North Lerwick. Most recently, field walking by the author and others, associated with Shetland Amenity Trust's "Viking Unst" project, began to recognise the potential for identifying Viking landscapes associated with the surprisingly numerous longhouse sites which were emerging from the scattald of Unst. Shetland's wealth of multi-period survival of field systems is unparalleled. Therefore, any meaningful comparison of sites of different periods and the development of agriculture must begin in Shetland. The results can subsequently be rolled out to, and tested in, other areas of the North Atlantic.

BROAD OBJECTIVES – STRUCTURES AND FUNCTION

Current analyses of field systems, including their boundaries, have tended to be based on construction techniques (boundary form) and the relationship of field forms with associated features such as house sites. Given the difficulty of dating dykes, this is allowing us to formulate general principles about the field systems based on form, which can be applied with a degree of confidence in situations where an associated datable site is not immediately apparent. The archaeological investigation of prehistoric field systems to date has begun to establish a typology for Shetland which allows differentiation between field systems of different dates based upon size, shape and association with structural remains. Preliminary soils based investigations of the Neolithic/Bronze Age field systems demonstrate a range of arable land management practices that appear to vary with soil environments (e.g. Chrystall, 1994; Simpson *et al.* 1998a; 1998b).

The current research seeks to take these analyses forward, by creating a quantified definition of prehistoric field systems in Shetland using Geographical Information System (GIS) techniques to provide a more secure interpretation. In undertaking this analysis particular attention will be given to the definition of Iron Age field systems, a period where boundary evidence is apparently absent from the current evidence. Norse yards have begun to be identified in the field; infield boundaries appear to be absent, possibly because they have never been sought. The GIS study will investigate whether it is possible to identify attributes which are period-specific and could enable identifications to be made in cases where associated diagnostic buildings were absent.

Once the different forms of field systems have been defined and classified, the associated soils will also be analysed and compared in order to identify possible differences in function. The results will produce a new integration of form and function, providing a more comprehensive understanding of the continuity and change in the field systems of northern latitudes, and will permit the recognition of the role of landscape inheritance in providing options for future generations.

Chapter 2: A Review of Prehistoric and Norse Landuse and Settlement in North Atlantic Shetland

Introduction

This chapter presents a theoretical framework for the study of landscape, sustainability, field form and function. It then places the existing work on Shetland field systems into a European setting, followed by a chronology and overview of settlement and economy in Shetland which gives a context to the following review of the soils evidence for land management practices in the North Atlantic. The purpose of this work is to identify the limitations in current knowledge and to construct a research agenda to address this. The chapter concludes with a summary of the key questions to be addressed and hypotheses which need to be tested.

THE THEORETICAL FRAMEWORK

LANDSCAPE STUDIES

"To be provocative, archaeology has a privileged access to landscape through time depth" (Stoddart, 2000:3)

Introduction

The concept of "landscape" was imported into Britain from the Netherlands ("landschnap") at the end of the 16th century. The concept applied to a unit of occupation or jurisdiction, rather than a pleasing scene. It was the human design and use of the landscape, populated by the people who worked it and moved about in it, that created the story (Schama, 1995:10). Henry Peacham's "Art of Drawing"of 1606 was the first British book to describe how to compose a landscape (Peacham, 1606 discussed by Semler, 2004).

The Development of Landscape Studies

Prior to selecting landscapes worthy of inscription as World Heritage sites, UNESCO defined "landscape" in three categories (Cleere 95: 65-66):

1. "clearly defined" landscapes which were "designed and created intentionally" e.g. gardens such as Versailles
2. "organically evolved" landscapes, arising from a particular initiative which evolved in association with and in response to the natural environment. This category includes relict archaeological landscapes e.g. ancient agricultural complexes.
3. "associative cultural" landscapes, sacred places e.g. Ayres Rock.

Archaeologists have formulated a number of definitions of "landscape" in recent years. Essentially it is the area between the obvious archaeological sites, the backdrop against which people live their lives. It is the space which provides the resources for living, the places of danger and the places of refuge which influence how people behave. Barrett (1991:8) described landscape as "the entire surface over which people moved and within which they congregated. That surface was given meaning as people acted upon the world… Thus landscape, its form constructed from natural and artificial features, became a culturally meaningful resource through its routine occupancy."

The American geographer, Carl Sauer, is credited as the first scholar to formulate the concept of "cultural landscapes" fashioned from the natural landscape (Sauer, 1925 cited in

Knapp and Ashmore, 1999:3) although Sir Cyril Fox wrote his "Archaeology of the Cambridge Region" two years earlier (Fox, 1923). Curwen's linking of prehistory with contemporary life in Lewis took place in 1938.

W.G. Hoskins (1955) was the first British scholar to consider the historical evolution of landscape through time, albeit that his observations were restricted to England and were largely dismissive of any prehistoric influence. His main contention was that earlier field systems are reflected in the present landscape. Indeed, Hoskins went as far as to say that, in some areas of England, the landscape was "virtually completed" (ie: had taken its present form) by the time of the Black Death. His book was reprinted over 20 years later (1977, introduction dated Nov 1976), the amended introduction stating that, in spite of the amount of work which had been carried out "there is still so much we do not know, so much work in progress, that a revision is still premature" (Hoskins 1981:16).

In 1974 Aston and Rowley made a related point, commenting on the increasing volume of literature but the lack of available practical advice. They set out to redress the balance with a publication intended to help people record vanishing landscapes: a manual of techniques, with chapters about maps, using aerial photographs, and fieldwork in towns, villages and the countryside. What was still lacking was much synthesis or analysis.

Fourteen years later, geographer B.K. Roberts produced a "study in historical geography" which focused on village plans as evidence of previous landuse. Roberts also considered his volume a handbook, establishing a system of classification of village development against which the histories of individual villages could be assessed (Roberts, 1987).

The limitations of these early studies are twofold. Firstly, they focused on England and made extensive use of tools not available in Scotland (e.g. the Doomsday survey, enclosure maps and abundant estate maps). Secondly, they concentrated on historic time. *"In general boundaries are one of the most ancient features of the English landscape – parish, county, hundred, estate."* (Hoskins,1981:13). Hoskins touched briefly on the pre-Roman landscape, but his general contention was that "The direct prehistoric contribution to the landscape is small …" although his conclusion to the introduction to the second edition was that "everything is older than we think." One of the themes explored within this thesis is whether there is a prehistoric component to the present day landscape.

"Theoretical archaeology" became established as a discipline within mainstream archaeology in the early 1980s, introducing new ways of trying to understand how people lived in the past. Consideration of the social dimension was, in part, an inevitable next step following landscape studies such as that of Renfrew (1979) who considered the Orcadian chambered cairns and what they might have meant to the Neolithic populace and, in Shetland, Fojut's (1983) examination of potential broch territories and communities. Post-processual archaeology was concerned with the "active role of individuals in constructing and interpreting the world around them and in continually reshaping culture and society." (Ashmore and Knapp, 1999:7)

Today's theoreticians emphasise the "socio-symbolic" aspect of the landscape, seeking non-economic perspectives on human/land relations. The "postmodernist" approach, (adopted by a number of disciplines including geographers, historians, anthropologists and folklorists) is concerned with concepts of memory, continuity, discontinuity, transformation (e.g. Rowlands 1993, Schama, 1995). The landscape is visualised as a "cultural image" where verbal or written representations provide images or "texts" of its meaning (Knapp and Ashmore, 1999:3). Bender (1993) edited a volume of site-based landscape studies by archaeologists, geographers and anthropologists who presented landscapes as being both shaped by and shaping human experience. Tilley (1994) produced an influential work on the "Phenomenology of Landscape" ie: landscape as experience, although it too focused on monuments. He presented landscape as unstable, moving along a continuum. Hirsch (1995:25) argued that landscape is not an absolute concept due to the relationships between space/place, visual/hidden, and inside/outside, derived from historical or cultural contexts.

Today there are almost as many ways of subdividing the themes in theoretical archaeology as there are practitioners (e.g. Schama, 1995 "wood, water, rock" or Crandell, 1993 "confronting, staging, cloistering, elevating, bewildering, offering a prospect, picturesque, democratic, perceptive"). Ashmore and Knapp's volume brings together theoretical approaches employed by British, American, Australian and Old World Archaeologists. Their four overarching themes are: landscape as memory, landscape as identity, landscape as social order and landscape as transformation (individuals moving to different places). They also subdivide landscape in terms of "constructed, conceptualised and ideational" (Knapp and Ashmore, 1999:5), which works better in the context of this study (above, chapter 1).

Most examples of theoretical archaeology having been applied to landscape are either those considered "sacred" (phenomenology) or are site/buildings based (structuralist). Work has been heavily weighted towards areas of exceptional Neolithic monuments: in Britain, particularly Wessex and Orkney. In recent years, the theoretical approach has become equated with academic excellence. The Dutch archaeologist, Kooijmans (2000: 324) warned that, as seen from abroad, prestige in British academic archaeology has concentrated too much on the metaphysical landscape at the expense of the functionalist approach. "Even if it seems rather reactionary, … the new landscape approach contributes little to our understanding of the relations between settlement and landscape in prehistory….we have almost forgotten that people also had to make a living, fulfil their basic needs of food and shelter, and needed protection from the hazards of weather and climate." The approach of this thesis will be heavily weighted towards a functionalist approach to Shetland's landscape, using tools developed for scientific disciplines.

SUSTAINABILITY

Forman (2001:481-2) presents four definitions of sustainable agriculture in current use:

1. Maximum yield based on locally available resources and long term environmental conditions.
2. The maintenance of agricultural production through periods of disturbance or stress.
3. An overall level of productivity achieved dependent on simultaneously maintaining soil, water, plant and animal resources for a whole unit.
4. "Low-input" agriculture where instead of increasing productivity, one raises profitability or net gain by sharply decreasing the expensive inputs of fertiliser.

Although Forman presents these as subtle differences, this understates the potentially very significant variations between them. In prehistoric times, there may have been no requirement to achieve a maximum yield, since this is only beneficial if there is a market for the surplus and therefore definition 1. will only apply if there are trade networks in place. Maslow's triangle of basic human needs (1943: 370-96) classified *Physiological Needs* (food, water, rest) as the fundamental human requirement, followed by a need for *Safety,* in terms of resources and property, as well as physically. Higher up came needs of *Belonging, Esteem* and *Self Actualization.* Sahlins (1974: 36-7) presented the Kalahari Bushmen, a contemporary tribe of hunter-gatherers, as the ultimate affluent society, as they could supply their physiological needs with between 3-5 hours work per adult per day. Their adoption of agriculture could potentially achieve periods of even greater leisure: time which was used for elaborate ceremonies and craftsmanship (*ibid:* 38), the values which came higher up Maslow's triangle.

Forman suggests that, on the basis of 30-50 years representing two generations, sustainability should be thought of in terms of periods of between 500-2000 years, overlapping changes in climate to which the environment may or may not adapt (Forman, 2001: 486).

<u>Adaptability/Community Resilience</u>

For a field system to survive for anything approaching 500 years, the key attribute it will required is adaptability: the ability to be modified in response to disturbance (Forman, 2001:484). This is more than a coping strategy, which is a response to a short-term abnormality but which does not result in long term change (Moss *et al.,* 2002). Maximum adaptability is achieved where the disturbance is frequent, but irregular, as this will enable the development of mechanisms for dealing with it (Forman, 2001: 503). In relation to field systems, such mechanisms may include changing crops or the ratio of arable: pasture, altering the nutrient input in terms of either quantity or substance, bringing previously unused land into cultivation, etc. Human activity and the relationship to the land have a cyclical relationship, described by Forman as a "feedback loop" (Forman, 2001: 505):

Harvest » More people » Less land » Fewer People » More land » More People » etc

(In this model, "more" and "less" land refers to the per capita area available.)

The larger the area, and the wider the range of ecological conditions within it, the more inert it becomes, requiring a greater degree of disturbance in order to impact on it. Thus a larger unit will be more stable, with a greater capacity to resist, or recover from, change (Forman, 2001:513).

Inheritance

Issues of inheritance, defined as the continued use or reuse of land, are entirely bound up with sustainability and adaptability. Armit discussed inheritance in the context of "Atlantic Roundhouses" (brochs) and wheelhouses, with the land holding being subdivided in successive generations (Armit, 2005:129-141). This study will explore issues of inheritance in terms of continuity/reuse or discontinuity/disuse of land over generations and across cultural changes.

Landscape Archaeology in Shetland

Previous Research

All the field surveys carried out in Shetland up to, and including, the Ordnance Survey fieldwork carried out in the 1960s, followed the pattern first set during their large-scale mapping of the islands in the 1870s. These first surveyors were military engineers who also recorded place names. Each name was verified by three local people of standing who were also asked to supply information about the antiquities of the area. This information was recorded in a series of "Name Books". Some surveyors recorded large amounts of information, others were less interested. More significantly, the local informants were often the laird, the minister and the local teacher in the district: perhaps the least likely people to have been brought up in the area or to know the land. This rather haphazard collection of information has tended to be self-perpetuating, with areas apparently devoid of sites therefore not being investigated during subsequent campaigns (Lamb and Turner, 1991:171-3).

In 1928 the Royal Commission on Ancient and Historical Monuments began their Inventory of Sites in the Northern Isles. Charles Calder carried out the bulk of the work in Shetland. By the mid 1930s, the scale of the job in Shetland overwhelmed the available resources, and the outbreak of war delayed publication until 1946. By then, Calder was aware of the large number and remarkable preservation of still unrecorded sites in Shetland, especially on the West Side. As a result, he made a number of subsequent return visits. His first publication of these visits reported the discovery of Stanydale "Temple" (Calder 1950). In 1956 he published a "Report on the Discovery of Numerous Stone Age house-sites in Shetland". This was a list of 57 house sites, which included a number of maps of the houses in their landscape settings: Gruting School with two house sites and numerous clearance cairns; Ness of Gruting including houses, field dykes, clearance cairns and lynchets; the Scord of Brouster with three house sites, field dykes, clearance cairns and Stanydale with its "temple", three other house sites, field dykes and clearance cairns.

The 1970s revision of the Ordnance Survey Shetland map sheets was preceded by a re-examination of all the previously included sites. A number of new sites were added during field work and still more were identified by aerial photography. These combined sources, together with local reports which had been collected by the Shetland Museum since its foundation in 1960, formed the starting point for the Shetland Sites and Monuments Record, created by the author in 1986.

Landscape archaeology in Shetland took a stride forward in the late 1970s when Alasdair Whittle undertook field survey and excavation at the Scord of Brouster. The excavations included a comprehensive survey of the site and its associated field system (Whittle 1986:4) as well as of a similar site at Pinhoulland (*ibid.*54).

A decade later, Olwyn Owen directed excavation and associated survey at Kebister (Owen and Lowe, 1999). The project was centred on an extraordinarily large building, initially thought to be a Viking longhouse. The interdisciplinary team included a botanist, a soil scientist, a tephrochronology specialist and a surveyor. Owen used the whole excavation team to plot the hillside as if it were an excavation area, mapping it using planning frames in grid squares. The results of what turned out to be a primarily post-medieval mapped hillside are impressive and highlighted the importance of, and the information to be gained by, looking at Shetland sites in their wider context.

When Shetland appointed the first Regional Archaeologist in 1986, Turner began a programme of “site validation” in order to refine and enhance the archaeological record. This programme also began by revisiting the recorded sites, adding new sites in the process. It quickly became apparent that visiting and recording individual sites had serious limitations in an archaeological landscape as rich as Shetland. The work therefore developed into a series of geographically limited topographical surveys which fed into the Shetland Sites and Monuments Record. The South Nesting Palaeolandscape Project (Dockrill, 1992; Shetland SMR) arose from this, focusing on burnt mounds within their wider landscape context and including evaluation excavation, pollen analysis and eventually micromorphology (Dockrill and Simpson, 1994).

In 1995 Shetland Amenity Trust and the University of Bradford began a second collaborative project: the examination of a broch in its economic and environmental setting. After twelve years in the field, the "Old Scatness Broch and Jarlshof Environs Project" is now in the final stages of publication. This project has involved comprehensive topographic and some geophysical survey and several campaigns of targeted micromorphology (e.g. Simpson *et al.,* 1998b; Guttmann, 2001; this study). This work has been followed by the Viking Unst project, which commenced in 2006 with a large field survey component, including this study (Turner *et al.,* 2013).

THE DYKES OF SHETLAND

The Ethnographic and Historical Evidence

Where areas of cultivation were demarcated by boundaries, these did not necessarily follow straight lines. Between the 17th and 19th centuries, hilldykes often took the form of the turf-built faelie dykes, dividing the settlement and infields from the scattald (the common grazing in the hill land). (Some scholars prefer the term "head dyke" to hilldyke, but this term has no past or present currency in Shetland.) (Brian Smith, pers. comm.) Turf dykes, or faelie dykes (being built of faels, or turfs), sometimes topped with a line of protruding sticks in order to deter animals from crossing, tended to meander, taking in earthfast stones and rock outcrops. Locally it is held that a meandering dyke had added strength which helped it to withstand high winds, and has the additional advantage of providing shelter for animals from many erts (wind direction). Once the infields were harvested, the hill dyke was breached, and the animals allowed to roam the infield over the winter, fertilising it as they went. Thus, turf dykes needed annual repair and the crofters were required to carry out the necessary maintenance. In 1827 the 14 tenants living at Laxobigging had over 3 miles of township dyke to maintain (Thomson 1998:122). In addition there would have been the dykes of punds (turf walled stock enclosures) and garths (poor quality grassland) to maintain. It was labour intensive work and a disincentive to build additional internal dykes that were not absolutely essential.

During the 18th and first half of the 19th century agriculture in Shetland was changing rapidly and intensified. Additional tenants were encouraged onto the land, which diminished the size of holdings. While this theoretically increased the available man power, in reality the lairds' reason for acquiring new tenants was to compel them to fish for ling. The rapid changes and the lack of labour meant that people relied on tethering animals and on tenants knowing where their rigs were, despite these being, in some cases, spread across an entire township. The introduction of large-scale sheep farming took place in Shetland in the first half of the 19th century, and brought about major changes. Tenants were frequently dispossessed, or at best reallocated land, as large fields were created and bounded by straight dykes. The linear pattern of dykes bounding Shetland fields today, together with the straight hilldykes, are therefore unlikely to have origins which go back more than 150-200 years: a significant factor when trying to unravel patterns of prehistoric landholding and development.

Fenton's book on traditional life in Orkney and Shetland in the recent past, classified fields using Orcadian terms (Fenton, 1978:13). His first category he called "pickie dykes" (picts'dykes), referred to by Lamb as "sub-peat dykes", both being misnomers in for dykes subsequently covered by peat growth, thereby assumed to be prehistoric. The comprehensive survey of the hillside at Kebister (Owen and Lowe, 1999) demonstrated, both by radiocarbon dating and by association, that in Shetland peat covered dykes can be more recent. The second group Fenton termed "gorsties" (Fenton, 1978:14) defined by Jakobsen in 1928 as *1) a ridge of earth remaining from an old fence (in the outfield), or 2) boundary (ridge of earth) between two pieces of arable land.* (Jakobsen, 1928, reprinted 1985). Fenton (1978:14) identified a third category of Orcadian dykes, associated with the name "Treb". Treb names tend to be associated with fertile farms and Fenton suggested that they might derive from Pictish land units (although he did not rule out a Norse derivation for the place name). The concept of "treb dykes" does not exist in the same way in Shetland, but the idea of continuity from prehistoric to later landuse and the question as to whether it constitutes any more than the inevitable reuse of the best land by succeeding generations, needs to be considered.

The Archaeological Evidence

There is a plethora of prehistoric field systems in Shetland. Initially these were identified as a feature of the West Side (Calder, 1956; Whittle, 1986). Fieldwork in other parts of Shetland is now demonstrating that the distribution is far wider than initially appreciated (e.g. South Mainland, Turner et al., 2004). In addition to the West Side field systems, Whittle identified lengths of wall which extend for considerable distances, radiating out from the infields at the Scord of Brouster and Pinhoulland. Similar patterns of dykes are evident in the vicinity of other prehistoric fields e.g. Stanydale. These lengths do not clearly define fields and may have served either territorial or social functions or both. They indicate that a high degree of social organisation existed in Shetland by the Bronze Age, and they are reminiscent of other early land divisions such as the Dartmoor reaves (Fleming 1988).

The Shurton Hill dyke protruded from the peat and comprised a discontinuous line of slabs of the local granite on which it sat, with no apparent infilling material (Whittington, 1978:31). Pollen analysis suggested that it had been built in heathland, and radiocarbon analysis from the soil beneath the dyke gave a date of 5050$\pm$85BP (CAR 253) (Ashmore, 1999:310) although it is notoriously difficult to be confident about dates from peat.

The discovery of ard marks at Sumburgh Runway under a Bronze Age house site (Downes and Lamb, 2000) and around the Iron Age Village at Old Scatness demonstrates Bronze Age and subsequent building on land previously cultivated in the Neolithic/Bronze Age. The construction of the runway makes it unlikely that the previous settlement will be discovered but raises questions about the attractiveness of an inherited agricultural landscape at this period.

Preliminary results from recent surveys suggest that, in areas where there is good preservation (such as the West Side, Nesting, the South Mainland and Unst) the best relict field systems survive on land which subsequently became scattald, frequently at 30-40m AOD or above. (Scattald is unenclosed hill land where crofters who paid "scatt", or tax, were entitled to specified rights, including grazing and peat cutting.) These sites on the agriculturally less favourable hill land, were presumably occupied at a time when there was an increased demand for agricultural land. This may have been the result of an increased population; the number of incomers or inheritance issues may explain why marginal land was settled during the Norse period (e.g. in Unst). The expansion coincided with a period when the climate was milder, making higher land rather more viable for settlement than it is today.

Between 1900 - 1500 cal BC, i.e. Late Neolithic/Early Bronze Age, there was a distinct and rapid shift in the climate to cooler and/or wetter conditions (Anderson, et al, 1998). Whether the result of ash in the atmosphere as a result of an eruption of Hekla (H4) in 3826 ± 12 BP (Dugmore *et al.,* 1995), lower sea-surface temperatures in the North Atlantic/Greenland, Iceland and Norwegian seas (Anderson *et al.*, 1998) or another reason, the effect was to increase the spread of blanket bog in northern Scotland. This apparently led to a gradual shift in farming-related activity across the region (Anderson, et al, 1998). The Bronze Age abandonment of settlements and field systems may have been influenced by, if not caused by, these conditions. Other possible factors include the increasing stoniness of worked land (Romans, 1986:126) or the effects of internal social processes (Hodder, 1981:10).

At the Scord of Brouster an increase in peat was observed around the lake basin from c.1500 cal BC, although the outer field system appears to have continued in use for at least another 500 years. Although the inner field system may have been abandoned due to increasing stoniness (Romans, 1986:126) both pollen analysis and bleached rim analysis suggest a phase of infield cultivation in the early centuries AD: abandonment may not be wholly due to environmental factors (Whittle, 1986:149). At Brunatwatt, Edwards and Whittington (1998) observed soil erosion and landscape degradation in the Early Bronze Age, and an increase in poorer sedge-grasslands at Troni Shun (both West Mainland).

Calluna heath spread during the Bronze Age at Kebister; muir-burn or grazing possibly causing the increased acidity of the soils (Owen and Lowe, 1999:76). That cultivation of barley began to cause soil erosion, was seen in the redeposition of soil as alluvium in the Burn of Kebister around 52 – 258 cal AD (Jordan, 1999:45). Although peat spread on the upper hillside during the Bronze Age, most of the lower slopes remained free for another 1500 years, and the excavators argue for a "general continuity of human activity". Ard marks were dated stratigraphically to the Iron Age, some containing broken ard tips and flaked sandstone bars, which had broken *in situ* during use. Whittington (1978:33,35) suggested that muir-burn hastened soil degradation and the onset of peat growth at Shurton Hill. The reasons for abandoning settlement on higher ground at the end of the Bronze Age therefore appear to be more complicated than a response to the deteriorating climate and onset of peat.

The fields on hill land must always have been more marginal, with an increased risk of crop failure than those on lower lying, flatter, more fertile, land. After these field systems were abandoned the land was subsequently considered unviable for anything other than grazing, which has facilitated the survival of the field systems.

Where the remains of settlements and field systems survive on lower, or more fertile land, the elements are more fragmentary. Nevertheless, where they do survive on land which was subsequently intensively worked, e.g. North Taingpool, the remains appear to conform to the same general pattern (Turner *et al*., 2004: 122-124).

During his excavations at the Scord of Brouster, Whittle cut sections across field system boundaries. These demonstrated the variety of construction techniques employed within one, apparently coherent, field system, and even within a single line. The duration of the occupation of the settlement sites indicates that the field system might have accreted over a period of perhaps as much as a millennium. The boundaries survive as discontinuous lines of stones, as low banks and as lynchets in several different permutations. The excavated sections range from something that resembles the top of a drystone dyke, but which could never have attained any height, to stone dumps, to large stones with cleared stone piled against them. Typically, lynchets contain stone cleared from cultivated land and have rolled down the slope. The pattern remaining today has subsequently been influenced by stone robbing and animal erosion over 2000 years. Yet while there is little uniformity of construction at Brouster, the Bronze Age field unit has a distinctive form, observed elsewhere on the West Side (Whittle, 1986:4,54) and also present in the South Mainland (Turner *et al.,* 2004). It comprises a cluster of irregular fields, a "Multiple Field System", with associated house site(s) which may or may not be set into the field walls themselves.

The pattern of settlement seen at a number of sites within South Nesting, e.g. Whalsay Willie's Knowe, Ward of Benston, Grunna Water and Vassa Voe is frequently recorded on

Ordnance Survey maps (all editions) as a "Homestead". Homesteads consist of an isolated house situated within or associated with an enclosure. They are more regular than the Multiple Field Systems, and have generally been assumed to be Neolithic in date (Calder, 1958). However, on the basis of artefact typology, Ballin Smith has dated the house site which she excavated at Catpund, and which clearly fell into the Homestead category, as being Middle Bronze Age (Ballin Smith, 2005). At North Taingpool, Exnaboe, South Mainland, both types of sites occur within a short distance of one another (Turner *et al.,* 2004). The Exnaboe evidence raises the possibility of shape being dictated by function rather than date (*ibid*).

Prior to this study there were no recorded field systems or territorial boundaries relating to brochs, other than their surrounding defence (which sometimes enclose a secondary broch village). However, the soils evidence from around the Broch at Old Scatness (Guttmann, 2006; Turner *et al.,* 2010) indicates that they must have existed.

The field dykes which appear to be associated with Norse settlement e.g. Gardie and Watlie, Unst, whilst not comprising straight lines, enclose a more regular overall shape than earlier field systems, and survive as more continuous boundaries. At Eastshore, South Mainland, a building which has typologically Norse characteristics is associated with a field wall which is modern and still standing to its full height. Comparisons with the Unst examples suggest that the modern Eastshore dyke might follow the line of the earlier Norse yard. The irregularity of the wall might indicate an even earlier date for the foundations. Further work is required to determine how typical this is and whether it is significant.

From the field survey of the Eastshore/North Exnaboe area, carried out by the author (Turner, *et al.,* 2004) which lies just to the north of Old Scatness, it is possible to begin to discern several characteristic landscapes:

- A Neolithic or Bronze Age enclosure with a house in the centre (a "homestead")
- a "typical" Bronze Age "multiple field system", and territorial dykes (strongly reminiscent of the West Side)
- rig lines from the late medieval/post medieval period, and dykes (in various states of preservation or decay, some still standing and associated with crofting remains)
- an area of settlement which includes a burnt mound and two house sites, one of which could be either prehistoric or Norse, as the visual evidence is open to interpretation.

As part of the South Mainland survey, evaluation trenches were excavated across some of the dykes of a Bronze Age multiple field system between Compass Head and Sumburgh Head, just south of Old Scatness (Simpson, 2001). The soil proved to be extremely thin and the structural evidence elusive. The artefacts recovered included rough stone tools and a saddle quern, most likely to be of Bronze Age date. Whilst not conclusive, this is an encouraging result.

THE CONTEXT FOR THE SHETLAND EVIDENCE

As already noted, the current vogue in archaeological landscape studies is to concentrate on landscape as "context" rather than more traditional approaches which treat landscape as either "object" or "subject" (terms after Darvill, 1997:2). The Neolithic period lends itself particularly well to the new treatment as many of its sites are monumental with no obvious utilitarian purpose (e.g. Stonehenge, Durrington Walls, Stones of Stenness, etc).

Ritual/sacred landscapes lie outwith the focus of this study, however the aim of this section is to draw out the strands of current debate which relate to the use of land to produce food.

Traditionally the advent of the Neolithic has been equated with the time when people became more sedentary than nomadic, a time of "social transformation as hunter-gatherers took on a new idea" (Thomas, 1988). This processual view has been questioned by a number of people (e.g. Whittle, 1997). The alternative argument runs that in Early Neolithic Europe (characterised by the Linear Band Keramik, commencing in 5500BC) large timber buildings or halls were built. These disappeared by the Later Neolithic and little evidence of domestic structures has been found predating the Middle Bronze Age. Whittle interprets the timber halls as gathering places for a kin or community group living an essentially nomadic life until the Middle Bronze Age, arguing that neither houses, arable or pastoralism need tie people to one place, and that movement, whether seasonal, annual or sporadic, may have been driven by physical, social or subsistence motives.

By contrast, and in the same volume, Cooney (1997:25) argued for a domestic interpretation for the Linear Band Keramik timber halls. Excavations at Skara Brae and Barnhouse in Orkney have demonstrated that there is a complexity of meanings within any given building (Richards, 1993). Wessex, which has a rich and monumental Neolithic but a lack of visible settlement, has tended to be regarded as typical. However, Cooney inferred that it was exactly this wealth which enabled the Neolithic people of Southern England to enjoy the luxury of a nomadic lifestyle.

Early Neolithic enclosures are prominent landscape features dating from c. 5000 BC in Europe (the Netherlands, Belgium, Germany, France and Southern Scandinavia), predating those in Britain by as much as a millennia. The earliest British examples identified had ditches and causeways (segmented boundaries) found in single or multiple circuits in Wessex and Sussex (Oswald *et al.,* 2001; Whittle *et al.,* 2011) Today they have been recognised as far north as Cumbria and also in Wales. Two examples from Cornwall and another from Carrock Fell, Cumbria, incorporate prominent outcrops and earthfast boulders in their boundaries. Abingdon incorporates a section of river. Once thought to occur on hilltops and promontories, the sites have now been identified on river terraces and valley slopes. The variation in size is vast: from 30m – 300m. For Scotland, Barclay (2001) refers to a "vast range of miscellaneous enclosures" largely identified from aerial photographs, as yet "barely explored". These include the Shetland "homesteads".

Two Scottish enclosures have been excavated from Blackhouse Burn, the smaller of which (c40m diam.) included a stony bank and internal features suggesting a timber structure interpreted as a ceremonial structure associated with transhumance (Lelong and Pollard, 1998).

Of the Neolithic enclosures excavated in England and Europe, the most common material recovered has been cattle bones. This has led to their interpretation as cattle kraals, but the locations (some surrounded by woodland, others adjacent to a scarp slope) suggest this is unlikely (Edmonds, 1999:92). Since the enclosures include limited evidence of settlement they have also been interpreted as meeting places, (like the *Linearbandkeramik* timber houses), situated in a zone between winter and summer lands (Edmonds, 1999:93-95).

Danish enclosures were constructed within a narrow time frame (3,400 - 3,150 BC), were short lived and were associated with forest clearance. Thorpe (1997) suggests that they might have enhanced the value of the land, possibly the result of conspicuous consumption, which rapidly exhausted the resources of a location. Several of these early enclosures were succeeded by large Middle Neolithic sites in Denmark which had settlement assemblages associated (e.g. Trelleborg, Sarup and Toftum). However, Middle Bronze Age settlement was also established at sites without earlier roots. It has been argued that the enclosures continued to have ritual significance, but that the investment in the fields, the increased longevity of settlement and variations in site size indicated the importance of occupying places in the landscape perceived as being of high value (Thorpe, 1997).

Sites which have produced large quantities of cereal, albeit dated slightly later in the Neolithic (38-37th C cal BC) (e.g. Balbridie, Aberdeenshire; Lismore Fields, Tankardstown, Limerick; Ballygalley, Antrim) do not fall into the "nomadic Neolithic" model (Cooney, 1997). Tilled areas would require protections and boundaries. Céide Fields, N. Mayo, includes evidence of enclosures, co-axial fields and megalithic tombs, interpreted as the organised management of grazing in an area which was climatically suited to year round use (*ibid;* Cooney *et al.,* 2011).

The fields of north Mayo, like those of the Boyne valley and of Shetland would have needed a greater investment of resources in order to make them productive. Thus the "Irish evidence provides an alternative one to that in vogue amongst many British archaeologists" (Cooney, 1997). There is considerable regional variation within Ireland and Cooney suggests that the picture in Britain was similar. This regionality also lies behind Barclay's admission that "the Shetland evidence rarely appears in syntheses of the British Neolithic" (Barclay, 1996).

Although it has been suggested that settlement began to cluster during Late Neolithic Shetland (Barclay, 1997:149), the only evidence of an early "village" is Jarlshof, where a group of "courtyard buildings" was superseded by a group of circular structures in approximately 700 B.C. (Downes and Lamb, 2000:121). Although there were three houses within the Multiple Field Systems at the Scord of Brouster, excavation demonstrated that these were not occupied simultaneously (Whittle, 1986); it is not yet known whether this was true at all the Multiple Field Systems with several houses.

The Scord of Brouster fields date to the Later Neolithic/Early Bronze Age, and were in use for over a thousand years (Whittle, 1986). At the local scale they have an aggregated field pattern, which gives the impression of piecemeal land enclosure. However, the microcosm seems to fit within a more extensive framework of territorial boundaries. The fields of North Mayo are coaxial, ie they have one dominant axis of orientation. They are apparently imposed on the landscape as the result of a single decision. Coaxial fields at Fengate (nr. Peterborough) were thought to be of a similar date and duration to the Shetland fields, although are now believed to be later. The "Celtic fields" of Wessex and Berkshire include both Bronze Age and Romano British examples. Coaxial fields in Swaledale, N. Yorks, where the stone dykes are 1 – 1.5m wide, include examples on poor soils.

Some of the Shetland fields are littered with small piles of stone, "clearance cairns", particularly the Multiple Field Systems (e.g. the Scord of Brouster). These appear again in the post-medieval period. George Low (1777) commented of 18th century Orkney:

The soil of this spot is sandy and light, but by the help of sea weed yields largely, and is only deformed by large heaps of stones which the people gather from the grounds but are not at pains to drive off, but throw them onto the next wastespot, even tho' this is capable of being turned to good advantage for the grass, which here, as was said before, rises with great luxuriancy".

Eighteenth and nineteenth century Scandinavian farmers believed that the stony soils retained the moisture better (Szabó, 1980). Roussell (1934), writing of the Western Isles contemporaneously, observed that "*only small patches of land were cultivated to meet the owner's needs …and barley fields of only a few square yards in extent were harvested by pulling the crops up with the hands."* Calder (1956), working on the West Side of Shetland, wrote that "*A local crofter informed me that surface stones littering some of the fields lessened by nearly 50 per cent the yield of the growing crops or grazing land."* However, the presence of clearance cairns littered across the fields, a practice that continues to a limited extent in Shetland even today, was clearly not widely perceived as an obstacle to agriculture in the Bronze Age.

Clearance cairns have been recorded elsewhere in Britain e.g. Cumbria, (Leach, 1983; Turner, 1987) but analysis of them has largely been concentrated on Scandinavia examples (Holm, 1999; Holm, 2002; Pedersen, 1999). Cairnfields in Scandinavia start in the Early Bronze Age, e.g. Forsandmoen, Rogaland where they are the first signs of people investing in the land. The Scandinavian cairns have similar dimensions to their British counterparts, 2-6m diam., elongated on sloping ground, and more rounded on flatter ground, 0.1 – 0.5m high and with the majority of stones being less than 0.3m. Unlike Shetland however, the cairnfields are up to 200ha in extent and apparently lacking in internal boundaries. Where an area is "extensively" cleared, the cairns are within throwing distance of one another (ie: a maximum of 10m apart). "Intensive" clearance, which pollen evidence from Hørdalen Vestfold shows began in the Roman Iron Age, resulted in larger open spaces, suggesting a dynamic process. In these areas the land between the cairns was better worked and was manured (Pedersen, 1999). According to legend, this land was tilled by the "hoefarmers", a group who died out with the Black Death (Holm, 2002). The Norwegian studies suggest that the move to a more sedentary existence is older than had been previously believed for Scandinavia.

The Dartmoor fields were laid out about 1,300 BC, demarcated by "reaves" (ruined walls) and associated with dispersed settlement. The reaves ran for long distances, crossing steep sided river valleys. Fleming (1989) argues that they must have been laid out by people who thought of land on a territorial scale rather than in smaller units. This resonates with the evidence from Shetland's West Mainland. In Fleming's model the socio-political entity held the land and administered it, and probably also owned land outside the boundary. These neighbourhood groups may have also worked together as bands of hunter-gatherers, but become more cohesive as the basis of subsistence changed. A greater investment of time and energy was required to practise cultivation but the gain would be longer term. Initially the principle need for boundaries would be to keep animals out: a communal ring fence would have fulfilled this. Internal boundaries would have been more labour intensive to build and maintain. Ring fences foreshadow the fealie dykes bounding the Shetland post-medieval townships. Fleming (1989) maintained that the coaxial boundaries of the reaves suggest that the internal divisions of the reaves were the work of the entire community rather than piecemeal division. The counter argument is observed in the piecemeal apportionment of Shetland's scattald (common grazing) today. When a crofter applies to apportion his/her percentage of the scattald the new fence lines run straight and square, entirely out of character with the rest of the land division in the islands. Internal boundaries, once established, may become fixed due to vested interest and local stability (*ibid*). Even an apparently simple and short-lived field system may be more complex than it appears: there are remains of posts and stakes below the ground surface of Dartmoor. Boundaries may have been intended to reduce conflict, but might increase it; they may have been intended to be egalitarian but could result in tighter control: they might also promote the responsible use of resources and regulate exploitation of the common land.

A peat sample from beneath a potentially similar dyke on Shurton Hill, Shetland Mainland, dates to c3600 cal BC (Whittington, 1978), i.e. earlier than the Dartmoor reaves and might have a pastoral function (Barclay, 1997). It is more than 400m long, passing close to a chambered cairn, crossing land over 150m AOD. There are other Shetland dykes which disappear into the peat extending from several of the Multiple Fields Systems, with which they are probably contemporaneous. The peat growth post-dates the creation of these dykes, which emerge from the peat at intervals, and are therefore also examples of lengthy land divisions. There are hints at a correlation between such dykes and chambered tombs, which lends weight to a territorial interpretation.

Llobera (1996) examined the Late Bronze Age linear ditches of Salisbury Plain from an entirely different perspective. He believes archaeologists have returned to a determinist perspective due to the use of GIS. He demonstrated that the use of GIS need not be restricted to Thiessen polygons, nearest neighbour analysis and site catchment analysis, but that it can be used to examine cultural information as well as environmental information. His aim was to put Tilley (1994)'s references to local topography and landscape features in relation to peoples' movement through the landscape into practice. Llobera examined "structures" (rules and resources) and "affordances" (properties of the environment perceived by an agent in the context of practical action) (Llobera, 1996, after Ingold, 1992). He claimed that people who share structures will inevitably share affordances and he used GIS in order to explore this.

Bradley *et al.* (1994) interpreted linear ditches as territorial markers and noted a correspondence between their layout and the topography. Llobera modeled the relationship between the ditches and the locations where the terrain changes aspect. The emphasis was on changes in the horizontal plane (aspect and bearing of ditches) rather than the vertical one (slope). 41% of changes occurred within distances of 10m and 70% in less than 40m, suggesting a relationship. The relationship between linear ditches and hillcrests were also explored. Viewsheds were examined for three areas bounded by linear ditches: two had boundaries which were visible most of the time from inside. From outside, the boundaries and the territory were far harder to see. This gave rise to the theory that space was segmented rather than being boxed in and that this suggested a higher level of cohesion. Space may therefore have been subdivided for organisational purposes, with ditches being informative markers, unrelated to control. Llobera admits that his conclusions are at best tentative, derived from little data, but that this demonstrates a "cognitive way" of using GIS, considering affordances derived from an individual's perspective within it. However, as he admits, even when it is possible to achieve a good result, there is no guarantee that ancient people did perceive their surroundings in this manner.

The most relevant study in Middle Iron Age landscapes is Fojut's examination of the broch territories in the South Mainland of Shetland (Fojut,1980; 1983; 2005a). He employed the "nearest neighbour index", developed by Clark and Evans in 1954, to determine that broch distribution in Shetland was regular rather than random. He identified three principal requirements in the territory: availability of arable, good grazing and access to the sea. Of these, he concluded that arable was least important, the requirements of a broch being defined as "a little cropland, plenty of grazing and access to the shore" (Fojut, 2005a:155). Of the 15 brochs which did not neatly fit this pattern, 6 were close to large bird nesting sites. Other resources required to maintain broch society (e.g. driftwood, seals, whales, fish, metals requiring fuel, bog iron and/or access to imports) may have been traded between brochs (*ibid:*156).

Using yields calculated by Fenton (1978:336) for bere cultivation in pre-improvement Orkney, and assuming 5% of the land taken up by banks, paths and ditches and another 33% of the land being fallow, and also assuming (after Clark and Haswell, 1967) an annual requirement of 210kg grain per person per annum as a minimum requirement for a cereal dominated diet, Fojut calculated that the area available to each broch in the South Mainland was over 100ha of potential arable land and that this would support a population well in excess of 100 people, even in bad years and allowing for some land being allocated to good grazing. Indeed Fojut suggested that even the smallest of these (Eastshore) could have supported between 128 and 343 people, depending on how intensively the land was used. Hamilton (1968:102) had previously suggested a more conservative estimate of 40-80 people, and Dockrill (pers. comm.) has recently made a similar estimate of 40-60 youths/adults.

Kemp explored broch territories in relation to their carrying capacity for cattle. He proposed a model for dairying comprising six cows and a bull, together with a maintenance level of immature animals which, in terms of calorific value, would supply the daily energy requirement for 9.1 adults during the lactation period. The main limiting factor determining how many cattle could be supported was the availability of hay and, perhaps, water for drinking and processing dairy produce (Kemp, 2001). Evidence of butchered bone from the broch ditch at Old Scatness challenges the assumption that all herds kept at this period would have been dairy cattle (Bond, forthcoming).

The local distribution of brochs contains pronounced variations, whether due to a socio-political constraint, e.g. defence or intervisibility, or the physical environment. Fojut concluded that a key factor determining the location of the 75 then known Shetland broch sites was defence which outweighed convenience, in all but 12 cases. (Of these, at least six were built over earlier settlements and 11 continued in use.) The four broch sites with no defensive potential were situated at least 500m from the nearest defensible site. He concluded that a defensive site was only desirable if it added less than 5 minutes hard walking to the scene of daily activity. Brochs were therefore sited "according to the dictates of the subsistence mode of life to minimise wasted time and maximise use of resources" (Fojut, 1983). As more information emerges concerning the contemporaneity of brochs and as the results of a study of broch intervisibility begin to emerge these conclusions are being challenged (Smith pers. comm.). The 1997 discovery of the Broch of Toab within his study area (Shetland SMR 5960) did not significantly change the resource based conclusions (Fojut 2005b:169-170). Fojut also suggested that the pattern of brochs in the landscape was normally anachronistic, relating to earlier settlement. He observed that many of the brochs were within areas where the un-amended soil is generally poor today. Fojut has recently lamented that his study, undertaken for a PhD in geography, was not subsequently pursued (Fojut, 2005b:166). In recent years there has been insufficient interaction between archaeologists and the earth sciences.

More recently Cowley (2005) considered the Iron Age landscape and political geography of Caithness and Sutherland noting that there are brochs spread across most of the lowlands. Earlier hut circles occur around the fringes of these brochs, but by the beginning of the first millennium AD settlement had become more nucleated, frequently centred on a broch. In contrast, the upland brochs are dispersed along the straths; the spacing is more regular, is along the valley sides, and frequently in commanding, isolated positions. Although there is some contemporary settlement at a higher level (e.g. Lairg, McCullagh and Tipping, 1998), first millennium AD hut-circle settlements are more numerous at slightly lower levels. Cowley suggests that brochs were introduced to the lowlands during evolving social change but they were imposed into upland Sutherland fully fledged possibly as expressions of local authority (Barrett, 1982). Cowley suggests the development of elites in the fertile lowlands may have resulted in competition for resources from the uplands (timber, grazing and people) leading to the need for upland brochs. A lack of settlement around them is interpreted as a result of rapid redundancy.

The field systems and territorial boundaries of the Late Iron Age are as elusive as those of the broch period. Armit (2002) suggests that land became subdivided through partible inheritance and cites the tripartite interiors of the Orcadian brochs of Midhowe and Gurness as potential evidence of this. He also suggests that the relative importance of sites might alter due to division. He proposes division of land as an explanation for the occurrence of two brochs in close proximity in Glenelg: Dun Troddan and Dun Telve. Armit considered that the pattern of inheritance led to longevity and apparent stability in the "Atlantic Roundhouse" population (Armit, 2005) and that a fairly egalitarian society made this possible. (He defined all the massive walled drystone structures of the Iron Age Western Isles together as "Atlantic Roundhouses"). Armit's egalitarian society contrasts with Dockrill's model of a chieftain society (Dockrill and Batt, 2004:136), but the broch at Old Scatness resembles those of Caithness and Orkney which are surrounded by a village, unlike those of the Western Isles.

As yet there is no evidence for either adjacent pairs of Shetland brochs or of their subdivision. While Late Iron Age structures occur in multiples, all the wheelhouses and Pictish houses discovered to date, with the exception of the possible wheelhouse at Robins Brae (identified when it was turned into the casing of a silage clamp) occur either at the landward end of the causeway to off-shore brochs (e.g. Burland, Trondra) or close to, if not within, the broch defences (e.g. Old Scatness; Jarlshof). The occurrence of several structures "replacing" a broch is easily explained by the dramatically reduced internal area available within them, and does not necessarily imply a more fragmentary, divided, community. In either model, patterns of landholdings and boundaries of estates did not necessarily change significantly. To date Shetland Aisled Houses and Wheelhouses have, apart from Robin's Brae, only been found in association with brochs and re-used brochs. It can therefore be assumed that in Shetland, however the land was managed, the broch estates continued to be occupied much as previously.

The settlement pattern of Shetland was somewhat dislocated by the arrival of the Vikings. The Vikings built very different, sub-rectangular, houses, lined with wood from the homelands. These contrasted with the drystone, curvilinear, building tradition which had been prevalent in Shetland for the previous four millennia. The extent to which the Vikings took over the pre-existing landscapes will be touched on within this thesis.

There is very little rural Viking settlement in Britain to compare Shetland with: patterns of landuse in Scandinavia in the Iron Age and Viking periods may contribute to understanding Shetland. The Shetland Vikings came from Western Norway where an infield/outfield system of farming probably developed in the Iron Age (Lillehammer, 1999:133). The fence (garðr) separated the arable (innan garðr) from the outfield (uban garðr). The traditional image was of the sedentary farmer inhabiting the infield (in mythology, the equivalent of Midgard, where the humans lived) and the outfield (Utgard, where the giants lived) was wild and hostile. Holm (2002) proposed that the outfield was more important to the farms than this suggests: hunting, metalworking using bog iron and herding cattle took place there. Infield fences were not static, being made of wood, turf, stone, or brush wood and were required for the hay meadows even if farms had no arable. Many farms had a cattle path leading from the residential area to outfield (Øye, 2005).

The outfield may not have been bounded and may have been in common ownership. Place-name evidence also challenges the picture of a stable Iron Age and Medieval period and it is suggested that the 18th century picture of settlement, created by folklore and retained subsequently, may be a response to other ethnic groups using the forests and mountains, e.g. the Samii (Holm, 2002). The presence of cairnfields in the forest is interpreted as indicating slash and burn agriculture, with the land being tilled from the Bronze Age perhaps as infrequently as 2 years in 20. Holm suggests that defining Eastern Norwegian Iron Age and Medieval farmers by the infield, may have caused it to be over-emphasised. Alternatively the outfield may have been stigmatised as a scary and undesirable place, in order to deter people from leaving farms: fishing in Iceland was similarly stigmatised in order to deter labourers from abandoning the land.

In W. Norway the outfield was more clearly an integrated part of the farm. The infield was generally defined by a stone "fence" with a cattle track leading into the outfield. The transitional zones (field to meadow and pasture to grove) were also significant within the farm, möld from these areas being included as part of the farm deeds (Holm, 2002).

A Norwegian farm could be small, representing a single family holding, or a large multiple unit (Øye, 2002). The Norwegian Vikings established both separate farms and also sheilings in remote and barren areas (Øye, 2005). Although there are sheilings in the Western Isles, Faroe (Mahler, 1995) and Iceland (Sveinbjarnardóttir, 1992) there is no evidence of them having ever existed in Shetland. Prior to 1970, knowledge of prehistoric agrarian settlement in Scandinavia was based on the visible remains of house sites, fields and "fences"; but the last 30 years have revealed many sites concealed beneath the tilth (Myhre, 1999:126). By the 1990s it was becoming apparent that there was far more continuity of landuse and habitation than had previously been recognised. (Fabech *et al*., 1999:18; Myhre, 1999:125-127; Lillehammer, 1999:133).

Danish farms were found to be less scattered than originally thought. Traditionally, villages were believed to begin between the Viking period and the High Middle Ages. Although some farms were individually fenced, villages defined by a single enclosing boundary have now been recognised in Jutland from as early as 500BC, the Pre Roman Iron Age (Rindel, 1999:81; Mikkelsen, 1999:183). In $2^{nd}/3^{rd}$ centuries BC in the Netherlands, villages did not remain static but moved around the resource base ("wandering settlement") (Gerritsen, 1999:144). In Jutland single farms still existed, but were relatively short lived, generally with no more than two building phases, whether the result of topography, the resource base, status or power, a specialised function or the home of an outsider (Mikkelsen, 1999:183).

By the 11^{th} century, some Faeroe, Icelandic and Greenlandic farms possessed extensive grazing land and decentralised seasonal habitation (shielings) (Mahler, 1991). Some of the earliest sheilings in Iceland are in low lying areas in remoter parts of the farm's territory and some later developed into farms in their own right (Sveinbjarnardóttir, 1992). Although sheilings were used in the Western Isles, there is no evidence to suggest that they ever existed in Shetland.

1299 marks the end of prehistory in Shetland: the earliest surviving document relates to a change in the way land in Papa Stour was valued and taxed. The picture presented is interpreted by Brian Smith (2000:7-14) as one where the Ducal Farm in Papa Stour was identical to the Earldom manors of Orkney. These were centred on a large core of old arable land with a fringe of farms occupied by ducal servants. By 1299 the manors were beginning to break up, as evidenced by this documented dispute between Ragnhild Simunsdatter, presumably of the peripheral farm of Bragaster, and Thorvald Thoresson, the ducal sysselman of Shetland. The fringe farms were becoming discrete properties with free tenants (Smith, 2000:3-4).

THE ARCHAEOBOTANICAL EVIDENCE

Archaeobotantical and faunal evidence is routinely collected during archaeological excavation, although survival is dependent on the very localised environment. This evidence provides a backdrop for considering the field systems themselves and is presented in Table 2:1.

	Botanical	Faunal	Sources
Neolithic	6 row hulled barley (wheat = ? weeds) Wild plants including lady's mantle, parsley pierts, docks, heather	Cattle (no juveniles) sheep	Scord of Brouster (Milles, 1986a; Noddle, 1986)
		Sheep, pigs, cattle, deer, seal, whale, birds, fish, otter	Knap of Howar, Orkney (Ritchie, 1985)
Late Neolithic/ Early Bronze Age	Hulled barley (local production) 28lb barley c. 2000cal BC, better quality than Brouster	Cattle, sheep	House 3, Scord of Brouster (Milles, 1986a) Ness of Gruting (Calder, 1956; Ashmore, 1999; Milles, 1986b)
		Reindeer, small fish, bird, shell fish	Orkney sites (Rackham, 1989)
Early Iron Age	Barley, 6 row hulled dominates naked Black oats introduced	Cattle, sheep, goats, pig Juvenile cattle (dairying)	Kebister (Jordan, 1999)
Mid Iron Age	Barley, 6 row hulled dominates naked	Cattle (dairy), sheep Birds – duck, geese, auks, gulls, shags	Kebister (Jordan, 1999) Old Scatness (Bond, *et al.,* 2002)
	Black oats = ? weeds Fat hen, wild radish, brassicas, corn spurrey	Cattle, sheep, fishing from shore + cod, plaice. Birds – puffin, domestic fowl, crows, gannets, cormorants.	Upper Scalloway (Sharples, 1998; Cerón-Carrasco, 1998; Holden & Boardman, 1998)
	Naked barley dominant in Orkney; Fat hen, sorrel, wild turnip,	Cattle, sheep/goat, pig, domestic fowl, fish, shellfish	Howe (Ballin-Smith, 1994) Bu & Gurness (Hedges, *et al.,* 1987)
Late Iron Age	Barley abundant, oats – using more land?	Expansion of dairying	Old Scatness (Bond 2002; Bond *et al,* 2010)
	Earliest secure date for flax (669-786 AD)	Pig dominant over sheep for a period, then reverses Fishing – longer lines – cod & cartilaginous species Fresh water – trout, eel	Upper Scalloway (O'Sullivan, 1998a,b,c; Holden & Boardman, 1998)
	Barley main crop		Saevar Howe, Birsay, Orkney (Donaldson & Nye, 1989)
	Oats main crop		Brough of Birsay, Orkney (Rackham, 1989)
Viking/Norse	Flax Barley and oats	Large rise in gadids (cod family) Cattle, sheep, pigs, horses, dogs, seabirds, limpets	Old Scatness (Bond *et al.,* 2010) Sandwick South (Bigelow, 1985) Hamar (Bond , 2012)
	Oats dominant Barley dominant Less cereal: oats favoured over barley	 Sheep neglected, dairying, pigs, gadids (cod family) Cod (wheat imported?)	ORKNEY: Tuquoy (Owen, 1993) Brough Road, Birsay (Bond, 1994) Pool (Bond, 1994; Bond 2007) Post C10th, Quoygrew (Barrett, 2005)

	Rise in oats and rye	Beef cattle Herring Dairying	S UIST: Cille Pheadair & Bornais (Parker Pearson, 2004) Udal (Bond, 1994)
	New introductions: Winter rye, herbs, vegetables, hemp, flax, fruit	Cattle, Sheep, Pigs, Horses, Geese, Hens Stockfish	NORWAY: Øye, 2002; Perdikaris, 1999

Table 2.1: A summary of evidence relating to diet and its changes over time.

ANTHROPOGENIC SOILS IN THE NORTHERN ISLES AND THE NORTH ATLANTIC

The first time that micromorphology was carried out in Shetland for archaeological purposes was associated with the excavations at the "Scord of Brouster" between 1977 and 1979 (Romans, 1986). Since then there has been a slow but steady increase in the frequency with which it has been carried out within archaeological projects, to the point where it is sometimes required as part of mitigation excavation associated with development, such as work associated with the Neolithic settlements found at Sullom and Firths Voes during the construction of TOTAL's Laggan – Tormore gas plant (2010/ 2011, post-excavation in progress). However, before micromorphology became part of the archaeological tool kit, archaeologists were already beginning to interpret soils. At Tougs, Burra, a secondary wall was found to seal a "deliberately augmented" sandy soil (Hedges, 1984). The soils underlying a field clearance cairn were noted as being high in organic content and were interpreted as evidence of the continued cultivation of land which was deteriorating (*ibid).* Tougs was situated in what, for Shetland, was good land and yet blanket peat was encroaching, interpreted by Hedges as an indication of the severity with which a Bronze Age climatic deterioration must be felt in Shetland.

Micromorphology has frequently been initiated by a pre-existing archaeological programme and therefore associated directly with occupation deposits, such as the floor surfaces, infills and hearths in the Viking longhouses at Hamar, Underhoull and Belmont (Hamlet and Simpson, 2012a & b). The number of field systems investigated, either within Shetland or in the wider North Atlantic, remains a low, but significant number. The aim of this section is to collate the resulting information in order to produce a picture of soil management in the North Atlantic area through prehistoric/ Norse times.

The Neolithic/Bronze/Early Iron Age

Late Neolithic/Early Bronze Age soils have so far been identified in Shetland and examined using soil micromorphology, and in some cases other tools, at four Shetland sites: the Scord of Brouster (Romans, 1986) where the soils are part of the multiple field system; South Nesting Hall (Dockrill and Simpson, 1994; Dockrill *et.al.*1998) where the buried soil is associated with a Bronze Age house; the Burn of Furze where a field system was also associated with a Bronze Age house site and dykes, and where fossil soils were sealed beneath a surface peat horizon (Hunter, 1996; Chrystall, 1994; Turner *et.al.* 2004) and Old Scatness where there was no pre-Iron Age structure evident but where the stratigraphic sequence and OSL both indicate a Bronze Age date (Simpson *et.al.* 1998b:80; Guttmann *et.al.*2008; Turner *et.al*, 2010).

Broadly contemporary soils have been examined in Orkney, at Tofts Ness, Sanday and in “The Heart of Neolithic Orkney” World Heritage area (Simpson *et al.*, 2006; Cluett, 2007). Of the latter, although Skara Brae has revealed pre-Iron Age soils, the primary soils have been lost, probably the result of deflation, and the results for Barnhouse (French, 2005;

Cluett, 2007:252) and Ness of Brodgar (Cluett, 2007:284) are inconclusive with reference to early cultivation. The soils at the Links of Noltland, Westray and at the Bay of Stove were identified as containing domestic waste (Bond *et. al.,* 1995): the former is currently under further investigation by Hamlet (doctoral thesis in progress). The Knap of Howar, Westray, was also surrounded by midden material which was spread to approximately 0.35m thick over 500m² (Clarke and Sharples, 1985).

At present there is no micromorphological evidence from the Neolithic/Early Bronze Age in the rest of the North Atlantic, although the palynological evidence suggests that there were sporadic episodes of cereal cultivation as far north as Northern Norway, in what was primarily a hunting-fishing economy (Johansen and Vorren, 1986; Simpson *et. al.,*1998c). The pollen evidence indicates a gradual reliance on agriculture and domestic animals in the Late Bronze Age. It further suggests that woodland clearance and agriculture increased during the Early Iron Age and ard marks have been dated to 1960 ± 100 BP (T-2629) (Johansen and Vorren, 1986).

Palaeoenvironmental work demonstrates that Shetland was lightly wooded prior to the ingress of the Neolithic population (Romans, 1986; Edwards and Whittington, 1997). At the Scord of Brouster (Romans, 1986:126), South Nesting Hall (1998:79) and Tofts Ness (Dockrill *et. al.* 1994:78,86) the first human intervention visible appears to have been the clearance of vegetation by burning, carbon flecking being apparent in the earliest soils. At Tofts Ness these clearly predate the first structure (*ibid*.78, 86) and may be the earliest, dating from the late 4th millennium BC and continuing through to the mid 1st millennium BC, albeit discontinuously (Dockrill *et. al.* 1994:77). The soils were created on windblown sand, high in calcium carbonate (*ibid*.75) and are contemporary with the earliest recorded Continental plaggen soils (Blume, 1998:2 cited in Dockrill *et. al.* 1994:77). They include burnt turf-based material (Simpson *et. al.* 1998a: 894), hearth ash, bone and human excrement (although not animal dung) interpreted as midden (Simpson *et. al.* 1998a: 739). In post-medieval/modern times up until the 19th century, in areas lacking peat, animal dung was important as a fuel and was not composted (Fenton 1978:206-9), a practice which possibly commenced in the Neolithic period in parts of Orkney. Soil management at Tofts Ness did not change significantly during the three millennia that the site was occupied (Dockrill *et. al.* 1994:78). There was a period in the Late Bronze Age when the increase in windblown sand made agriculture unviable for a period, but its resumption is evident from the ard marks which are sealed by an Early Iron Age midden but continue beyond it (Dockrill *et. al.* 1994:88).

If the picture presented at Tofts Ness is one of intensive land management in response to environmental deterioration caused by windblown sand, that at South Nesting could be considered a response to environmental deterioration due to increasing podzolisation (Dockrill *et. al.* 1994: 92). Here a series of soil pits identified a buried soil between 0.1 – 0.6m below the surface, covered by humified peat. The soil was interpreted as an "infield", situated around a Bronze Age house, the limits of which were defined by a rock outcrop, a burial cairn and lynchets, dated by the presence of ard marks, pottery fragments and stone tools (Dockrill *et. al.* 1994: 79). The soil around the unexcavated Hill of the Taing homestead also displayed indications of a cultivated soil, improved with peaty turf, ash and organic materials, possibly including animal manure, but this soil has not been examined by micromorphology (Dockrill *et al.* 1998:80).

The pattern of landuse at the Scord of Brouster (Romans, 1986:130) includes a main period of cultivation followed by abandonment (evidenced by bleached rims on stones at the surface), then a further attempt to recultivate (visible as a thin layer of colluvium over the bleached rim sequence) which is finally covered by a peaty turf. The time lapses between the end of the cultivation and the development of the peaty turf vary across the site (*ibid.*130). In some cases the cultivation was not sufficiently intensive to destroy the stability of the surface turf, for example around the earliest house, House 2. This is interpreted as the result of sowing using widely spaced seed drills rather than ploughing. Romans believes that this would produce a sustainable yield (*ibid.*131).

The principal cause of environmental deterioration evidenced at the Scord of Brouster is different again. The initial stoniness of the soil was 40%, high but manageable in a brown soil (Romans, 1986:131) and possibly reflected in the method of drilling of at least some of the earlier soils. With cultivation, the stoniness rose to 60%. Midden material, containing diatoms, charred peat and charcoal, was spread on the field which was closest to House 1, but it is unclear whether this was the result of a systematic process or reflected proximity to the source of the material. Therefore, soil erosion is interpreted as being the factor which brought about the demise of the settlement (*ibid.*131). There is no evidence of a more intensive plaggen system having been employed which might have prolonged the life of this, already long lived, settlement.

The Burn of Furze shared the characteristics of a wet, acid, soil environment with both the Scord of Brouster and South Nesting (Chrystall, 1994; Turner *et al.,* 2004). Here, augering identified a pattern resembling rig and furrow 8m wide by 0.25m deep. This system would have improved drainage conditions for arable crops. Significant volumes of domestic waste were added and considerable effort was invested in managing these soils, arguing that arable activity was very significant to the Neolithic/early Bronze Age economy (Turner *et al.,* 2004).

Investigations in the World Heritage area of Orkney revealed that midden material dominated by fuel residues had been used at Skara Brae at a period when it had been essential to stabilise deflating sands in order to cultivate them in the Late Bronze Age/Early Iron Age (Simpson, 2006; Cluett 2007: 280). As at Tofts Ness, animal manure was evident at the edge of the occupation area, possibly the place where the dung had been gathered and stored (Simpson, 2006). French suggested that the soils around Barnhouse were pasture and possibly arable (2005) but Cluett's studies did not identify any unambiguous evidence of use, either here (Cluett, 2007: 252) or at the ceremonial Ness of Brodgar (Cluett, 2007: 284).

The Bronze Age soils at Old Scatness were characterised by wind erosion and deposition (Simpson, *et. al.* 1998b: 116) and in some respects were more akin to the Orcadian soils than the other Shetland studies examined hitherto. In common with all the other Neolithic/Bronze Age sites, the soils were stabilised with the addition of domestic waste to the soils. The Later Bronze Age soils included substantial amounts of peat fuel ash in addition to midden material. Guttmann (2005) has proposed that rather than middens being spread on the field, agriculture is being carried out on top of earlier, flattened, middens in small plots which are closely akin to gardens and that this is what is being observed at the

Knap of Howar, Tofts Ness, Noltland and at Old Scatness, where the midden content is particularly high (Guttmann *et al.,* 2006). However, the extent of midden material at the Knap of Howar and also at the Burn of Furze makes this seem improbable, and, as Guttmann concedes, the arable area at Tofts Ness expanded during the Bronze Age (Guttmann *e. al.,* 2006: 61).

The picture of soil amendment from the Neolithic period through to the early Iron Age appears fairly uniform throughout the Northern Isles. All the sites appear to have faced environmental pressures of different origins, but the method of agriculture remained the same: after an initial phase of clearance by burning, midden material was added to the soils. The creation of rigs identified at the Burn of Furze has not been identified elsewhere at this date, but the midden material would have helped to stabilise the soils at all the sites and added a degree of fertility, which would have varied according to the content of the middens, unburnt organics being more productive than fuel ash.

All the sites appear to have faced environmental pressures of different origins, but the method of agriculture remained the same: after an initial phase of clearance by burning, midden material was added to the soils. This would have helped to stabilise the soils and added a degree of fertility, which would have varied according to the content of the middens, unburnt organics being more productive than fuel ash.

The Iron Age

To date, Iron Age soils have received less attention than earlier soils, which, in part, reflects the pattern of recent archaeological excavation in the North of Scotland. A pre-broch soil at Bu included a "ploughed soil" which gave rise to soil creep and was sealed by the construction of the broch (Hedges, 1987). The Middle Iron Age is dominated by Broch sites, which are expensive to excavate and Late Iron Age settlement sites are hard to locate at all, other than in circumstances where they are associated with earlier brochs. Three sites in the South Mainland were investigated within the course of one study: Old Scatness, Jarlshof and Clevigarth (Guttmann *et al.,* 2008). Adopting a site-based approach, a buried soil was located at Clevigarth but charcoal from it was dated to the Neolithic/Bronze Age. Ash and charcoal were the main components of the bioturbated soil, and no evidence of Iron Age amendment was identified (*ibid:* 820). In contrast, there was clear evidence of Middle Iron Age soils at Old Scatness demonstrating extremely high phosphorus levels (*ibid*.: 821). The soil is described as having a more cohesive structure than the Neolithic/Bronze Age soils and it was a lighter orange under optical incident light. The changes were interpreted as being the result of adding more organic material, probably animal manures, to the soils. The dusty clay coatings in the soil voids may be the result of disturbance, due to ploughing (Turner, *et. al*., in press). The soil at Jarlshof was different again, displaying lower levels of enhancement, both in terms of ash and also in levels of phosphorus (Guttmann *et al.,* 2008: 821). All three sites included dusty clay infillings or coatings, which were interpreted as evidence of disturbance arising from agriculture (Guttmann *et al.,* 2008: 821; Turner *et al*., in press). Guttmann therefore concluded that not all Iron Age settlements were equally energetic in creating arable soils and that their economies must be different, resulting in the trade of agricultural produce.

The Late Iron Age: Picts and Papar

Late Iron Age soils are apparently missing from the soil profile at Old Scatness and are not well attested elsewhere. The reason for their apparent absence at Old Scatness may reflect a continuity of use extending into the Viking period. A project targeted at locating deep anthropogenic topsoils which may have been introduced by incoming priests, or "papar", returned mixed results (Simpson *et al.,* undated). Deep (0.4-0.6m) top soils were discovered immediately adjacent to Teampull Mhoire chapel in Pabbay, but none were located by augering at Paible, Taransay although deep middens (up to 1m) were located adjacent to St Keith's chapel *(ibid)*.

The Viking/Norse period

The only Viking/Norse field systems subject to soil analysis in the North of Scotland are those from Old Scatness in Shetland (Guttmann, 2001) and Quoygrew in Orkney (Simpson, *et. al.,* 2005). At Old Scatness, the anthrosols continued to be worked during the Viking and Norse phases, but there was a reduction in manuring and a return to the reliance on domestic waste material, particularly ash based material derived from hearths. This was evident both in the soil content (fish and animal bone as well as charcoal) and also in the reduction in phosphate content (Simpson *et al.,* 1998b; Turner *et al*., in press). Bond (2004) draws parallels with a report of the Napier Commission of 1884 (1218), where crofts of 5-10 acres in South Cunningsburgh were carrying as little as a single cow. This resulted in there being little dung available to fertilise the fields: in this instance crofters were prevented from stripping the hill for turf and so were limited to using seaweed. Against this explanation is that the beginning of the Viking Age corresponds with the "Medieval Warm Period" (Dark, 1999). This would favour an increase in fishing and dairying (Barrett, 2003) as well as potentially increasing the availability of drier land for crops such as flax and barley, and extending the length of the growing season. An alternative explanation is that the Iron Age soils retained sufficient fertility to enable lower levels of amendment to take place. In either event, the practice at Old Scatness contradicts the previous hypothesis that there was a continuum of manuring practice from the Iron Age to the Viking/Norse period. The expansion of manured soils at the edges of the area may therefore be Iron Age rather than Viking/Norse expansion (Simpson, *et. al.,*1998b:122).

At Quoygrew, Westray, excavation revealed a Viking settlement which gradually increased the intensity of its fishing and agricultural practices. However, the intensification of fishing took place in the Late Viking/Early Norse period, whereas the intensification of arable agriculture came later, dated to approximately 1256 - 1400AD, perhaps as much as 250 years later than the marine (Simpson, *et. al.,* 2005:357). The soils were naturally thin but were deepened up to 0.95m. The material added to the soils at Quoygrew was derived from stripping turf from the hill slopes, which was first used as bedding in byres, then composted with animal manures and seaweed, before finally being added to the soil (Simpson *et al.,* 2005: 376). This method of managing the soils has parallels on the Pleistocene sands of Belgium, Germany and the Netherlands, where heather and grass turves were stripped from podzolic soils and utilised in the same way (Pape, 1970:241). Managing the soils in this way would have allowed for a considerable increase in the productivity of the land (Adderley, *et. al.* 2000; Simpson, *et. al.* 2002). Fishing had been important to Quoygrew earlier in the Viking Age and it was concluded that the inhabitants were responding to a market for fish which opened up in Europe before the development of a market for Orkney grain in Iceland and Norway (Simpson, *et. al.,* 2005: 376). An alternative reason for the late development of arable agriculture at Quoygrew could be the expansion of the population and a push into less favourable agricultural areas of Orkney and Shetland, creating the need for good arable land to be used more intensively. A third possibility was that the introduction of flax (as evidenced at Old Scatness; Bond, 2010) led to the pressure on good land increasing and a consequent need for expansion.

At Marwick, Orkney's west mainland, a manuring system began in the Norse period (12^{th} – early 13^{th} centuries AD (Simpson, 1997) and continued into the late 19^{th}/early 20^{th} centuries (Thomson, 1981). Here the use of manure was proposed as a response to a lack of seaweed (Fenton, 1978) and its area of use was largely restructed to the "tunmal", the land close to the farmstead which was not subject to periodic redistribution (Simpson 1997: 366).

Studies have been carried out on the plaggen system of soils in Papa Stour (Davidson and Carter, 1997; Guttmann, 1998). Davidson and Carter adopted a landscape approach, investigating five sites where traditional farming was still being practised in 1967, when it was recorded by Fenton (Fenton, 1978). The Papa Stour soils were spade cultivated and included manures derived from hill turf, which had been used to construct dykes and roofs, then incorporated into byre bedding or was used as fuel before being put onto the field. The soils were up to 0.75m deep. The content of the soil was not uniform: two different soil parent materials were identified and the concentrations of peat and hearth ash were variable. Subsequent work has demonstrated that the soils were effectively over-manured, to the detriment of the hill land (Adderley *et al.,* 2000). It has been suggested that this system had its origins in the Norse settlement of the island (Davidson and Carter, 1997: 829, (mis)quoting Crawford, 1984, 55-56). However, although the post-1299 rental evidence demonstrates that the Papa Stour "house divisions", or rental divisions, were either unusually large or unusually wealthy, due to their exceptionally high value, (Crawford, 1984:47), extreme caution should be exercised in suggesting that the methods of agriculture remained the same throughout this time without more concrete evidence. Studies at Bragaster, Papa Stour (Guttmann 1999; 2001), the ducal farm at the centre of the dispute in the 1299 document (Crawford, 1984: 49), revealed distinct strata with raised pH values, enhanced magnetic susceptibility and phosphates, were highly biologically active and enhanced with animal dung and peat ash. The visibility of the strata demonstrated that material was added rapidly, but there are no published dates for the soils arising from the work.

Investigations have been carried out on Norse soils both in the Scandinavian homelands (Simpson *et al.,* 1998c) and in other parts of the Viking world (Simpson *et al.,* 2002*;* McGovan *et al.,* 2007, Adderley *et al.,* 2008). A dated pollen sequence from Őrsnes, Lofoten demonstrates that *Hordeum* (barley) was introduced c.700AD and that there was a concomitant increase in *Poaceae* (grass) and decrease in *Pinus* and *Betula (*Simpson, *et al.,* 1998c: 1185). Small cultivation terraces were created on sandy soils in sloping locations and wet and dry turves, ash, fish waste and domestic animal manures were added, deepening them by up to 40cm (*ibid*.:1192). This both stabilized the soils as well as assisted in maintaining fertility in a freely draining environment (*ibid*.: 1192). The more peaty soils in the area were not cultivated until the late 1800s (*ibid*.: 1197). Similar terraces have been recorded in south-west Norway, but not investigated micromorphologically (Myhre, 1985).

Three sites of differing status in the Laxa Valley, Iceland, were shown to be manured to a level which would allow for subsistence requirements of hay to be grown, but that, were extra manuring possible, this would have made little difference to productivity, given the constraints of climate. It could however, have created a buffer to ameliorate year to year climatic changes (Adderley and Simpson, 2005). The palynological evidence from Northern Iceland indicates that, in spite of documented evidence of trade in grain with Orkney (*Islendinga* and *Bandamanna Sagas,* cited in Barrett *et al.* 2000), small amounts of *Cerealea* was being grown: primarily *Hordeum* (barley) with some *Avena* (oats) (Simpson *et al.,* 2002). Samples taken from both Akurey and Ketilstaðir included a few heated minerals, charcoal and bone fragments, indicating that low rates of domestic waste were being added to the Norse soils, and that the fuel residues originated as peat (fine grey material with diatoms present) (Simpson *et al.* 2002: 431). Soils at both sites included fungal spores, suggesting the presence of limited animal manures which may have been the result of grazing rather than the addition of manure. Phosphorus values were slightly higher at Akurey (Simpson *et al.* 2002: 432), thought to be the result of adding seaweed. Modelling of the soils, climate and land management also indicates subsistence levels of production for barley, with no surplus being produced (Simpson *et al.* 2002: 439).

According to Øye (2005) the West Norwegian Vikings fertilised their fields with cattle dung, seaweed, turf and ash. Turf and ash is documented as fertiliser in Faeroe (Mahler, 1991) and in Iceland cow dung was put on the hayfields (Buckland et al, 1992). Other agricultural improvements in Norway included modifying the slope, which began in the Iron Age (Austad and Øye, 2001). This also took place in Faeroe where the slope on a 3m wide strip might be as much as 0.5m from one long side of the strip to the other. Initially in

Faeroe all such strips were on either south or east facing slopes and were designed to catch as much sun as possible (Arge, 2005). In Sandnes, Greenland, the season was extended by covering the infield with drainage channels (McGovern, 1992) and in Iceland deep drainage ditches were dug into the infield (Buckland *et al.,* 1991).

Conclusions

Research carried out prior to, and during the course of, this study is sufficient to create a model of the pattern of agriculture and land management in the North Atlantic area from the Neolithic to the Norse period: a span of over 4,000 years. The foregoing literature review has revealed hints that the use of midden material, for example, might be localised in extent (eg: Scord of Brouster, Knap of Howar) and Guttmann has even suggested that cultivation is taking place on top of middens.

However, all the micromorphology to date has been based on evidence which is linked closely with site based, settlement, evidence. This is especially true of Guttmann's work at Old Scatness (Guttmann, 2001) which, whilst providing an exceptional chronological slice through time, is also taken from one point around a very extensive site and very close to the focus of occupation. Her work at Clevigarth and Jarlshof provide hints that the picture is more diverse than previously imagined (Guttmann *et al.,* 2008: 821). This study will therefore adopt a landscape-based approach in order to test the hypothesis that the pattern, which has emerged to date, is representative of agricultural practice at any given period. It will do this by changing the focus from the occupied areas and middens, generally considered to be the "sites" to explore more distant parts of the fields, the "landscapes" in between the "sites". This study is located in Shetland because the survival of the field patterns there is exceptional, but the results will have implications for the North Atlantic area.

THE RESEARCH AGENDA

The foregoing review demonstrates that palaeo-environmental studies have given rise to a clear picture of what agriculture was being practised when. It is evident that fields were created and managed and this differed over time. Some sites had a longevity whilst others were single period and this is likely to be linked to the productivity of the land managed by that site.

One of the most significant limitations of the evidence presented stems from the fact that the importance of the field systems to an understanding of settlement has frequently gone unrecognised in archaeological projects which have been site-focused. Indeed, with a few notable exceptions (e.g. Rod McCullagh's work at Lairg, Sutherland 1998 and the surveys of the Royal Commission on Ancient and Historical Landscapes), the work in Shetland has been at the forefront of developing a more integrated approach. Even so, questions of field form and function have rarely been considered. This is a significant omission because the soils and field systems potentially hold the key to understanding the organisation and management of land in early societies, and this understanding is fundamental to an understanding of how these societies functioned.

To some extent, the lack of previous investigation of field systems through time is understandable: the upland landscapes of Scotland and England (e.g. Kilmartin, Dartmoor, Cumbria) are strongly associated with a single period. The range of landscapes which survive in Shetland have not been recognized elsewhere and are only just emerging in Shetland due to the increasing amount of topographical field surveys carried out over the past 25 years. This work has tentatively begun to establish a typology for Shetland which allows differentiation between field systems, classified in terms of field form. This relates fields to associated settlement forms which appear to be contemporary, although work at the Scord of Brouster demonstrates a longevity of use which complicates the picture. The resulting discussion of field systems has been limited and has only rarely considered field function. There is an absence of established relationships between field form, settlement and function.

Approach

This study will examine the evolution of Shetland field systems over a period of approximately 4000 years, from Neolithic to the Viking/Norse. The parameters of field system evolution are location, form, function and their inter-relationships. Geographical Information System techniques are used to quantify locational attributes and field system forms, with soil analyses used to define field functions.

The objectives of the study are:

1. The identification of factors influencing the location of field systems. This will consider topographical aspects such as geology, height, aspect and viewsheds, as well as the soils environment.
2. The identification of factors which influence field morphology, considering the extent to which field systems of different periods have different forms.

3. The examination of field function, establishing how fields were used over time, and how this changed in terms of both soil environment and in the pattern and intensity of use.
4. The results of these three aspects of the Shetland field will then be integrated and assessed to identify indicators of longevity and adaptability and the extent to which field systems were sustainable.

To achieve these objectives, a landscape approach considering past agricultural practices will be developed; the study will also test the extent to which such an approach has validity. In so doing the study will develop new diagnostic tools, test emerging models for soil and field system management in the North Atlantic, and assess the extent to which thin acid soils (on which the Shetland field systems are based) retain cultural information.

The initial task arising requires a definition of the types of field system to be investigated. The literature search demonstrates that these fall into four, apparently discrete, typologies:

1. Homestead Enclosure: a single house situated fairly centrally within or beside a single sub-circular enclosed area.
2. Multiple Field Systems: A series of irregular, sometimes tear-drop shaped, enclosed areas which share boundaries and may have accreted over a period.
3. Iron Age field systems, identified previously as worked soils but lacking in boundary evidence.
4. Viking or Norse field systems. Yards associated with longhouses have been identified, but infield boundaries hitherto undiscovered.

The next step was to identify potential sites in areas which can be targeted by field survey. The initial choice of sites drew on the literature search and existing records lodged with the Shetland Sites and Monuments Record held by Shetland Amenity Trust. This desk based assessment was then developed by field visits to ensure consistency of approach and to make a visual assessment of levels of data survival.

The study uses four inter-related methods to examine sites:
Selected sites were recorded in the field by GPS survey. Field system chronology was examined on the basis of site morphology with reference to previous excavations, and refined using Shape Analysis. The survey results were mapped using GIS, which allowed the shapes of the recorded fields to be analysed. The component characteristics of the field boundaries were examined in order to identify whether these were significant in terms of site type or period and whether they could be used as diagnostic identifiers.

Soils investigations took the form of auguring and targeted small scale soil profile excavations were used to locate and sample buried soils. Soils were investigated by soil micromorphology in order to establish soil environments and land management practices. This approach, now well tested, was recommended by Edwards and Whittington in order to further establish soil status (1998) for the Multiple Field Systems. Changes in land management practices could be of particular significance in order to determine the degree to which changes related to period, the extent to which the reuse of land was desirable and whether inheritance was a positive or negative factor in land use. The extent to which the picture obtained from the sample areas provided a model which could be adopted more widely was also addressed.

In addition soil micromorphology was used to help ascertain whether there was any environmental change which might impact on landuse, for example was there a period of increasing wetness on upland Bronze Age sites?

Combining the results of the survey (shape analysis and boundary analysis) and soils work (augering and micromorphology) tested whether form can be linked to either date or field function. The results of this study will significantly advance our understanding of prehistoric settlement patterns over a 4000 year period, from the earliest settlers through to Norse. If a relationship between field form, function, settlement and date could be established, this would be a major advance, both in our understanding of Shetland's archaeology, and also in providing a model which may hold good for large areas of Scotland, particularly the North and West, and also for related areas throughout the North Atlantic area.

Chapter 3: Results and Discussion 1- Research Sites Survey

Introduction

This chapter provides the context for the sites investigated within this study. An outline of the selection procedure is followed by the field methodology and the results. The survey plans are presented over Ordnance Survey mapping and vertical aerial photography. Sites are described discussed in terms of the surrounding landscape. The chapter concludes by outlining new observations arising as a direct result of the survey.

SELECTION METHODOLOGY

The previous chapter outlined four categories of field system to be examined: Homestead "Enclosure" sites, generally classified as Neolithic, but potentially Bronze Age; the more complex Multiple Field Systems, also Neolithic/Bronze Age in date; field systems associated with archaeological evidence for the Iron Age Brochs (if identified); and Viking/Norse field systems.

In order to carry out the analyses, the field systems were chosen as being good examples of one of the four chosen categories although most are still lightly grazed today. The other determining factor was that the field boundaries were sufficiently complete to provide an accurate picture of the original form of the field unit(s). A widespread geographical coverage was also desirable, although this proved to be more difficult. An initial desk based assessment was carried out using Shetland Amenity Trust's Sites and Monuments Record. Searches were made by "site type", which identified the locations of "homesteads" "field systems" "brochs" and "longhouses" in Shetland. The detailed record for each of these sites was then examined; those which had potential were identified on basis of the description and field notes within the record.

The multi-period landscape at Underhoull, Unst, was also included. This site is a palimpsest of layers of relict landscape: the presence of a souterrain, a broch, and at least two, and possibly four, Viking/Norse longhouses indicate the longevity and complex nature of the site. Underhoull will be included at the end of the study in order to test the methodology in better understanding a multi-period site.

The list of potential sites was further refined through a combination of local knowledge and a series of field visits which established the completeness of the field system elements. A number of sites were eliminated, either because the systems were incomplete, or because the landscape was more multi-period than anticipated. The aim was to select six examples of each site type for survey and more detailed study (figure 3.1). The Homestead Enclosures comprised four in South Nesting, one in the South Mainland and one in the West Mainland. The Multiple Field Systems comprised four on the West Side and two in the South Mainland. Excluding Underhoull, and as a result of field work, three sites with Broch boundaries were located; these had a good geographical spread throughout Mainland Shetland. The Viking/Norse longhouses with associated field systems were all in Unst, although Eastshore, South Mainland, was included and Quoy Unst were included as additional examples of Norse yards.

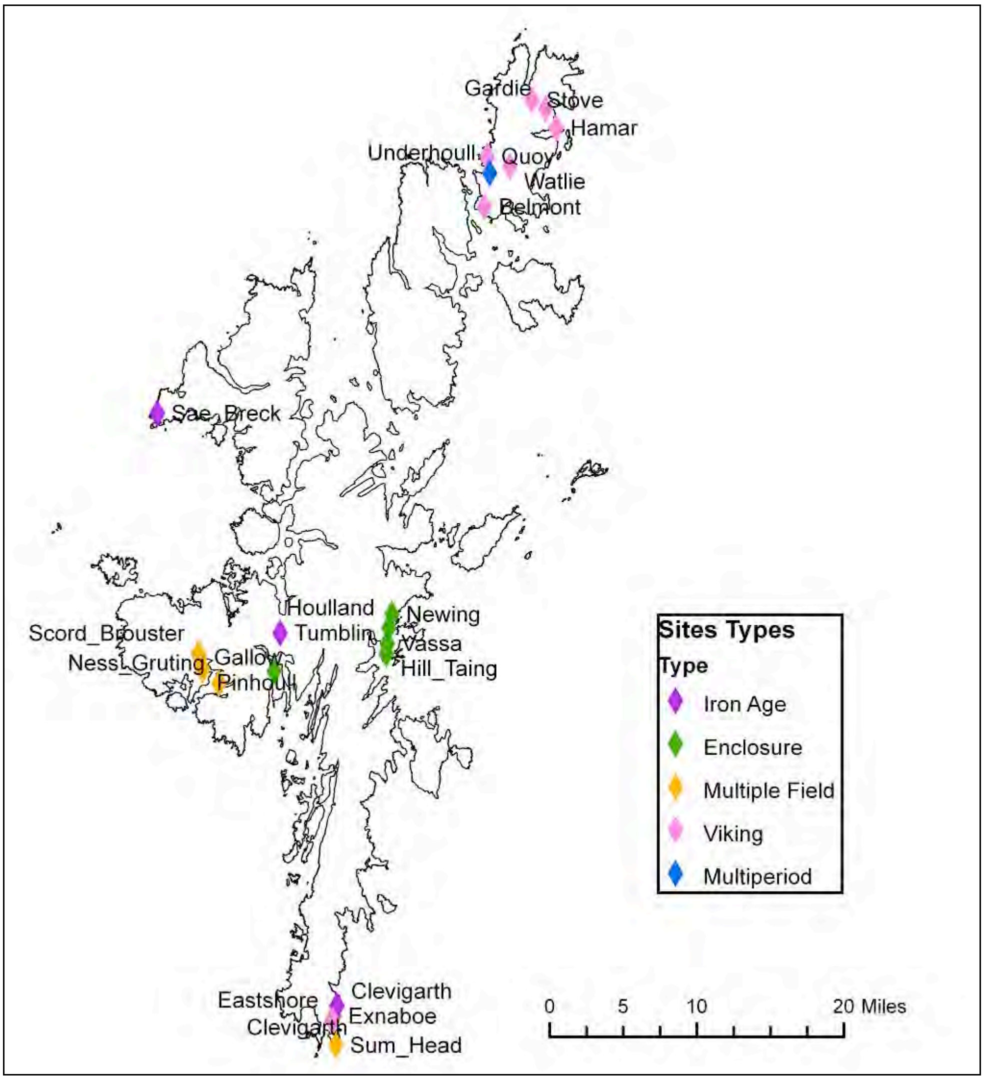


Fig 3.1 Sites selected for inclusion within the study

Although the sites initially investigated had a wide geographical spread, the best examples tended to be clustered within more limited areas. The majority of sites were located on what appeared to be peat, peaty rankers or peaty podzols soils. Reasons for this will be explored within this study. A possible explanation for the use of higher, more marginal land might have been a response to factors such as increasing population pressures or an amelioration of the climate, which would be harder to identify from this study.

Field work established that the impact of post-medieval/modern crofting was rarely entirely eliminated, although it was never intensive in the study areas. The impacts of crofting in these areas frequently involved soil or peat stripping or possibly soil amendment, which was not always apparent during field examination. The risk of crofting reuse affecting sites was reduced by avoiding locations which clearly included rigs or which appeared on the 1st Edition (1878) Ordnance Survey maps as being in cultivation.

The field boundaries studied were classified primarily according to their associated features. In the case of Homestead Enclosure sites and Multiple Field Systems, in the examples chosen the survey clarified which elements belong to the field system and which, if any, are later. This is true for some, but not all, of the Iron Age and Norse boundaries. In cases of ambiguity, the field survey was overlain on the First Edition Ordnance Survey mapping (1878). This assisted in interpreting boundaries which may either be later or have been reused. In most cases, the geo-referenced First Edition maps are not as accurate as the more recent mapping and aerial photographs. In consequence, it was necessary to adjust the position of the survey data slightly in order to compare it meaningfully against the 1878 mapping.

FIELD SURVEY, RECORDING AND GEOPROCESSING METHODOLOGIES

Topographical survey was carried out at each site using Differential Geographic Positioning System (DGPS), incorporating everything which might comprise a fragment of field boundary and related features. The early prehistoric ("Homestead") Enclosures were amongst the easiest sites to map. The later, irregularly shaped field systems and more complex sites needed a more systematic approach to ensure total coverage. In these cases the area was walked prior to survey and each feature was marked with a survey flag.

Detailed field notes were made in tandem with the survey describing the feature, its vegetation cover, etc. Early on in the study it became clear that a survey sheet would be required in order to systematically record key attributes, including the size and density of the stone, the height and width of earthworks, the aspect of slopes, etc (Appendices B and C). The result of this work forms the basis of the boundary analysis (Chapter 6).

Some of the sites under consideration have been surveyed in the past (e.g. Scord of Brouster and Pinhoulland, Whittle 1986; Exnaboe and Sumburgh Head/Compass Head, Turner 1996). Initially it was believed that the amount of new field work required by this study could be minimised, using scans of existing surveys as the starting point. This approach was quickly abandoned as it became clear that surveys undertaken using a variety of different instruments, in some cases by different people, were insufficiently consistent. As a result all the sites studied were surveyed or resurveyed for this research ensuring the rigorous and uniform approach necessary to assess the component parts of a site, eg: lengths of walling. Each site was eventually visited between three and ten separate occasions prior to soil surveys.

The DGPS data was geo-processed digitally, using contemporaneous information from the Ordnance Survey website and Leica's Geo Office programme. There was a problem in correcting Shetland data during most of the field work period, because the most northerly Ordnance Survey Reference Station was at Sumburgh Head, the southern-most tip of Shetland; this was compounded by the Sumburgh Head Station not functioning for periods of time. The location of the most northerly Reference Station has changed more recently to Lerwick, however, the majority of the sites in this study are located to the north of Lerwick. Thus, for most of the survey work, all the Ordnance Survey reference data lay within an acute angle to the south. This will have affected the precision of the results, but overlaying the survey results onto the most recent Ordnance Survey mapping and geo referenced aerial photographs, suggests that in most cases any error encountered was less than the width of the lines of the survey at the scales being used. Transformed data was imported into Arc GIS, which was used to create plots of the sites and for undertaking all aspects of mapping for this research.

SURVEY RESULTS AND SITE DESCRIPTIONS

The descriptions which follow arise from the initial field survey. Where relevant they incorporate information derived from the Shetland Sites and Monuments Record (SMR), much of which was originally compiled by the author. Additional information derived from mapping and field survey, excluding the field boundary details, is listed for each site. The Drift Geology was derived from the Institute of Geological Sciences One-Inch Series for Shetland. The Solid Geology was taken from the British Geological Survey 1:250,000 series, Sheet 59, 50N 02W. The maps in this chapter are not reproduced to a consistent scale. (For mapping to scale, enabling direct comparison, see Chapter 5.) The base mapping selected for the site location maps includes both vector and raster mapping. Vector maps are “cleaner” in appearance and are more current in their detail (e.g. incorporating fences erected within the past two years) but in some cases they include unhelpful lines which do not have an obvious relationship to the topography. In such cases, the older, raster maps provide a clearer impression of the landscape. The contours are derived from the vector mapping, and are depicted in green. These are sometimes at variance with the raster contours, which do not always exist as continuous lines. The survey results are shown in red and sometimes include short lengths of modern field boundaries. Some of these correspond perfectly with the base mapping; others reflect either a recent realignment of modern boundaries (e.g. the northeast fence line at Exnaboe) or the fact that older Ordnance Survey mapping (the raster data, based on the 1973 survey) is known to be less accurate in remoter, less populated areas. When the sites are depicted by the Ordnance Survey on the raster maps this is usually schematic rather than a true representation (e.g. the Homestead Enclosure at Houlland).

The majority of sites within this study are located at greater heights than the modern settlement, on land lightly grazed by sheep, and having impoverished soils. There would have been settlement at lower levels, on soils which were easier to work and closer to the sea but these have been destroyed by later settlement, agriculture and coastal erosion. Where they survive at all, they tend to be more fragmentary.

HOMESTEAD ENCLOSURES

The defining characteristics of "Homestead Enclosure" sites are that they comprise a boundary which is sub-circular and include a house site either within, or at the edge of, the enclosure. Their simple appearance is suggestive of an early, and therefore Neolithic, date but excavated examples are few and the majority predate the raft of more sophisticated dating techniques which are becoming increasingly available to even modest archaeological projects. It is therefore difficult to date them with any certainty, although approaches have been proposed based on house typology (Turner, 1998; Downes and Lamb, 2000:119-123). Ballin-Smith (2005:75) suggested that the excavated example at Catpund is Bronze Age on the basis of the artefact assemblage which she compared with that from the Scord of Brouster, House 1, radiocarbon dated to between 2510±70BP and 1715±75BP (Whittle,1986:75). This comparison suggests that the sites are contemporary. Dates associated with recent work on the TOTAL base at Sullom Voe (excavated by ORCA, 2010/11) are awaited.

The Enclosure Sites in this study have clear complete or near-complete enclosure boundaries. The Enclosure may have originally been part of a more extensive pattern of land use in which the boundaries were either never created or are no longer visible. Boundaries may not have been required, for example where stock were tethered, or where cultivated areas were defined by natural boundaries, such as a break of slope or a burn. Alternatively, boundaries may have been constructed of materials which have not survived and are less readily identifiable in the present landscape. This will be explored by boundary analysis and, subsequently, by augering and micromorphology.

Croag Lea (HU 338 497, Sand, West Mainland)

Shetland SMR: 2379

Solid geology: Permeation gneiss

Drift geology: On boundary of till and morainic drift/hill peat

Height AOD: 38-42m

Local aspect of site: Southeast, although the aspect of the hill is north-west

Croag Lea is situated on relatively flat land, with a difference of exactly 2m in height recorded at points across the site during the topographical survey. The site is located in enclosed scattald. The aspect is north-westerly but this is, to some extent, blocked to the west by a knoll which the Ordnance Survey map records as rising to 46m AOD. The ground is predominantly dry and covered with grass which has been grazed, with some reedy grass and patches of sphagnum moss.

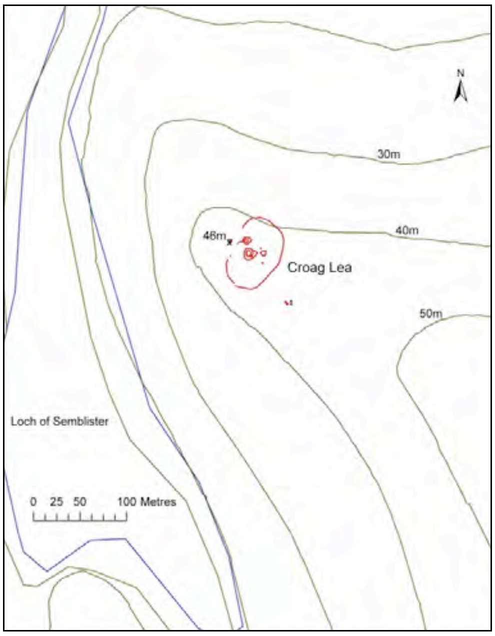


Fig 3.2a Croag Lea survey on Ordnance Survey Map (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.2b Croag Lea survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The oval shaped enclosure is incomplete on the west side: the knoll rises from where the boundary might have been expected to be. This gap may never have been closed; alternatively stones may have been removed from this point, perhaps being reused in the later features constructed within the enclosure. A third option is that the gap may have been closed with a fence or vegetation, now leaving no visible evidence. There is an anthropogenic cairn on the summit of the knoll. The interior of the enclosure contains more features than usually found within such an Enclosure, some of which may not be contemporary, although it is probable that the house site is. The house has well-defined external edges on the western edge and clear indications of internal wall faces, largely turf covered. Adjacent, and to the east of the house, there is a heel-shaped feature with stones set on edge. Its interior is higher than the surrounding ground surface and it may be the remains of a post-medieval/modern plantiecrub (a small dry-stone enclosure, for growing curly-kale plants, found throughout Shetland). A grass covered feature to the north of the house may have been predominantly turf-built, incorporating one large stone, apparently bedrock, and may also be a late addition to the enclosure. The enclosure also contains a large triangular orthostat, 1m high, to the northeast of the house and a recumbent stone 0.6m SE of the house.

Exnaboe (HU 403 117, Dunrossness, South Mainland)

Shetland SMR: not recorded

Solid geology: Fish bed/Flaggy Sandstone

Drift geology: Bedrock at or near surface

Height AOD: 23-27m

Local aspect: Southeast

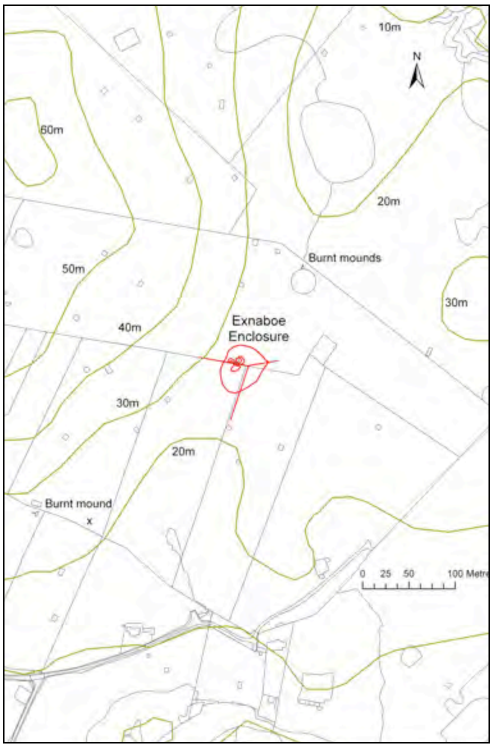


Fig 3.3a Exnaboe Enclosure survey on Ordnance Survey Map (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.3b Exnaboe Enclosure survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Exnaboe is situated at the upper end of gently sloping land; the land rises more steeply above it. The site was first identified by the author, as part of the Old Scatness Broch and Jarlshof Environs Survey (Turner *et al.* 2001, no.1176:59). The site has been dissected by three modern fences, with the result that each of the three segments of the site has been subject to different styles of land management in the recent past. The ground is dry, and appears to be well drained, in all three segments. The northern segment is part of the unenclosed and unimproved scattald, with short grazed grass. The southwest segment has the longest grass and is the least heavily used section of the site. The southeast segment is the smallest of the three and supports short, well-grazed, improved grass.

The enclosure is sub-circular, the boundary irregular on the east side. The entire circuit of the boundary is visible. The enclosure contains three features. An oval mound lies just west of the centre, is approximately 7m N-S by 10m E-W, and probably represents the house site. An arc of bank adjacent, open to the south, is situated to the northeast of the house mound. Immediately north of the house there is a dry-stone plantiecrub. The plantiecrub is situated on a mound approximately 0.5m high, which suggests that there is earlier archaeology underneath. The underlying remains might be part of the house, or perhaps another building. It is not uncommon for plantiecrubs to be located over archaeological sites, incorporating some of the pre-existing large stones into the later crub (Hunter, 1996: 99). The putative house mound is situated in the southern segment of the site; the arc and plantiecrub are both located in the northern segment.

Hill of the Taing (HU 461 516, South Nesting, East Mainland)

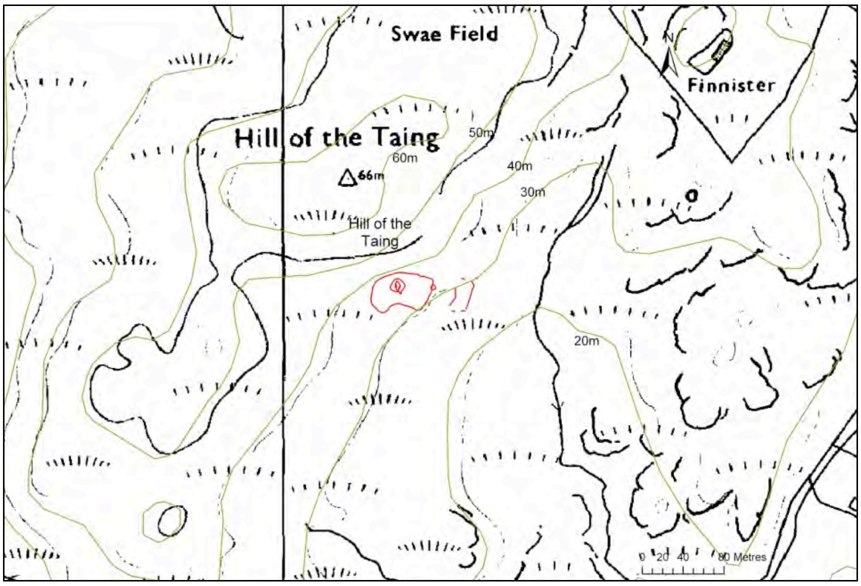
Shetland SMR: 956

Solid geology: Calc schist

Drift geology: Till and morainic drift/bedrock at or near surface

Height AOD: 31-40m

Local aspect: East



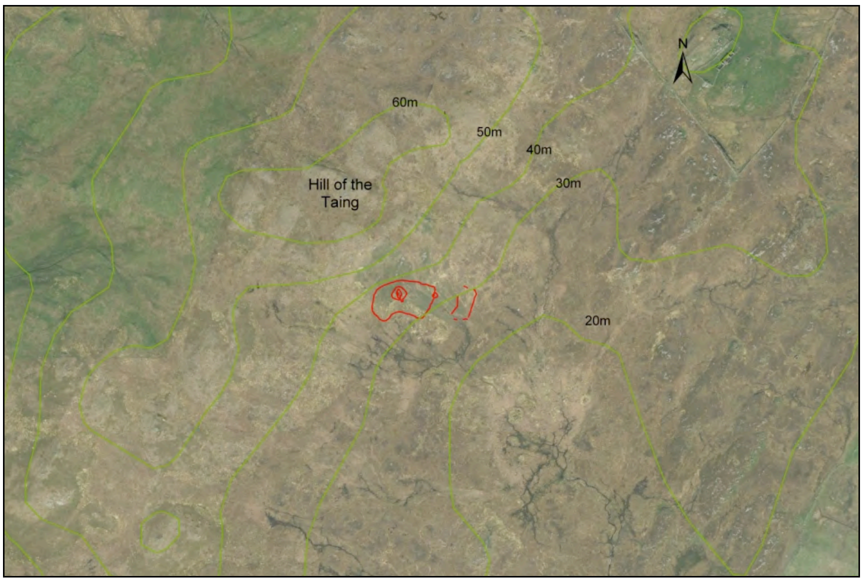


Fig 3.4a Hill of Taing survey on Ordnance Survey Map (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.4b Hill of Taing survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The Hill of the Taing Enclosure is situated on land which slopes gently from west to east. The enclosure is situated in the unenclosed scattald. The easterly aspect faces towards a shallow valley, which begins below a lynchet, partially defined by bedrock. Below this lynchet are other lengths of dyke in a u-shape, which could be considered to be forming another, smaller and not necessarily related, enclosure. The eastern side of this enclosure is formed by a line of discontinuous stones set othostatically and being between 0.4 to 0.8m in size. Although there is a prehistoric house approximately 300m to the north of the enclosure site and a “figure of eight shaped” prehistoric house approximately 400m to the east, there is no sign of any connecting dykes or other earthworks linking them. These houses, visible as unexcavated earthworks, are located at similar heights in areas of flat land in the undulating hill, which rises to 66m. They are not intervisible and may not be contemporary with one another. The ground on the west side of the Homestead Enclosure is boggy, the vegetation comprising sphagnum moss and long reedy grass. The ground to the east of the house is considerably drier, the vegetation comprising short maritime heath.

The Enclosure is kidney-shaped with an indentation on the southern side. At the northern end, on the east side of the Enclosure, the dyke merges with a circular pile of stones most of which are flush with the current ground surface. Some of the stones appear to be part of the dyke. It is possible that this is either an area of tumble or an earlier clearance cairn; it has no visible structural elements. The character of the dyke varies; it disappears beneath boggy ground for short stretches (e.g. points 102-103), incorporates a rock outcrop, and on the eastern length of the north side the fairly continuous dyke has the appearance of revetting the hillslope which rises directly from it. The impression gained is that the Enclosure took advantage of a small area of relatively flat land in an upland situation. The Enclosure contains a well defined prehistoric house site, with an orthostat which protrudes 0.75m above ground. Much of the internal wall-face is visible, constructed of medium (0.4-0.5m) sized stone. There are no other features visible within the Enclosure.

<u>Houlland</u> (alternative name: Whalsay Willie's Knowe) (HU 463 544, South Nesting, East Mainland)

Shetland SMR: 977

Solid geology: Calc schist

Drift geology: On boundary of till and morainic drift/bedrock at or near surface and lake alluvium.

Height AOD: 23.5-27m

Local aspect of site: North, within a "bowl" which, in macrocosm, faces south.

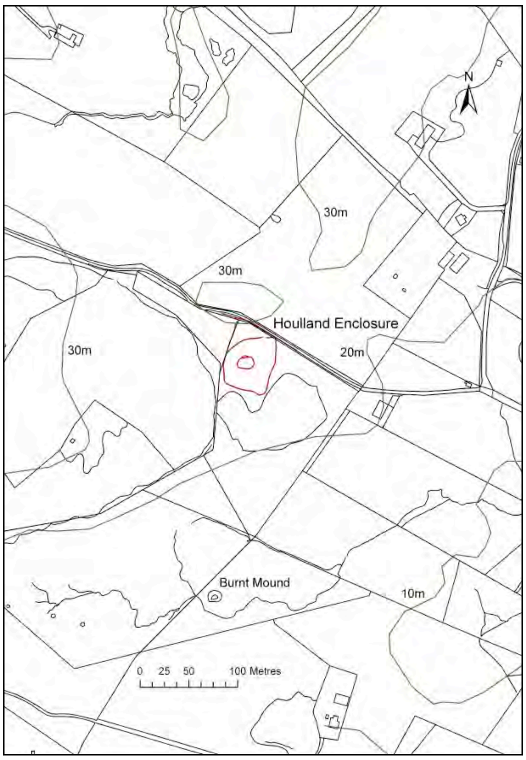


Fig 3.5a Houlland survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.5b Houlland survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Houlland is situated on land which slopes gently from the south (upslope) to the north. It is situated in a bowl with slightly higher land surrounding it on all sides. At the scale mapped by the Ordnance Survey (1:10,000, 1978), the aspect is southerly. The ground is wet and used as enclosed grazing. The vegetation on the higher ground, to the south, is short grass. To the north, the vegetation includes sphagnum indicating that the ground is wetter. As at the Hill of the Taing, the site appears to utilise a flat area of ground in an undulating landscape. The land to the west, lying between the site and the hillslope, is improved pasture.

The enclosure is curvilinear, but could be described as sub-rectangular as much as sub-circular. It is almost continuous, the line being broken for short lengths in two places on the north side of the dyke. A length of dyke projects northwards from the north-western most point of the enclosure. Where this dyke ends there is a stone setting adjacent to the modern fence line. It may be a relatively recent post-setting belonging to a previous version of the fence. To the north of the fence is a farm track, beyond which the land becomes rockier with ephemeral traces of dykes. There is no direct relationship and so whether they are related to the period of the Enclosure, or to the more recent track, is uncertain.

The Enclosure contains a single house site, which survives as a mound with a fairly level interior. Although stones are visible within this, the only identifiable structural feature are kerbed sections of the external wall face.

South Newing (HU 467 559, Nesting, East Mainland)

Shetland SMR: 992

Solid geology: Permeation gneiss

Drift geology: Bedrock at or near surface and lake alluvium.

Height AOD: 36-47m

Local aspect: South southeast

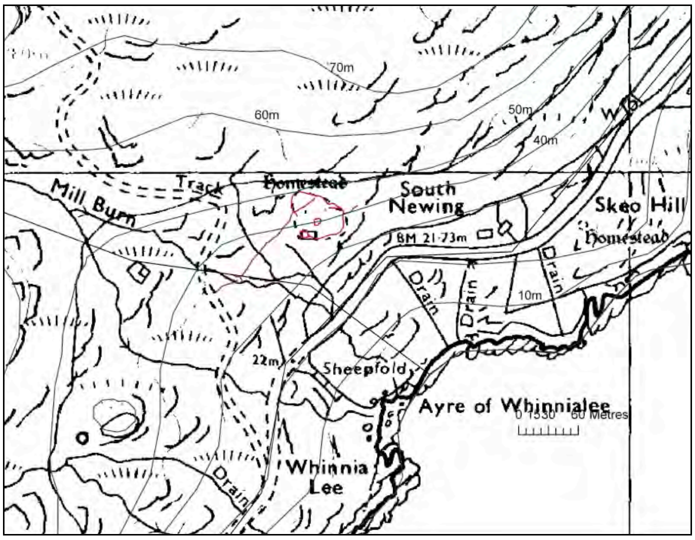


Fig 3.6a South Newing survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.6b South Newing survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

South Newing is situated on land which slopes from north to south and is surprisingly steep, with a slope of 11m being recorded across the site. The ground is wet and used as enclosed grazing, the vegetation comprising grass, sphagnum and small bog plants.

The enclosure is curvilinear but irregular. There is a gap on the east side. On the north side of the break, the dyke survives as a discontinuous line of large stones and it is possible that the missing length of dyke may have been removed in order to construct the plantiecrub which has been built on the south west edge of the space and which reuses the Enclosure as its northern wall. The Enclosure is situated at the bottom of a sharp break of slope. This gives the most northerly length of dyke the appearance of revetting at the base of the hillslope. There is a length of dyke which commences at the northeast outer edge of the enclosure and can be traced beyond the Enclosure for approximately 20m to the northeast. It respects the line of the Enclosure edge and so could be part of an associated field system. The northwest section of the enclosure is bisected by a dyke which continues for over 100m to the southwest, beyond the edge of the enclosure. This dyke is likely to be later than the enclosure, as it appears to completely disregard the existence of the Enclosure.

The enclosure contains an irregular mound of stone which was first interpreted as a prehistoric house site by Calder (1956: 367). There are no clear internal features or walls visible. There are two large stones in the northeast area of the site; the more easterly of these is earth fast. There is a line of dyke just inside the northeast area of the enclosure which is aligned east-west. This dyke ends at the enclosure edge and may represent a re-alignment of the enclosure boundary at this point. As previously noted, the dyke which enters the enclosure from the southwest probably post-dates the enclosure.

Vassa (HU 462 527, South Nesting, East Mainland)

Shetland SMR: 961

Solid geology: Calc schist

Drift geology: Till and morainic drift/bedrock at or near surface

Height AOD: 8-13m AOD

Local aspect of site: South, although the landscape faces west towards the voe. The land immediately to the north of the Enclosure, including the house site, rises to 17m.

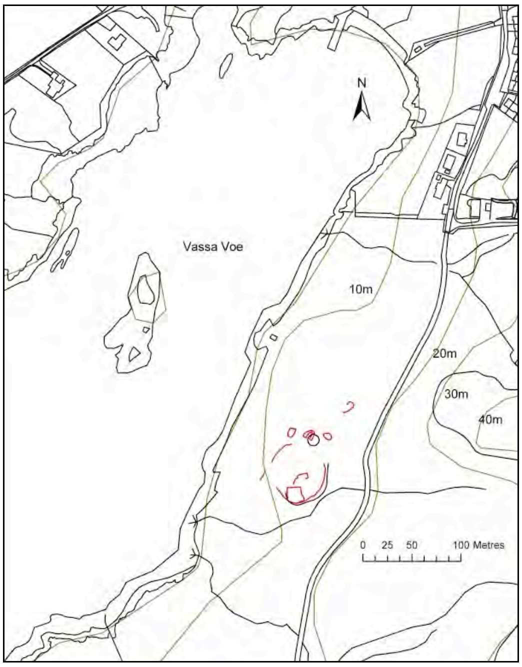


Fig 3.7a Vassa survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.7b Vassa survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Vassa is situated on land which slopes east to west, towards the sea, and which also rises to the north. The ground is dry, the vegetation being sphagnum and heather; there has been peat cutting in the area.

The Enclosure is the least complete of all those surveyed; the overall shape is close to circular. The gaps in the boundary are on the west and north sides. The house site lies on the northern edge, at the point where the boundary is missing, but it is outwith the projected circumference, situated on a slight rise, with causes it to overlook the enclosure. The house is oval, with a clear kerb on the west edge. The entrance is at the south end of the house, facing the Enclosure. There is bedrock immediately adjacent, west of the house. Beyond this is a platform which is cut into the hill at the southern end and slightly banked up at the northern end, making it approximately level. It is possible that this is a hut platform. To the east of the house is a mound, possibly the result of peat cutting. Inside the Enclosure are two areas which have been stripped, probably for peat.

MULTIPLE FIELD SYSTEMS

The Multiple Field Systems comprise several small, irregularly shaped fields, described by Noel Fojut as tear-drop shaped (pers. comm.), and which are usually, but not necessarily, contiguous. Each contains one or more visible prehistoric houses and many also contain mounds of stone cleared from the fields.

Until recently, all the known Multiple Field Systems were located on the West Side of Shetland. Four of these have been included in the study. Two other sites of broadly similar appearance located in the South Mainland were selected in order to improve the geographical spread. Many of the field systems on the West Side have lengths of substantial prehistoric dykes between them. Some of these appear to be aligned on hill tops or on Neolithic chambered cairns, and some follow ridges or shoulders of hills. These often disappear into areas of deeper peat between the sites.

The Multiple Field Systems appear to be more complex than the Homestead Enclosures, but they are not necessarily later in date. Whittle's excavations (1986) demonstrated that the Scord of Brouster spanned the Neolithic/Bronze Age, the earliest occupation dated to around 2500BC, ending around 1500BC, possibly due to the start of the peat growth. Whittle also established that the field system developed over time, although elements of both the inner and outer field systems may have been in place early on in the life of the settlement.

Scord of Brouster (HU255 516, Walls, West Mainland)

Shetland SMR: 2209

Height AOD: 26-50m

Solid geology: Old Red Sandstone

Drift geology: Bedrock at or near surface

Local aspect of site: Southwest/East, following dominant aspect of the land

Alignment: Across the hillslope

The Scord of Brouster Multiple Field System is situated on a sloping hillside at the foot of a ridge which rises steeply immediately to the west. The ground slopes to the east, towards the burn which links the Loch of Brouster and the Upper Loch of Brouster. Today the slopes are stony, with a thin cover of acidic grassland, patches of sphagnum and areas of bare, eroding peat. The ground is wet underfoot for much of the year.

Excavating the site in the late 1970s, Alasdair Whittle described the field system at the Scord of Brouster as consisting of “six contiguous irregularly shaped fields ... in which three houses were separately distributed and containing numerous clearance cairns, and three less well defined areas, two of which comprised stretches of walling seen or traced under peat and one of which contained numerous clearance cairns in an area of very shallow peat cover but only sparse traces of walling.” The present field survey, carried out about 30 years later, without reference to Whittle, is incredibly close to the original. However, the field system is defined here as comprising eight fields on the basis of the plotted field boundaries.

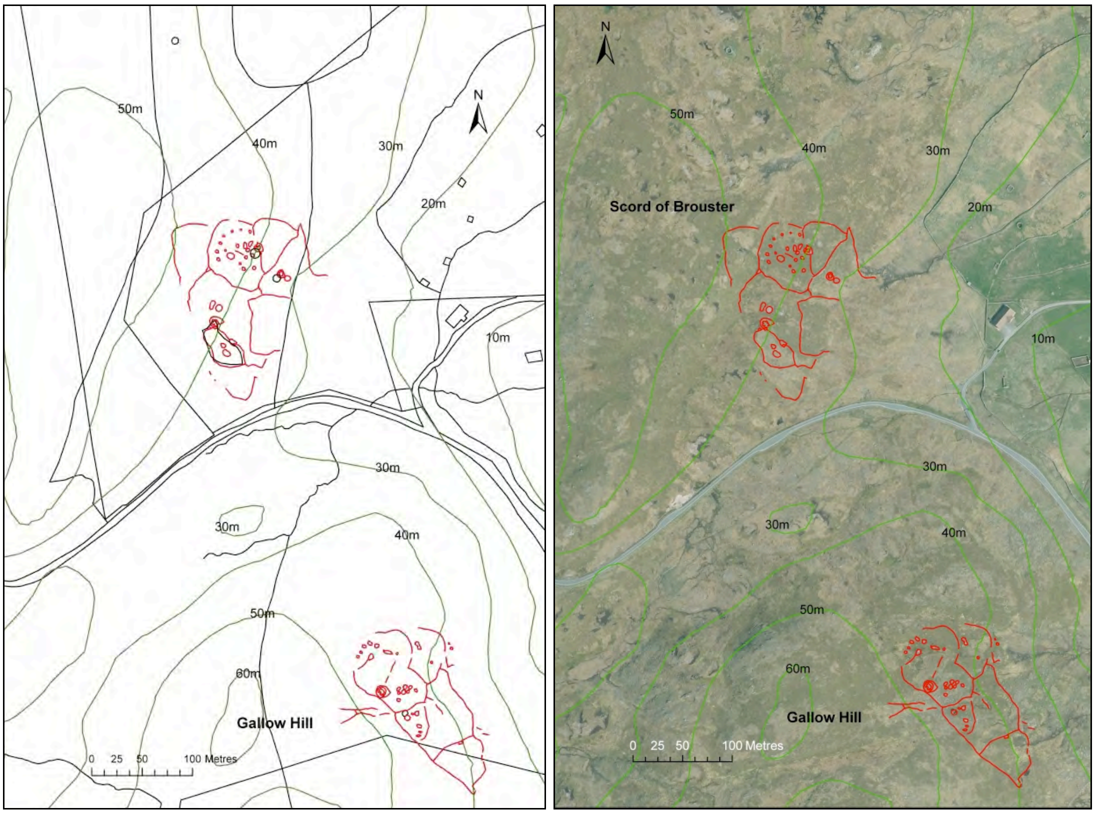


Fig 3.8a Scord of Brouster and Gallow Hill survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.8b Scord of Brouster and Gallow Hill survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The three houses, a kerbed cairn and numerous clearance cairns, as well as some archaeological spoil heaps, are now clearly visible in the landscape. Prior to the excavation Calder identified and recorded a field system here (1956). The excavation established a chronological sequence for the houses. Whittle named the earliest structure "House 2" (Whittle, 1986). It is located between fields F1 and F2 (this study) and is sub-circular with a kidney-shaped interior. The construction date was 2440±80BC (CAR-252), but it overlay a timber structure dated between 2505±70BC (CAR-250) and 2590±65BC (CAR-251). Whittle's "House 1", located at the edge of Field 7 (this study), was the most complex building, with four orthostats surviving, creating six internal side recesses during later phases, constructed in 2195±70BC (CAR-246). The latest structures in the sequence were two buildings within Field 4 (this study). Two dates were obtained for phase 1: 1360±60BC (CAR-477) and 1470±70BC (CAR-479), indicating a timeframe of 1420-1400BC. A kerbed cairn, thought to be founded on a clearance cairn, believed to be modified after the field system was abandoned, is located in Field 5 (this study).

The boundaries of Field 7 are clearly visible (and appear on the most recent Ordnance Survey mapping), a phenomenon which Whittle attributed to the removal of peat from the field. The other boundaries vary in clarity and this, together with the passage of 30 years since the excavations, during which vegetation changes have occurred, accounts for differences in the two surveys at the edges of the field system. The surveys were undertaken at different times of year: Whittle in summer when the light was good but the vegetation more abundant; the present survey in winter when the vegetation was low, as were the light levels.

The irregular fields have little obvious consistency of shape, beyond a general tendency to be slightly etiolated at the southern end. This shape is enhanced visually by the overall shape of the field system which has begun to be described as "tear-drop shaped". Noel Fojut (Historic Scotland) has suggested that the shapes of the fields are determined by how far someone could throw a stone, the elongated end being down the slope (pers. comm.). However, although the shape of the field system deludes the eye into believing that the site is indeed south facing, in reality, it is in fact east facing.

Whittle excavated sections of field boundaries as well as the structures, and some (but not all) of these trenches are still visible e.g. the junction of three boundaries between fields F2, F3 and F5 (this study). Some spoil heaps arising from the excavation are still visible, including a prominent mound lying to the west of the kerbed cairn.

Gallow Hill (HU257 512, Walls, West Mainland)

Shetland SMR: 2364

Height AOD: 35-51m

Solid geology: Old Red Sandstone

Drift geology: Bedrock at or near surface/Peat

Local aspect: South-east

Alignment: Across the hillslope

The SMR and RCHAMS previously recorded this site as a "house site", although the associated field system is well-defined and far clearer than much of that at the Scord of Brouster, approximately 500m to the northwest. This study therefore comprises the first identification of the site as a Multiple Field System.

The Multiple Field System at Gallow Hill is located on a hillslope, which rises to the west and is covered in thin acidic grassland, with sphagnum becoming dense on the lower slopes. Field 1 and the northern half of Field 2 are in slightly lower lying land; the sphagnum is deep and extensive in this area. The field system is aligned along the hillslope, predominantly between the 40 and 50m contours. The field system includes areas of numerous clearance cairns, and areas where these are rare. The area below the Multiple Field System includes large numbers of clearance cairns, not plotted as they did not occur in conjunction with field boundaries, the focus of this study. However, it does suggest that this area was also cultivated. The ground undulates locally and includes some steep slopes, although this does not appear to be a factor which influences either the frequency of clearance cairns or field boundaries: the land was intensively used regardless of the slope.

Fig 3.9a Field boundary within Gallow Hill field system
Fig 3.9b Two part house site within field system at Gallow Hill

Although overlooked by previous research, the field system is well defined: many of the boundaries clearly visible in areas of thinner vegetation. There are areas where boundaries disappear into the peat. The most well-defined prehistoric house site is situated in Field 2 (this study), just below the southwest field boundary, one of the highest points within the site. The house site has grass covered walls over 1m high and structural stone is visible within the interior. There is a disused plantiecrub in Field 4 (this study), to the south, standing to full height. Unusually there is no trace of an underlying prehistoric house site, although the crub would have been constructed from stone from the field system. Additional possible house sites lie east of the principal field system. One of these incorporates bedrock (which is generally close to the surface) making identification less certain. The third structure is a little to the east of this and comprises a house and possible outbuilding adjacent, reminiscent of “House 3” (Whittle, 1986). Alternatively, the “outbuilding” might comprise stones from clearance being deposited beside a short length of dyke. Excavation would be required in order to clarify this.

Ness of Gruting (HU277 484, Gruting, West Mainland)

Shetland SMR: 2308

Height AOD: 16-36m

Solid geology: Old Red Sandstone

Drift geology: Boulder clay, undifferentiated glacial drift

Local aspect: Southeast

Alignment: Diagonally across and down the hillslope

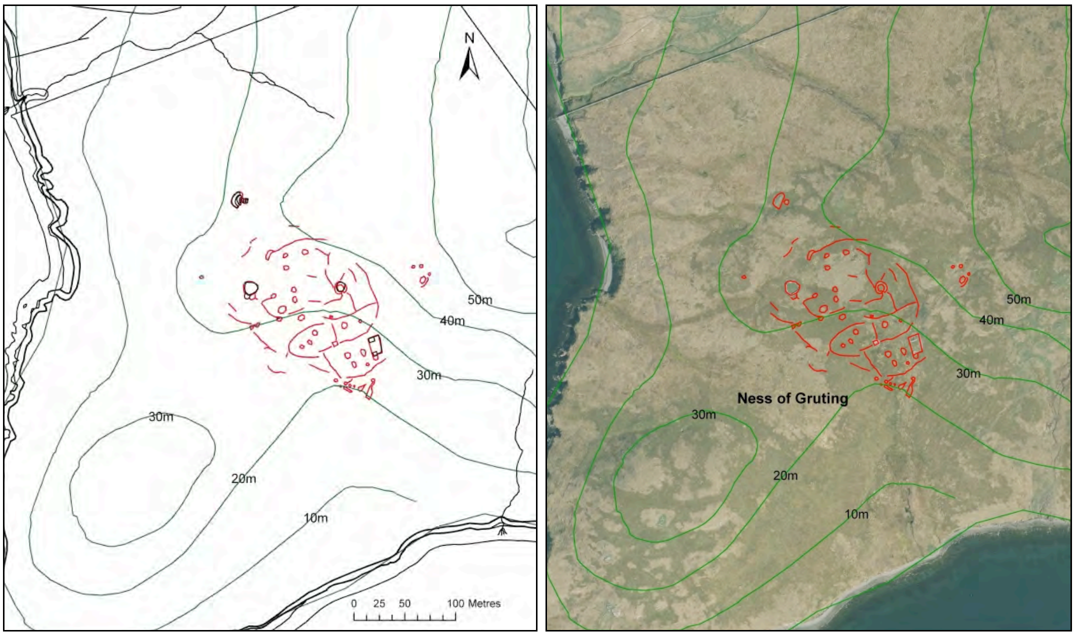


Fig 3.10a Ness of Gruting survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.10b Ness of Gruting survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The Multiple Field System at the Ness of Gruting is located on the west shoulder of the hill, which is flatter land within the hillslope. The vegetation is mainly acidic grassland on peat, with disused peat banks in the area. The field system contains two prehistoric houses. The house to the west has a plantiecrub constructed over it; the house mound is visible on the south side and some large stones, including one orthostat, protrude from the bank. The prehistoric house site to the east comprises a well-defined bank standing approximately 0.75m high. Earth fast stones define the inner edge and there is an entrance in the southeast side. When Calder surveyed the site (1956) he identified three houses, one of which is a burnt mound to the northeast of the field system which incorporates heated-shattered stone. There is a more recent rectangular sheep enclosure to the southeast and what appears to be the base of a second, sub-rectangular, plantiecrub, constructed of stone at the south end of the junction of the boundaries of fields 4 and 5 (this study). The mapped field system includes six small fields with fairly complete boundaries, but this is clearly an underestimate of the original number: there are several fragmentary lengths of boundary and clearance cairns to the northwest. There are also clearance cairns at the southern end of the field system, but none in the immediate vicinity of the east house. The fields below this house include terraces bounded by lynchets up to 1.75m high.

An additional house, excavated by Calder (1958), lies on the east side of the ridge. This house and field system was initially surveyed for this study, but work was discontinued as the cultivated areas largely consist of terraces and fragments of lynchets. The discernable field edges were too fragmentary to be examined accurately using Shape Analysis.

Pinhoulland (HU250 498, Walls, West Mainland)

Shetland SMR: 2305

Height AOD: 3-39m

Solid geology: Old Red Sandstone

Drift geology: Peat

Local aspect: Northeast

Alignment: Across and down the hillslope

The Multiple Field System at Pinhoulland is situated on land characterised by acidic vegetation and exposed peat and includes areas of standing water and sodden sphagnum moss. A modern fence crosses the site at the north edge of Field 4 (this study). The northern field is grazed by ponies and sheep and the grass is of considerably better quality, probably "improved".

This Multiple Field System is extensive, comprising extremely well-preserved boundaries, structures and clearance cairns. The Ordnance Survey Recorders noted ten structures in 1968 (Shetland SMR). Whittle noted eight (1986) and Edwards and Whittington defined the system as comprising seven houses and two enclosures. Without excavation it is almost impossible to be definitive as to how many features are buildings, but the number of stone built buildings within the field system is remarkable and, at present, unparalleled.

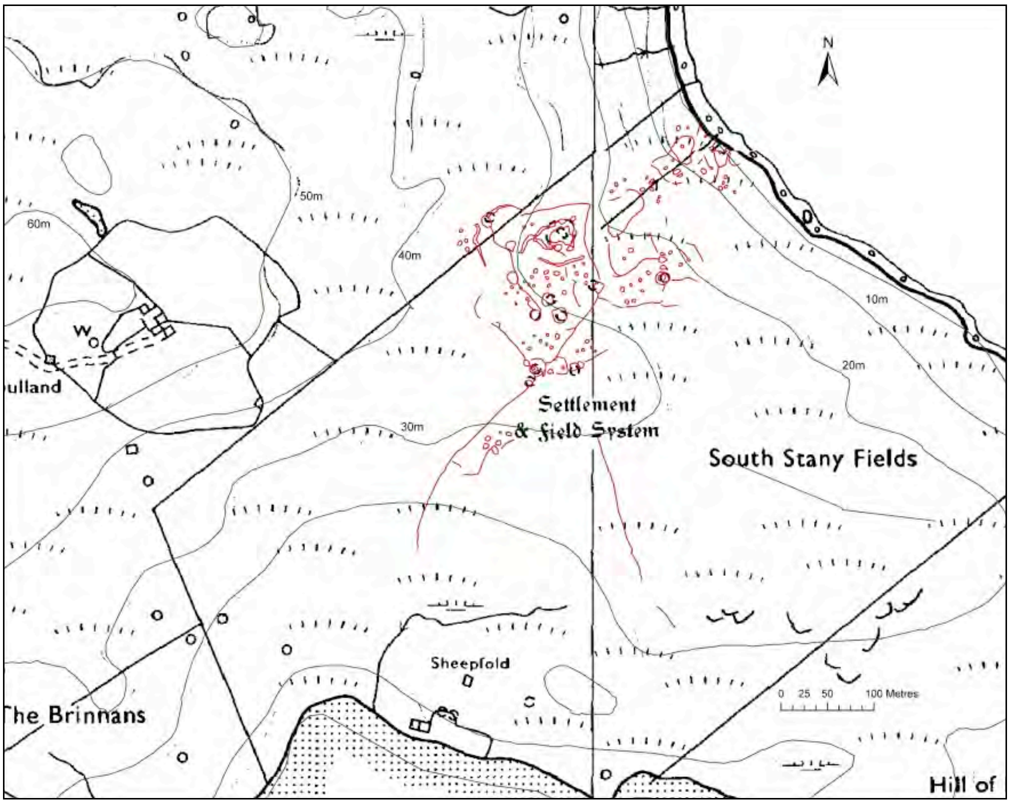


Fig 3.11a Pinhoulland survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.11b Pinhoulland survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

This survey defined eight potential prehistoric "house sites", which vary considerably in size and degree of preservation. The house which dominates the field system is situated in the middle of the enclosure or Field 6 (this study), the mound of which is approx 16m by 12m externally. The walls are up to 4m thick and inside there are orthostats and other traces of stonework. A small oval mound to the south, situated against the enclosing boundary, was interpreted as a structure by previous recorders. There is a second house to the west, on the edge of the boundary of Field 5 (*ibid*), a third on the boundary to the southeast of Field 4 (*ibid*) and an additional three buildings in the southwest segment of the field. The seventh prehistoric house lies beneath a disused plantiecrub which is exceptionally irregular, incorporating orthostats into the walls. The presence of a plantiecrub in an area which today looks unpromising, indicates that the land was still an uncultivated part of the croft in the post-medieval/modern period. There are the remains of one or two structures north of this, which may be the remains of a sheep pen. The eighth potential house is located just below the ridge, at the highest point of the field system. This appears to comprise two sections: a "living area" and a smaller "porch or workshop" (similar to House 3, Scord of Brouster, Whittle, 1986). There are two additional mounds on the western boundary of Field 4 (*ibid*), both of which would fit comfortably within the category of structures in terms of size. Neither of these has any visible internal features, however.

The ridge itself may have been artificially enhanced: the east slope resembles a lynchet. There are three mounds which occur together in the area: one on the highest point of the ridge; the other two just below the break of slope, immediately to the east. One of these was recorded by Whittle as a structure. All three bear a resemblance to sub-rectangular chambered cairns. It would be unusual to find chambered cairns within a field system if they were contemporary, but the ring cairn at the Scord of Brouster post-dated the field system (Whittle, 1986). It would also be unusual to find three chambered cairns together but the number of "houses" already proves that this site is exceptional and the geographical location is appropriate for chambered cairns. There are additional structures located northeast, by the coast, which are the most recent constructions on site; they comprise a boat noost, a duck house and a ruinous sheep pen standing 0.4-1.5m high.

<u>Sumburgh Head</u> (HU407 085, Sumburgh, South Mainland)

Shetland SMR: 3821

Height AOD: 22-64m

Solid geology: Fish bed/Flaggy Sandstone

Drift geology: Bedrock close to surface

Local aspect: West

Alignment: Across the hillslope

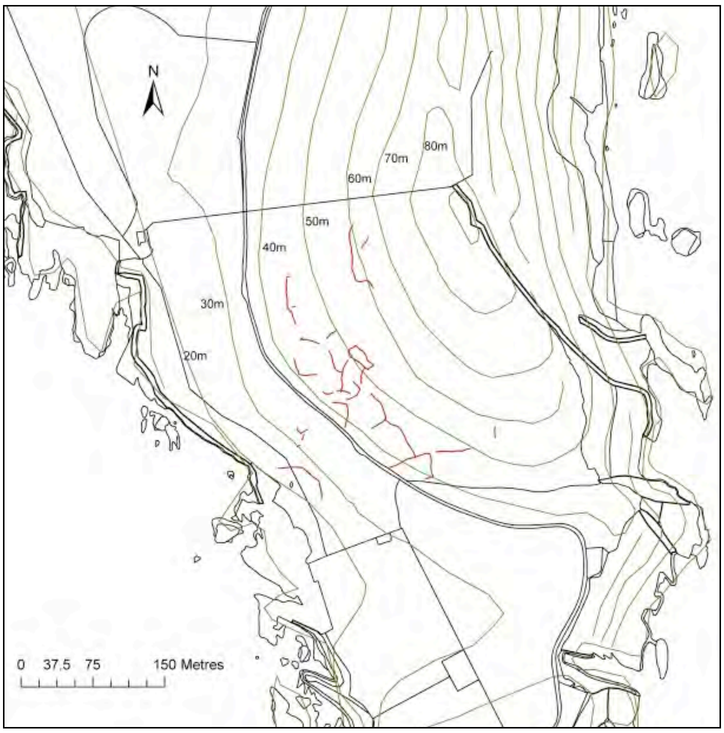


Fig 3.12a Sumburgh Head survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).

Fig 3.12b Sumburgh Head survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The Multiple Field System which has been given the name "Sumburgh Head" is situated on the unnamed ridge between Sumburgh Head to the south and Compass Head to the north. The field system is aligned NW-SE, bearing a strong relationship to the lie of the land between the 40 and 50m contours. The thin cover of maritime grass may result from its having been scalped, possibly to deepen the soils which lie on the flatter and more extensive land to the northwest: an area which today comprises part of one of Shetland's largest, and most intensively worked, farms (Sumburgh Farm). The majority of the boundaries survive as low earthworks, some very ephemeral and two surveys in differing lights (low cloud and strong light) gave slightly differing results.

The site includes one identifiable prehistoric house, situated towards the northwest end of the field system, above a terrace. There is a possible Orcadian stalled cairn a short distance to the north, although trial excavation by the author in 1997 was inconclusive and Audrey Henshall has suggested that it might be a second house (pers. comm.). Mounds in the lower fields to the northwest, recorded by the author in 1998, have the appearance of barrows, also unusual in Shetland. The fields themselves are generally smaller than those of the other Multiple Field Systems. They suggest a pattern of land use which maximised the potential of every available, relatively flat, piece of land. Today the field system largely stops at the east verge of the modern road, although there is a well defined enclosure to the west of the road which might be contemporary with the field system**.** The flatter, more low-lying land to the west of the road has been used more intensively in recent times.

Clevigarth (HU407 129, Dunrossness, South Mainland)

Shetland SMR: 622

Height AOD: 13-21m

Solid geology: Sandstone

Drift geology: Bedrock at or near surface

Local aspect: East

Alignment: Along the hillslope (although the land is exceptionally flat).

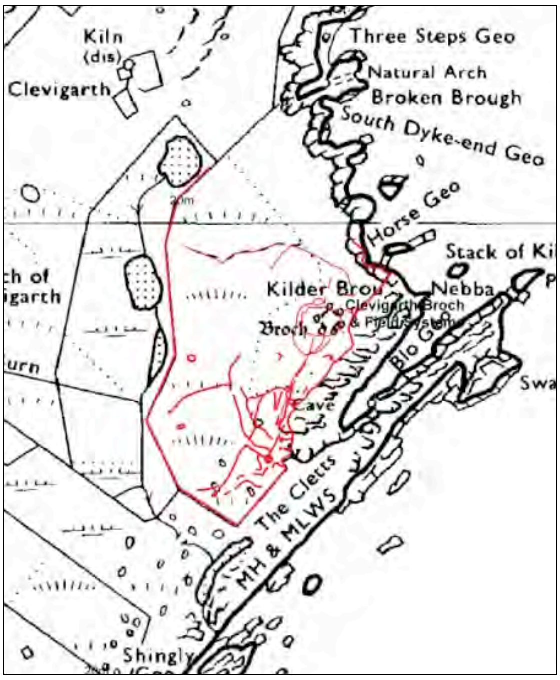


Fig 3.13a Clevigarth survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).

Fig 3.13b Clevigarth, First Edition (1878) Ordnance Survey map

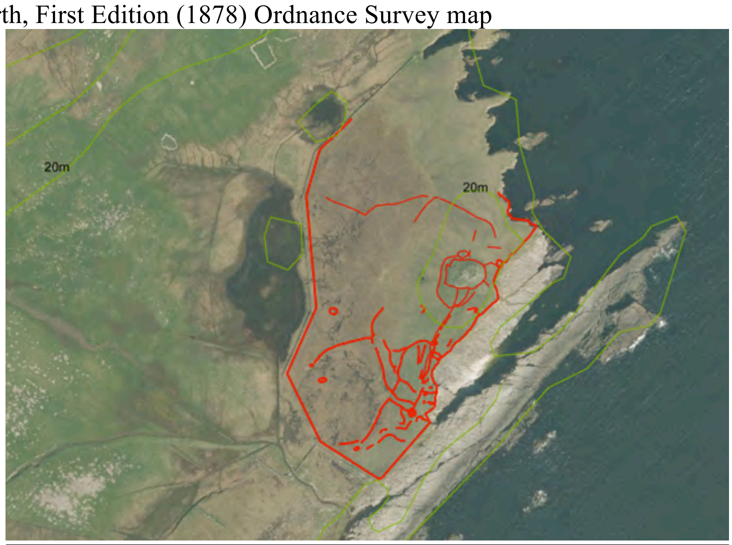


Fig 3.13c Clevigarth survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Clevigarth is included both as a site with a broch boundary (north of the Broch earthworks) and also with a Multiple Field System to the south. The remains of the boundary north of the Broch are not on the First Edition map, although there is an indication of it on the 1973 edition). The remains have no relationship to the boundaries which do appear on the map, or to any features other than the Broch. It is therefore reasonable to assume that the decision made in the field, that the boundary is associated with the Broch, is correct. The site is located on unusually flat land compared with the other Broch sites and is generally flatter than the other Multiple Field Systems. The Broch is located at the cliff edge, afforded additional protection on the east side by The Cletts, a ridge of rock which runs parallel to the land on the far side of Blo Geo.

The Scheduled Broch survives as a mound, about 19m diameter, and 3-4m high. There are traces of inner and outer walls visible. There are indications of outbuildings, including a crescent-shaped mound to the north which resembles a burnt mound in shape (although this is very unlikely to be the case as the feature is more likely to post-date the construction of the broch). Soil survey was carried out by Simpson and Guttmann (2008) on the flanks of the broch mound to search for midden material or signs of cultivation. Their work identified a pre-Iron Age phase of cultivation when midden was added to the soils, but revealed no sign of Iron Age agriculture.

To the south of the broch is a field system which has not hitherto received much attention. Geophysical survey was carried out at the same time as the site was being mapped by the author (Dockrill, Turner and Brown, 2003). The fields were assumed to comprise a Multiple Field System which pre-dated the broch. The irregular shapes of the fields appeared to support this interpretation. To the north the Broch, the line of the boundary interpreted as belonging to the Broch period respects the broch to some degree.

BROCH BOUNDARIES

In 1855 Sir Henry Dryden listed 75 Brochs in Shetland. Since then at least another six have been discovered, five of them in the past 25 years. Taking place-name evidence into account, the number of probable Broch sites in Shetland stands at approximately 120. Whilst the exact role and function of Brochs is hotly debated (e.g. Turner *et al.,* 2005), it is clear that at least some of them have contemporary amended soils surrounding (Simpson *et al.,* 1998, Guttmann *et al.,* 2008). The boundaries of the fields around the broch at Old Scatness are not, however, visible due to the build up of later soils above them. An initial SMR trawl of Brochs in Shetland suggested that there were no such boundaries to be found, but during the course of this study, four possible candidates have emerged: Clevigarth, Tumblin, Sae Breck and Underhoull. In no case does the visible portion of the boundary under scrutiny completely surround the broch, but each does appear to have a relationship with the broch and in only one case (Tumblin) is there a plausible alternative explanation for the boundary.

<u>Tumblin (also known as Houlland) </u>(HU345 539, Bixter, West Mainland)

Shetland SMR: 96

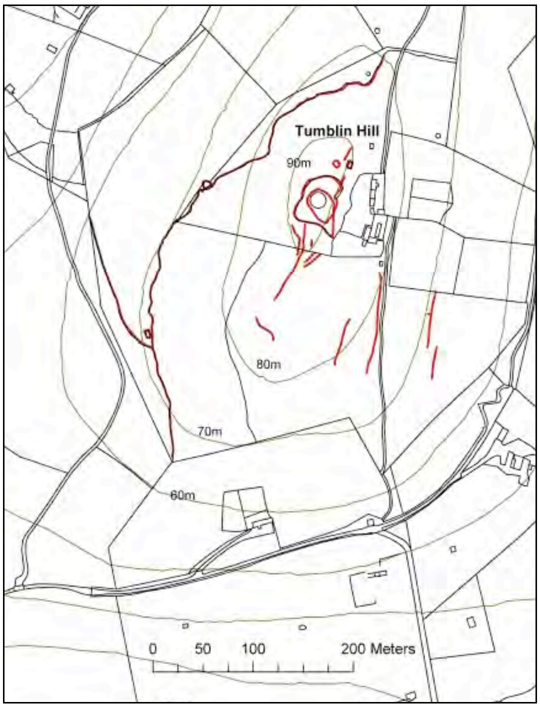
Height AOD: 58-84m

Solid geology: Permeation gneiss/Serpentinite

Drift geology: Peat

Aspect: South and East

Alignment: North-South



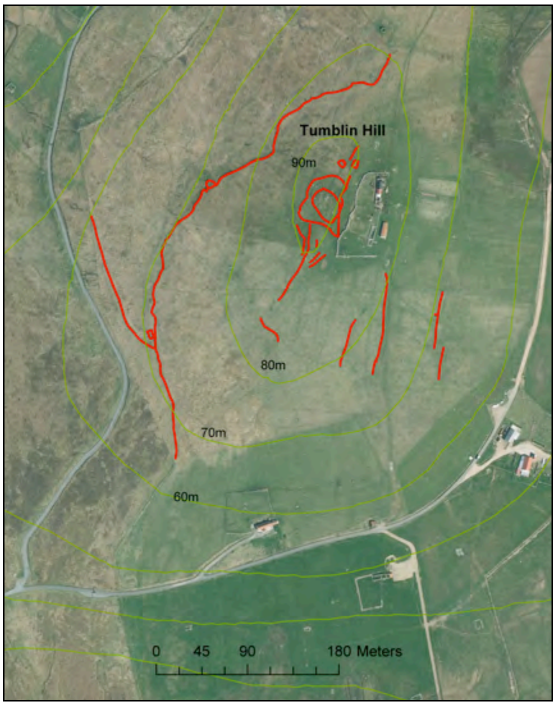


Fig 3.14a Tumblin survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.14b Tumblin survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Tumblin Broch is located on the top of Tumblin Hill, west of a croft house. The vegetation today comprises acidic grassland which is locally boggy. The turf covered, scheduled, broch mound, is approximately 16m diameter and 2m high. The ramparts immediately around the mound stand up to 1m high. There are several substantial linear features, both banks and lynchets, aligned approximately north-south: that located just west of the track stands to 1m high; these appear to be rigs. There are two substantial boundaries west of the broch. The northerly boundary has been recorded as Tumblin 1 in this study. A length of boundary which meets Tumblin 1 at a y-shaped junction beside a sheepfold, together with the continuation of the dykes to the south, has been labelled Tumblin 2. Whilst the plan suggests that Tumblin 1 includes the southern part of that boundary, it has been recorded as part of Tumblin 2 because field observation of the construction and appearance of the boundaries suggested that the southern section is part of the west boundary. The 1st Edition (1878) Ordnance Survey map shows that Tumblin 1 and the portion of boundary to the south formed part of the post-medieval township boundary of East Houlland. In the absence of excavation, it cannot be conclusively established that the boundary has Iron Age origins. However, there seems to be no compelling reason why the township boundary would enclose the broch: the thin, peaty, acidic soils lie on the western edge of the township, somewhat isolated from the rest of the township by topography and the land west of the Broch faces west, rather than east, unlike the remainder of the township. For most of its length the township boundary is depicted on the map with either straight or smoothly curving lines, but it is markedly different in the immediate vicinity of the broch where the boundary is more meandering. This is a further indication of an earlier origin for this portion of the boundary. This line may have been followed due to the pre-existence of a boundary making it easier to include this area than to create a new line. Alternatively, Iron Age agricultural practices might have made the inclusion of this area desirable.

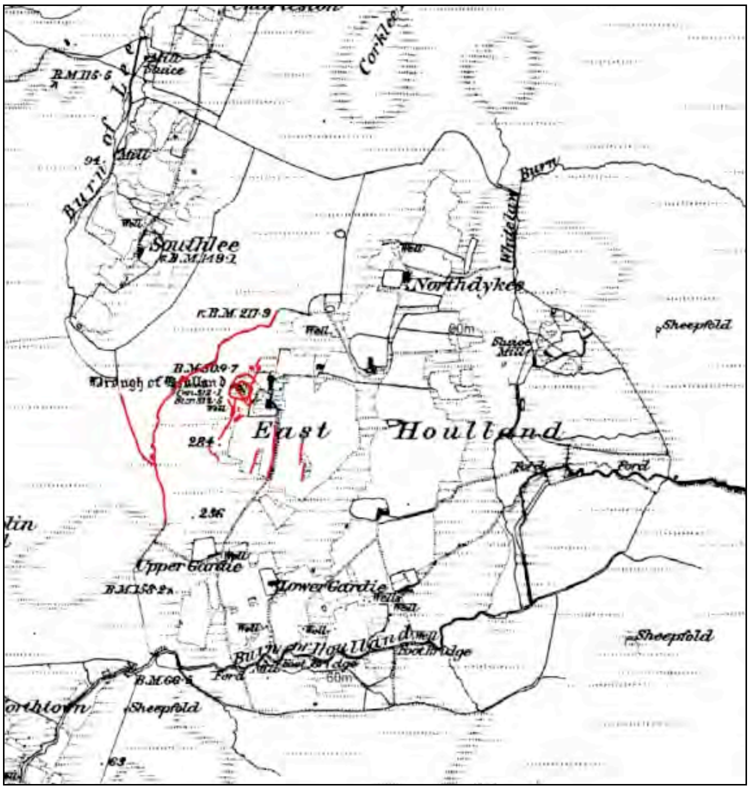


Fig 3.15 Tumblin, First Edition (1878) Ordnance Survey map

Sae Breck (HU210 780, Eshaness, North Mainland)

Shetland SMR: 107

Height AOD: 27-61m

Solid geology: Old red sandstone/tuff (including ignimbrite) massive, blocky. Chilled at base and vesicular near top, with inclusions and fissure fillings of sandstone.

Drift geology: Bedrock at or near surface/glacial deposits.

Aspect: Highest point at centre, where broch is situated.

The scheduled Broch is situated at the highest point of the hill. It commands a good view, which has been utilised since the Iron Age. The foundations of concrete structures have been inserted into the top of the Broch; there is also a rectangular concrete building immediately to the west and a hexagonal building immediately to the north stands to about 2m. These are labelled on the Ordnance Survey map (1973) as "coastguard lookout". There is also an Ordnance Survey trig point pillar set into the south of the Broch.

Two field boundaries have a direct relationship to the Broch. The more prominent of these, Sae Breck 2, follows the contours for approximately 35m at its eastern end. However, it turns at an angle of about 135° and climbs the hill steeply, cutting the southern edge of the Broch mound, which it clearly post-dates. It continues west, down the other side of the slope, until it reaches Gerdie Loch. One of the concrete buildings is situated directly beside it, adjacent to the west side of the broch. The boundary terminates in stones which project into the loch. The Sae Breck 1 boundary is located west and north of the broch. On the west side it follows the contour of the hill closely. The boundary sweeps around the northern hill slope, continuing northwest before disappearing close to recent sheep pens. The southern end of the boundary disappears into flatter, hummocky ground: tracing hummocks suggests numerous possibilities for the continuation of the boundary, but none with any certainty.

The majority of the still traceable length of Sae Breck 1, and the east side of Sae Breck 2, are both shown on the First Edition Ordnance Survey map. This is a measure of the visibility of these earthworks in the late 18^{th} century landscape and does not mean that either were in contemporary use. Neither boundary has any relationship with land which was enclosed at that period: the township of West Houlland lay further east and its later expansion stops at the Loch of Breckan, although the church and burial ground are located in the hill land to the west of the loch.

On the northeast side of the broch there are traces of small rectilinear fields at the foot of the small hill crowned by the Broch which are completely divorced from the enclosed land and there is a strong possibility that they were associated with the Broch and are Iron Age in date. They are different in character to the rig lines (not surveyed) which are visible still further northwest. The rigs are on flatter land and have no cross divisions or any stone visible within them. Small, rectilinear fields which may be contemporary with Broch sites have not hitherto been recognised in Shetland.

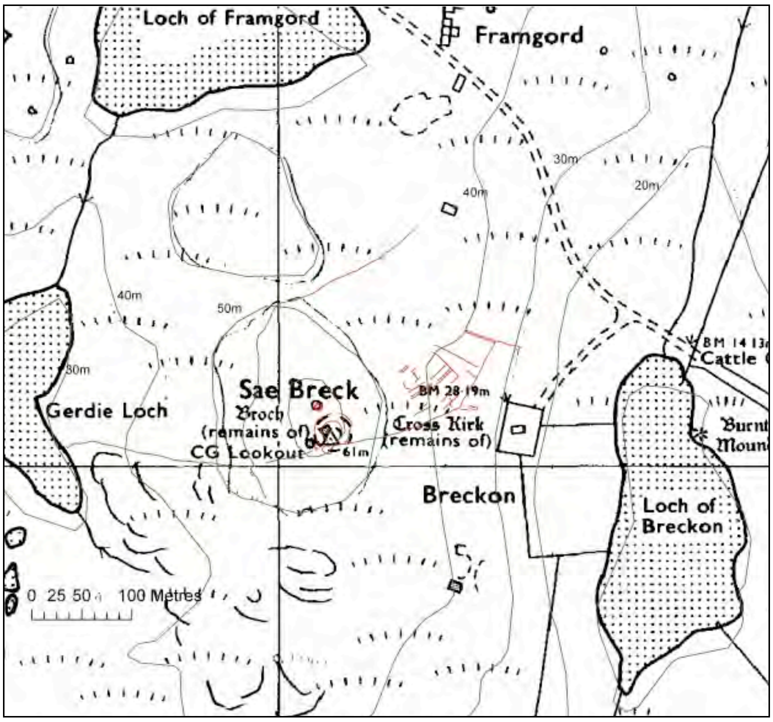


Fig 3.16a Sae Breck survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.16b Sae Breck survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

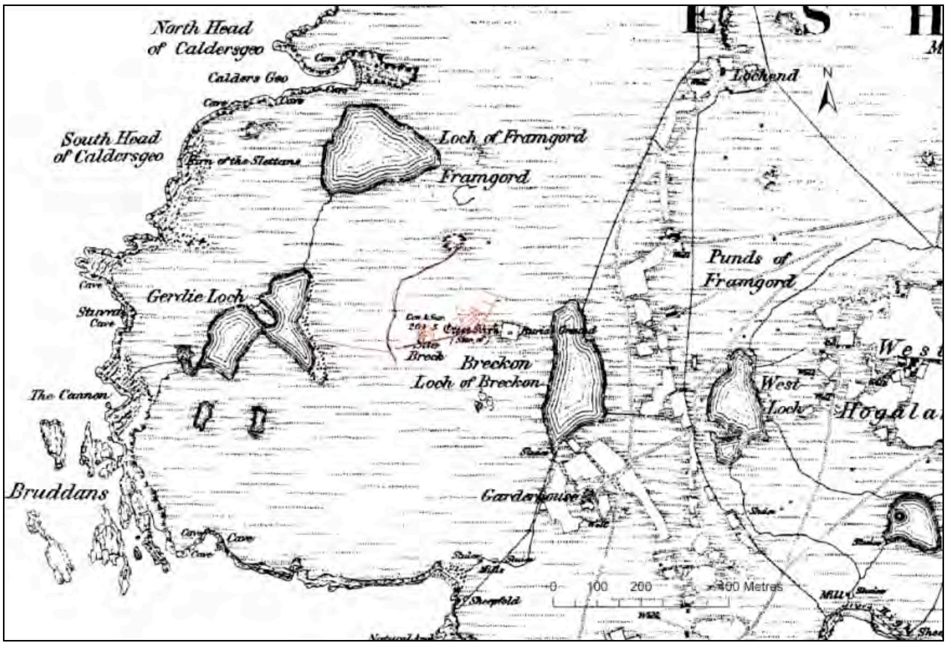


Fig 3.16c Sae Breck, First Edition (1878) Ordnance Survey Map

NORSE SITES

With one exception, the Viking/Norse sites examined in this study are located in Unst. Unst, the most northerly island in Shetland, has over 60 possible longhouses (Turner, *et al.*, 2013). This is the highest density of rural Viking settlement remains to be found anywhere, including in the Viking homelands of Scandinavia. The longhouses appear to have been the main buildings of Viking farms and these are predominantly aligned down the slope with either a byre or a hall at the lower end. Some have associated outbuildings and all those in the study have a yard attached to them. At both Stove and Eastshore (the latter in the South Mainland of Shetland) at least part of the yard boundary has been incorporated into recent use. In every case other than Eastshore, the long wall of the house is incorporated into the boundary of the yard. In some cases the sites have associated earthworks which appear to have been the infield boundaries. This is the first time these have been identified in Shetland. Many of the sites are on land which, today, appears to be very unpromising farmland.

Belmont (HP568 007, Belmont, Unst)

SMR:152

Height AOD:10-50m

Solid geology: Serpentinite

Drift geology: Bedrock at or near surface

Local aspect: West

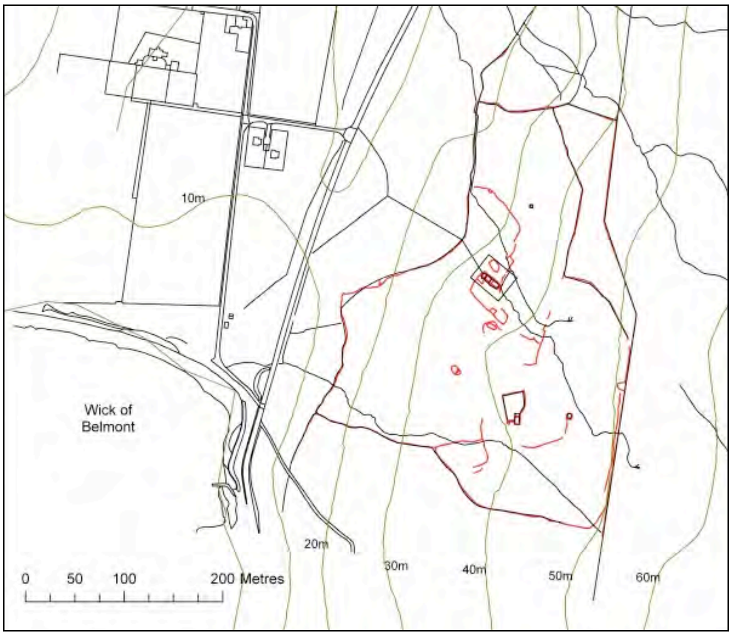


Fig 3.17a Belmont survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.17b Belmont survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The longhouse and associated field system at Belmont lies on acidic grassland, on a wet hillslope with a thin cover of peat over the bedrock. A burn runs to the upper end of the longhouse, where it was diverted south via drains along the outside of the house. This is one of three burns which flow through the infield. The hill dyke associated with the township of Belmont bounds the western edge of the site. Immediately below this the grass is more improved, but the area at the foot of the hill, (adjacent to the road today) is very boggy. The longhouse has been excavated as part of Shetland Amenity Trust's Viking Unst project and was shown in fact to have comprised superimposed three Norse buildings (Larsen *et al.*, 2013) suggesting that this was a long lived settlement. Finally, a plantiecrub was constructed over the lower end of the site. There are two candidates for yards, which may have been associated with different phases of the longhouse; a long-wall of the longhouse is incorporated into each.

The location of the Norse settlement, on the hillslope over looking flatter, more cultivable land, suggests that the land below was already in use when the higher farm was established. There is no visual evidence of this; subsequent landuse, including the Designed Landscape of c1775 (see below), the modern intensive use of the land and coastal erosion, may all be possible contributing factors in this.

The longhouse (at approx 30m AOD) was sighted in the middle of the infield rather than at the highest edge: a substantial proportion of land is higher than the longhouse, in contrast to some other examples. An outhouse lies adjacent to the north side of the longhouse; evaluation excavation suggests it was used for cooking and metal working (Larsen *et al.*, 2013). A later croft house and its yard are also situated to the south, within the infield (at approx 40m AOD) which suggests that the land supported a subsistence level of farming, whether arable or pastoral, for a protracted period, although today the land is very impoverished. There are also fragments of other boundaries within the infield. There are indications of a Bronze Age use of the landscape in the form of two separate groups of cup-marked rocks: one is located in the lower (western) boundary of the site; the other was found during excavation, on bedrock adjacent to the south side of the longhouse (Larsen *et al.*, 2013).

The infield boundary is well defined on all sides. The lowest (west) side appears to correspond with the later township boundary. The upper (southeast) boundary is located very close to a recent stone dyke which is still in use today. Although there is some similarity between the line of the modern stone dyke and that of the earlier boundary along much of its length, the modern wall follows a straighter, more angular course to the east of the infield. The northern infield boundary appears to have been continued as a length of more recent dyke, whilst the southern boundary has no relationship with the post-medieval or modern pattern of land use.

Of the two surviving yards, the northern one has a near complete boundary begining at the southeast corner of the house site, curving north and then northwest to meet the north-south boundary now formed by the township dyke. The boundary between the west end of the house site and the township boundary is absent. The southern yard is more fragmentary and there are a number of short lengths of dyke which might form part of it. The northwest dyke and its return to the southeast is convincingly part of the yard. The dyke which projects from the southeast side of the house site is also very probably a yard dyke. It is even possible that these two dykes, if projected to their crossing point, formed the complete yard. The boundaries which have been proposed as forming the yard, however, include the full length of the boundary which starts in the northeast corner and then returns to the southeast. This boundary terminates in a low platform, included in the definition of the southern yard. Alternatively, it is possible that the line of the northwest-southeast boundary continued, joining the dyke to the east which shares the same alignment. This dyke continues southeast until it forms a T-junction with another boundary. If the northeast end of this boundary once continued along the same alignment, it would meet a corner of the infield boundary: it may have been the boundary of an earlier phase of the infield. Given the longevity of the site and the incomplete survival of the yard boundaries, it is necessary to treat results relating to this boundary with a degree of caution.

On the First Edition Ordnance Survey map (below) the township boundary is shown starting at the coast, south of the "Dock of Belmont", and progressing northwards to the southwest end of the Loch of Snarravoe. The length of dyke above it, interpreted both as the boundary of the infield and the township, may represent a later intake of land by the township, possibly for water or hay meadows. The case for this boundary serving as the infield boundary is supported by the fact that the well-preserved yard boundary terminates where the two meet. The land to the east is significantly flatter than that of the infield, above it, which today has poor, thin acidic soils. The yard boundaries and the longhouse are not shown on the First Edition map, although the plantiecrub built over the southern end of the longhouse is included. A dry-stone dyke, maintained and in good repair today, serves as the hill-dyke and is situated immediately to the east of the upper (east) side of the infield. The hill-dyke continues north and encloses an area named "Setters of Belmont"; this suggests that the Norse infield area became part of a later and larger intake of hill land. Not all of what has been interpreted as the infield boundary is depicted on the First Edition map. It is clear that the boundaries were not part of the pattern of land use in 1878, other than on the west side. The difficulties of interpreting the boundaries at Belmont are compounded by the creation of a Designed Landscape (as defined by Historic Scotland's Inventory) on the flat land to the west, around Belmont House which was completed c 1775 by Thomas Mouat. The designed landscape has made it more difficult to trace the township boundary and may have also obliterated parts of the earlier Norse boundary.

Fig 3.18.a and b Belmont, First Edition (1878) Ordnance Survey map with and without survey data

<u>Eastshore</u> (HU 402 113)

Shetland SMR:

Height AOD: 2-5m

Solid geology: Fish bed/Flaggy Sandstone

Drift geology: Bedrock at or near surface

Local aspect: Northeast

Fig 3.19a Eastshore survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.19b Eastshore survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The longhouse at Eastshore is situated within an area of small enclosed fields, probably related to the Fishing Station to the east, which also overlies Eastshore Broch. The longhouse comprises well-defined, turf-covered walls, with stone protruding intermittently and defining the northern most end. The longhouse is aligned NE-SW, the northeast end being the higher, the walls at this end standing 0.5m high. There is no internal subdivision of the longhouse but there are traces of a side room to the south. The surrounding dyke, which stands between 1-1.3m high, has been interpreted as the yard for this site because it is very sinuous and there is no obvious explanation for that, other than following the line of an earlier dyke. However, a dyke with these characteristics would normally be prehistoric and this dyke is the only one of the yard dykes which does not incorporate a long wall (it includes the line of a side room) all of which throws this interpretation into doubt. There is no visible evidence of an infield; the density of dykes standing to full height has removed any evidence.

Gardie (alternative name: Brookpoint) (HP 635 115, Haroldswick, Unst)

Shetland SMR: 3548

Height AOD: 10-25m

Solid geology: Serpentinite

Drift geology: Bedrock at or near surface

Local aspect: Northeast

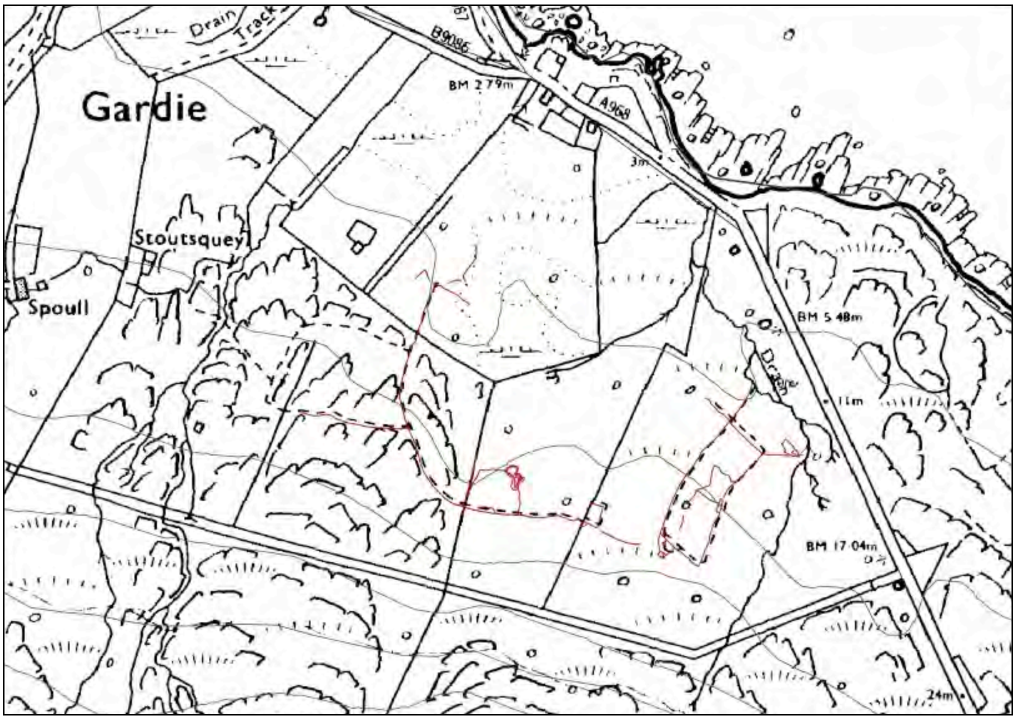


Fig 3.20a Gardie survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).

Fig 3.20b Gardie survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The longhouse at Gardie is situated at the higher end of the field system which today lies in an area of impoverished acidic grassland overlying a thin covering of peat. The peat or earlier turf appears stripped from what today is very stony land, particularly on the lower (northern) end of the infield. The lower area is also wetter than the upper slopes, where the grass is sufficient to permit grazing by sheep and the drainage is better.

The longhouse lies at the northeast corner of the yard and a circular structure is located at the northwest corner of the longhouse. Hansen (1996) has suggested that this might be the drainage sump for a byre, presumed to exist at the lower end of the house. However it has a similar internal area to the longhouse and it seems more probable that this was a cook house or outbuilding associated with the longhouse with which it shares a wall. The longhouse shares its southern boundary with the yard dyke. The infield dyke is clearly visible for a considerable length, although its northern boundary has not been identified. A length of boundary projecting outwards from the west edge of the infield may represent an additional, perhaps later, intake of land into the infield. It is very clear from the Ordnance Survey map that the Norse field system bears no relationship to the present day pattern of land division. A later yard or sheep pen which has been constructed to take advantage of the southern end of the infield boundary is distinguished by being built of coursed stone.

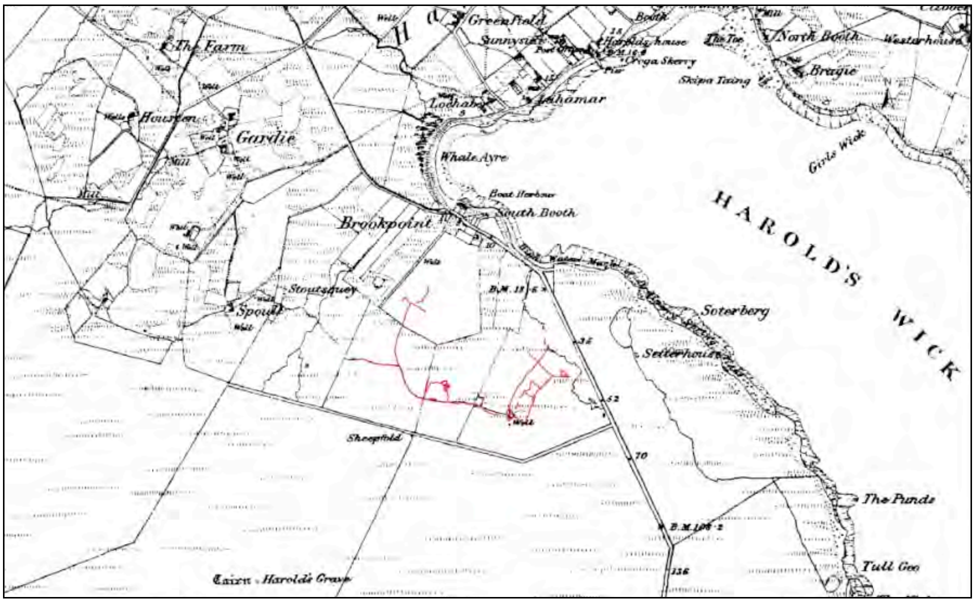


Fig 3.20c Gardie, First Edition (1878) Ordnance Survey map

The longhouse at Gardie lies east of the boundary of the later township of Gardie. The township was subsequently extended to the southeast and took in land at Spoull, Stoutsquoy, Brookpoint and land further east. The "quoy" name indicates a place where cattle were gathered, whether overnight or for milking, before the land was taken into the township. The land divisions in the later intake are more linear than those of the original township and would have divided into rigs more easily. The boundaries associated with the Gardie longhouse bear no relationship to this later intake. The clear relationship between the longhouse, the yard and the infield makes Gardie a compelling candidate for a complete surviving Norse field system, but the pattern of landuse changed significantly when the township was established.

A second possible longhouse associated with the infield, and a possible enclosure, were surveyed at the east side of the infield however an early spring visit revealed that this was an illusion created by outcropping bedrock. Nonetheless, there are three other confirmed longhouse sites less than a kilometre from Gardie: Spoull and Stoutsquoy to the north, and Soterberg to the southeast. "Harold's Grave" is located in the hill above Gardie, locally considered to be the grave of the Norwegian Viking King Harald Hårfagre *(Harold Fairhair)* who gave his name to the bay "Haroldswick".

Hamar (known locally as Jacob Johorassen's House) (HP 646 093, Baltasound, Unst)

Shetland SMR: 3471

Height AOD: 35-47m

Solid geology: Serpentinite

Drift geology: Bedrock at or near surface/Glacial deposits (undifferentiated): mostly thin till without peat cover.

Local aspect: South

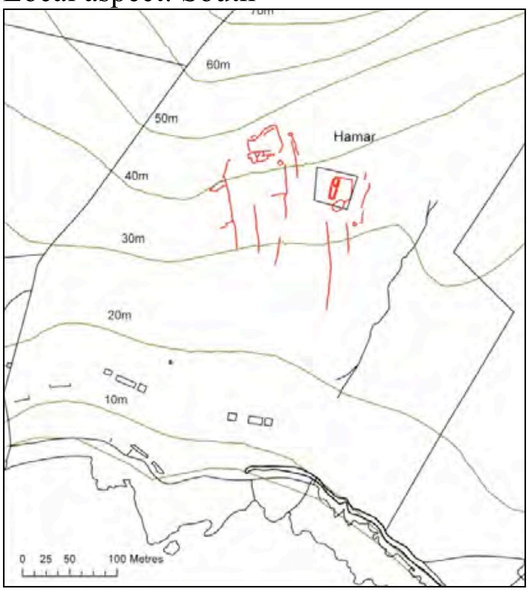


Fig 3.21a Hamar survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.21b Hamar survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

There are two longhouse sites at Hamar situated on sloping ground which supports grassland grazed by cattle. The soil is locally thin, having been stripped in the 17th century as evidenced by a piece of pipkin found during excavation (Brown in Bond *et al*., 2013). This lower building, a longhouse with a yard attached to the east side, has been fully excavated (Bond *et al*., 2013). The lower, earlier, longhouse (Hamar 1) is known as Jacob Johorassen's House, although there is no local memory of why this should be (Duncan Sandison, pers. comm.). Hamar 1 has been described as "the best preserved longhouse in Scotland" (Fojut, letter to Shetland Amenity Trust) and, prior to excavation, was assumed to be a single phase dwelling. Fojut's interpretation was based on both the remarkable preservation of the house and the unpromising condition of the surrounding land today. It was therefore assumed that Hamar 1 was a short-lived farm which failed due to the poor agricultural value of the surrounding land. Excavation has demonstrated that this was far from the case. There were at least three different buildings superimposed, the earliest being a sunken floored house, resonant of a 9th century or later Norwegian style of pit house (Bond *et al*., 2013). The date of the primary hearth in the pit house is 1065-1250 cal AD and dates for the later buildings had a broadly similar range. (The excavators hope that this might yet be refined by further statistical work (*ibid*)). Hamar 2 is situated slightly higher up the hill (at 44m AOD, as opposed to 36m AOD) under a steeper rock face. Unlike the earlier longhouse which is aligned down the slope, the higher house is aligned across the slope, although the earthwork remains demonstrate that there was an earlier phase. The upper building has a yard to the north, located above the house. This building and yard have been dated by excavation and were abandoned by 1450-1635 cal AD (Bond *et al*., 2013). One outcome of the excavation was to demonstrate that the area supported a high quality barley crop throughout the period of occupation, continuing after the later house had been abandoned (Summers in Bond *et al*., 2013). Below the buildings several low ridges aligned down the hill are either the remains of rigs or were created by stripping the turf. There are no visible remains of an infield boundary today, although the presence of grain mixed with the weeds of cereal crops from both house sites demonstrates that there was a successfully cultivated infield here (Summers in Bond *et al*., 2013). If infield boundaries ever existed as earthworks, evidence may have been removed when the soils were stripped. An examination of the First Edition (1878) Ordnance Survey map shows that the hill land on which the two houses are located lies outside the township that included the crofts of Hamar and Littlehamar. There are no associated boundaries visible on that map.

Fig 3.21c Hamar, First Edition (1878) Ordnance Survey map

<u>Quoy</u> (also known as Newgord) (HP 5713 0628, Unst)

Shetland SMR: 3466

Height AOD: 50m

Solid geology: Amphiboles, laminated horneblende schists, steatite, serpentinite, gneiss

Drift geology: Glacial deposits (mostly till, formerly covered by peat)

Local aspect: Northwest

Fig 3.22a Quoy survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.22b Quoy survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The longhouse at Quoy lies within enclosed grazing land and today its yard falls within three modern fields. The longhouse is in the northernmost field, which comprises rougher grazings than the improved fields to the south. The longhouse is aligned down the hillslope, the lower end includes stone on end which might be

part of an entrance way. It has three side rooms attached to the western long-wall which almost doubles the floor area of the longhouse. There are three rooms within this, the middle of which had a doorway surviving between it and the primary longhouse. There are few stones visible in either the longhouse or the yard perimeter. There is no trace of the infield boundary: there are remains of rigs and agricultural ditches in the vicinity, demonstrating that the land has had a long period of use. This appears to have obliterated any evidence of an infield.

Stove (HP620 124, Haroldswick, Unst)

Shetland SMR: 3549

Height AOD: 31-35m

Solid geology: Serpentinite

Drift geology: Glacial deposits (undifferentiated): mostly thin til without peat cover.

Local aspect of site: The house site and yard are at the highest points, with the land being lower both to the north and slightly lower still to the east.

The longhouse at Stove is situated on grassland which is used as pasture and appears to be good quality by present day Unst standards. The longhouse has side rooms off the eastern long wall, which by comparison with Sandwick South (Bigelow, 1985) may indicate a relatively late Norse date, although the recent work at Upper Underhoull and Hamar demonstrates that this is not necessarily so (Bond *et al.*, 2013). The yard, situated west of the house, is constructed of roughly built stone and stands up to 1m high. The modern fence line crosses the yard. The yard continues to the north, where it was incorporated into a relatively recent stone built boundary, now in a state of disrepair and which in turn is now followed by the modern fence line. The bank at the northeast corner appears to be the point at which the infield boundary joined the house, from where the line runs east and south. A straighter boundary, to the south, may be more recent; it is located in a different modern field, which has been grazed more intensively. North of the site are two other lengths of bank and two further structures but it is not possible to ascertain their date: the structure in the middle could be Norse, while that to the north is more prehistoric in character.

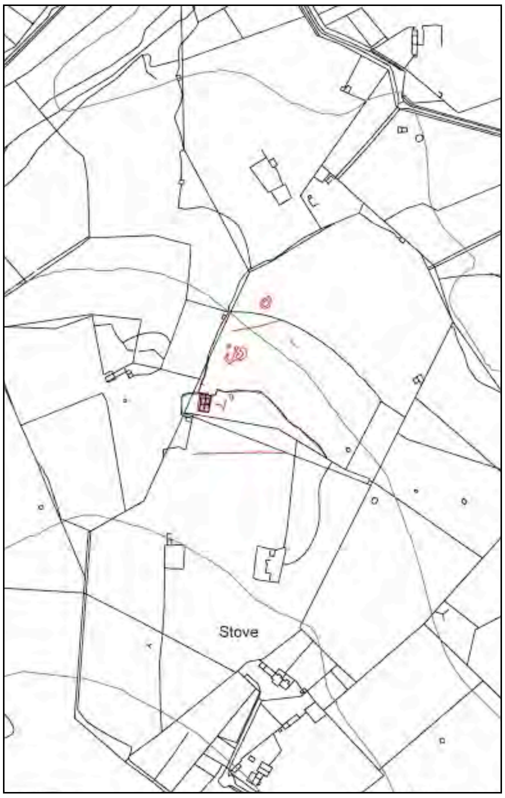


Fig 3.23a Stove survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.23b Stove survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

Overlaying the survey plan on the First Edition (1878) Ordnance Survey map shows the Norse longhouse at Stove located just inside the northwest boundary of the township of Stove. The original township boundary followed and incorporated the western edge of the yard boundary, which now survives as a ruinous coursed dyke, and is therefore atypical of other township boundaries. The northernmost, and most prominent, length of the infield boundary is depicted on the First Edition map. The boundary has no obvious relationship with the pattern of land use contemporary with the map. The township was extended to the northwest prior to 1878, incorporating Watquey and Brecken.

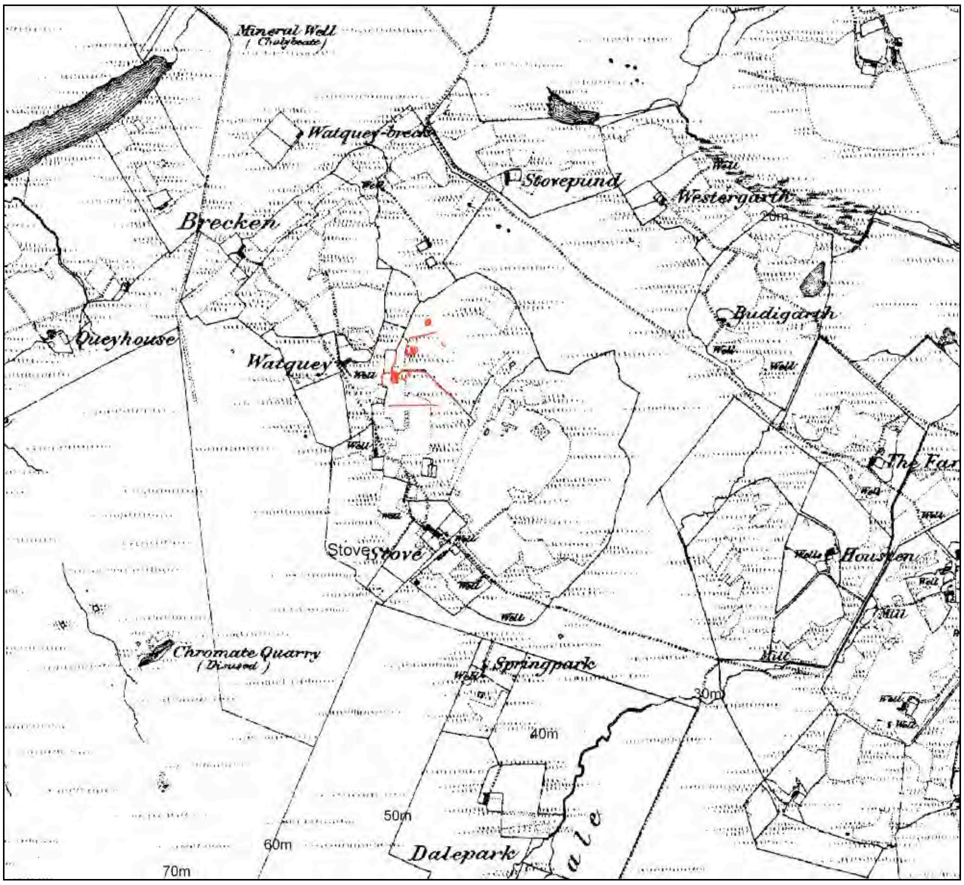


Fig 3.23c Stove, First Edition (1878) Ordnance Survey map

Watlie (HP 596 052, Watlie, Unst)

Shetland SMR: 3467

Height AOD:18-54m

Solid geology: Serpentinite/Pelitic schist

Drift geology: Glacial deposits (mostly till, formerly covered by peat)

Local aspect: Northwest

The longhouse at Watlie lies in damp, peat-covered, acidic grassland which includes patches of sphagnum. The longhouse is aligned downslope; an additional area of higher ground to the southwest might conceal the remains of one or more side rooms. The longhouse has two yards, one on each side of the longhouse. The smaller yard, to the north, is clearly defined. The yard to the south comprises a lynchet at the foot of outcropping bedrock to the east and a boundary which is also part of the infield dyke to the south. The township dyke continues to the southwest and probably defines part of the boundary of the infield. The infield boundary on the north side is more fragmentary. Other lengths of boundary in the area might be associated with the croft remains to the north of the site. There are several mounds in the area, one of which (north of the longhouse) is heel-shaped indicating that it is likely to be Late Neolithic/Early Bronze Age in date, whether domestic or funerary. Another mound, situated along a boundary southwest of the longhouse, is a stone setting which resembles a Viking grave, although it may be a boundary feature. West of and just above the longhouse are the remains of a stone structure, possibly a cook house or outhouse associated with the longhouse, later reused as a plantiecrub. At the edge of the loch there are two boat noosts: that beside the water's edge is stone lined; the second, a winter noost, is situated above the high water mark.

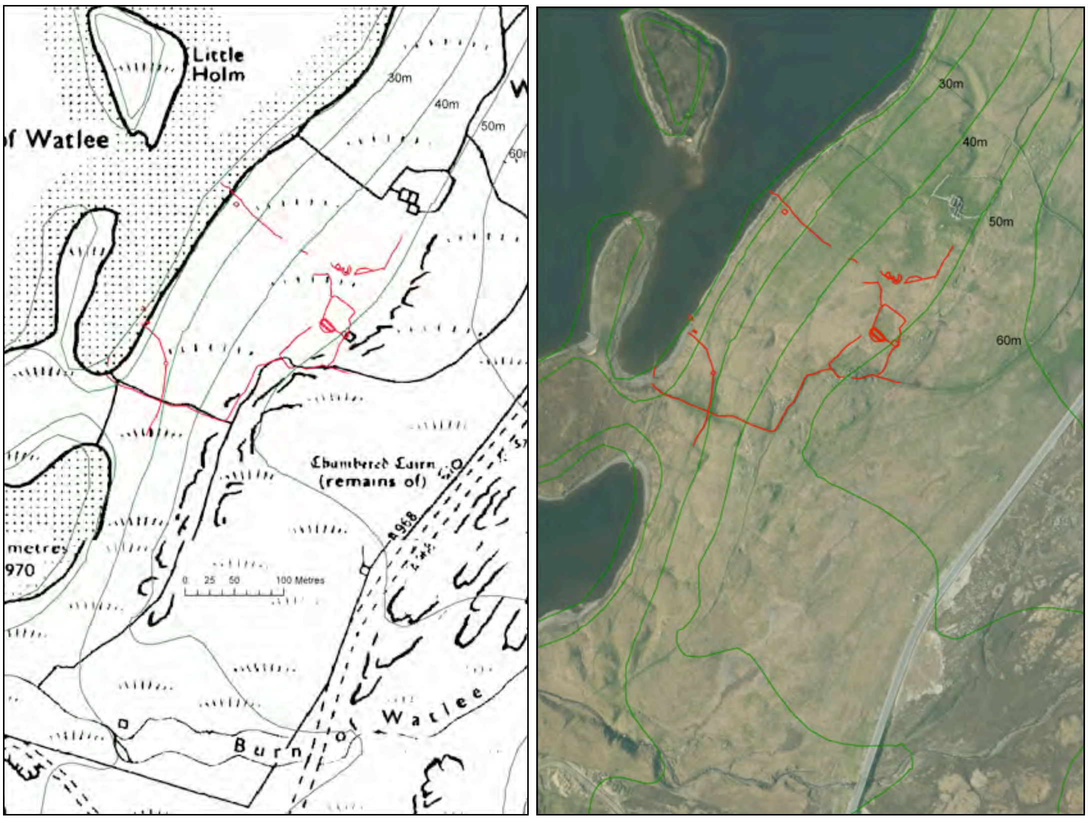
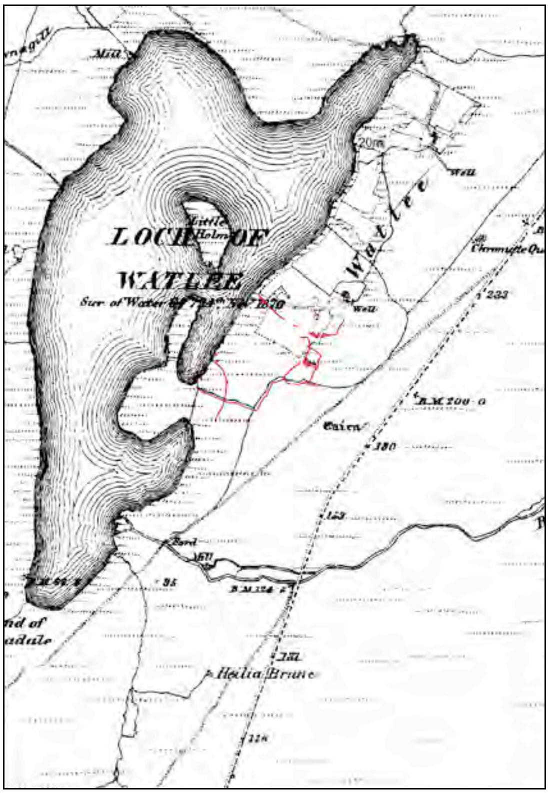


Fig 3.24a Watlie survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service).
Fig 3.24b Watlie survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

The Norse site at Watlie falls within the boundary of what is either a small township, or single croft, of Watlee and the two share a boundary on the south side. In the field the dyke appeared to "dogleg" to the west, ending at the loch: the map indicates that the township boundary continues further south. The return to the west is interpreted as the point at which the Norse remains and the township boundary diverge. However, the Second Edition (1900) map shows that the area of the Norse site was brought back into use within the 22 years between the two mapping exercises. Neither the yard, the longhouse nor the northern, more ephemeral, infield boundaries are depicted on either the First or Second Edition Ordnance Survey maps.



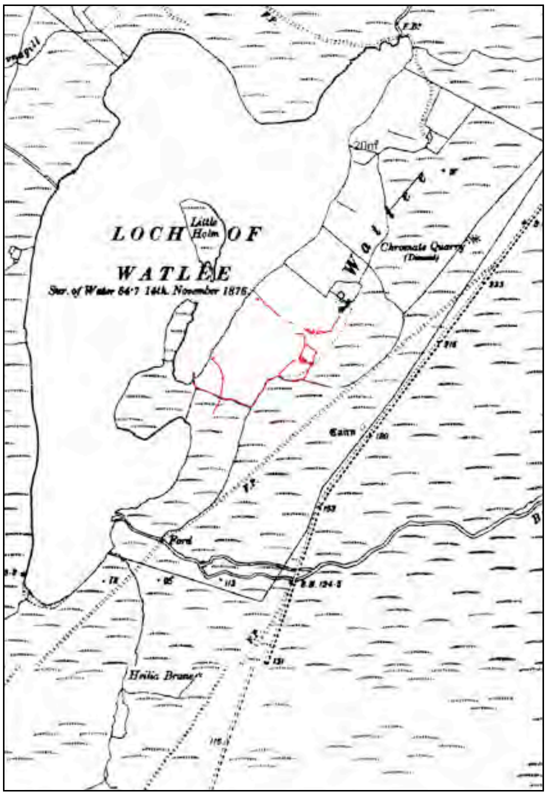


Fig 3.25c Watlie, First Edition (1878) Ordnance Survey map.
Fig 3.25b Watlie, Second Edition (1900) Ordnance Survey map

DISCUSSION OF RESULTS OF FIELD SURVEY

There are a number of new observations arising from the field survey alone. At the site specific level these include a previously unobserved Multiple Field System identified at Gallow Hill and the detail relating to most of the field systems. More significant are the new period-specific discoveries.

1. This survey is the first recorded observation of boundaries which appear to be non-defensive but have a direct relationship to Brochs. These have been recognised at three sites included in this chapter and Underhoull (Chapter 9).
2. The small rectilinear fields associated with the brochs at Sae Breck (and at Underhoull) which may have an Iron Age date, are also a new discovery for the Iron Age of the north and accord with Guttmann's suggestion for at least some Iron Age agriculture being carried out in garden plots (Guttmann, 2006) although not necessarily related to earlier middens.
3. The survey is the first time that yards associated with Viking/Norse buildings have been mapped in Shetland and comprises the first recorded observations for the survival of infield boundaries in the North Atlantic.

The results of the survey alone have therefore contribute to a greater understanding of how past peoples used the landscape of Shetland and demonstrate the value of adopting a landscape approach rather than a site focused one.

Chapter 4: Results and Discussion 2 – Place Analysis

Introduction

This chapter seeks to investigate the topographical and spatial relationships of the sites in this study through time. It follows up attributes of sites recorded in the previous chapter (3): geology, height above Ordnance Datum (AOD) and aspect. Aspect has a relationship to the amount of sun and therefore warmth which the land receives and this explored further using GIS Spatial Analysis. The study also investigates site alignment. Viewsheds are considered using GIS. The results of this chapter will demonstrate which, if any, of these spatial considerations appear to be significant in the choice of settlement site and if so, when and why.

GEOLOGY

The six Homestead Enclosures in the study are located on three different solid geology types. Three (Hill of the Taing, Houlland and Vassa) are on calc schist, which could potentially produce a reasonable agricultural soil. Exnaboe was situated favourably: at the junction of fish beds, which would have added some phosphate and therefore added a degree of fertility to the soil, and flaggy sandstone, which although soft, is good building stone. Croag Lea, however, is situated on granitic gneiss which would produce a thin, stony, acidic soil. The drift geology may have counteracted this, as it includes till and moraine. Granitic gneiss may have provided good building stone, dependant on localised jointing. South Newing is also on granitic gneiss, but a limestone band runs through the area and the drift geology includes lake alluvium: both of which could have contributed to the fertility of the area. All six sites therefore had agricultural potential, particularly if the soils were amended in order to maintain and enhance fertility and geology may have influenced location. This is not immediately apparent from the condition of their soils in these areas today.

Four of the six Multiple Field Systems are located on the West Side of Shetland, situated on Old Red Sandstone. Soils derived from sandstone are likely to be free draining, less prone to water-logging and easily worked, but nutrients could leach rapidly, requiring soil fertility to be maintained. Today these sites are all in acidic, peaty, land. The drift geology is mapped as "peat and/or bedrock at or near the surface" (1:50,000 Ordnance Survey Geological Maps, sheets 127 & 128 Drift Edition) and as such does not contribute much additional nutrition. However, if managed, these soils could have been productive and the longevity of use identified by Whittle at the Scord of Brouster indicates that they were (Romans, 1986; Whittle, 1986). Work on the soils at Old Scatness (e.g. Guttmann *et al*, 2008; Turner *et al*, 2010; Turner *et al*, in press) demonstrates that Old Red Sandstone, which produces quartz sands, can provide a foundation for productive soils. The Sumburgh Head site is located on fish beds, close to flaggy sandstone. As at Exnaboe, the fish beds would have provided a degree of natural fertility, whilst the nearby sandstone provided good building stone. Clevigarth is also situated on sandstone: at the edge of a boulder strewn cliff, testament to the power of the sea which would also have enhanced the calcium content of the soil through spray. The correlation between the Multiple Field Systems and sandstone suggests that Neolithic/Bronze Age people enhanced the soils, making them productive. This will be tested by soil micromorphology, which has the potential to demonstrate anthropogenic activity in the context of natural pedogenic and sedimentary processes (Dockrill and Simpson, 1994). Archaeologists are just beginning to understand the importance of the sandstone in the West Mainland and siltstone in the South Mainland to the manufacture of the stone tools (e.g. ard points, spades) found in abundance at the Scord of Brouster (Whittle, 1986). Shallow quarry pits and associated chipping floors have recently been identified both at Sumburgh Head (Turner, in prep.) and in the hill in the West Mainland (observation by Turner and Cowley). The accessibility of stone for tools would be important to the economy of the Multiple Field System settlements. The hinterland may have been as important to the economy of the sites as the cultivated land itself. Geology may therefore have influenced the location of successful field systems in ways which were only indirectly related to soil productivity.

Of the Broch sites Clevigarth is situated on sandstone and Sae Breck is on Old Red Sandstone/tuff, described as "massive and blocky" (Ordnance Survey 1:50,000 Geological Survey). The Broch builders were selective about the stone they used, particularly for the foundations: sandstone is soft and crumbles under pressure. The Broch at Tumblin is situated on the boundary of granitic gneiss with serpentinite. The granitic gneiss may have provided good building stone, dependent on the jointing, and the serpentinite would have produced good soil. Two additional Broch sites will be considered later in this study: Old Scatness which is on Old Red Sandstone, and Underhoull which is on psammite (metamorphosed sandstone). Psammite splits easily into parallel sided blocks which would be good for building. The soil at Underhoull was modified by the glacial till which contained serpentinite, making it more basic and less acidic. Fojut (1983; 2005: 149) observed that all the (then known) brochs were built on the 50% of Shetland which had good building stone in the vicinity. He suggested that this was because "good building stone breaks down into more satisfactory parent material for soil". Fojut studied brochs in terms of the resources of their hinterland; however, of all the field systems, broch fields are the least likely to be subsistence driven, broch locations being determined by more complex forces (for a flavour of the debate see Turner *et al.,* 2005). Some brochs, e.g. Old Scatness, clearly produced agricultural surpluses for trade (Dockrill *et al.*, 2004) whereas others are located in areas of limited agricultural potential and factors such as sight lines and intervisibility, appear to be of greater significance than economic considerations (B. Smith and G. Johnston, in progress).

The five principal Norse sites in the survey are located in Unst, where there is the greatest density of rural Norse farms anywhere (including Scandinavia). The best surviving examples, all situated on serpentinite, are possibly in the more fertile areas. In order to determine whether geology is a significant factor in determining site location, all the potential longhouse sites currently known in Unst have been plotted over a map of Unst geology (Shetland SMR, 2012; British Geological Survey, EDINA 2012).

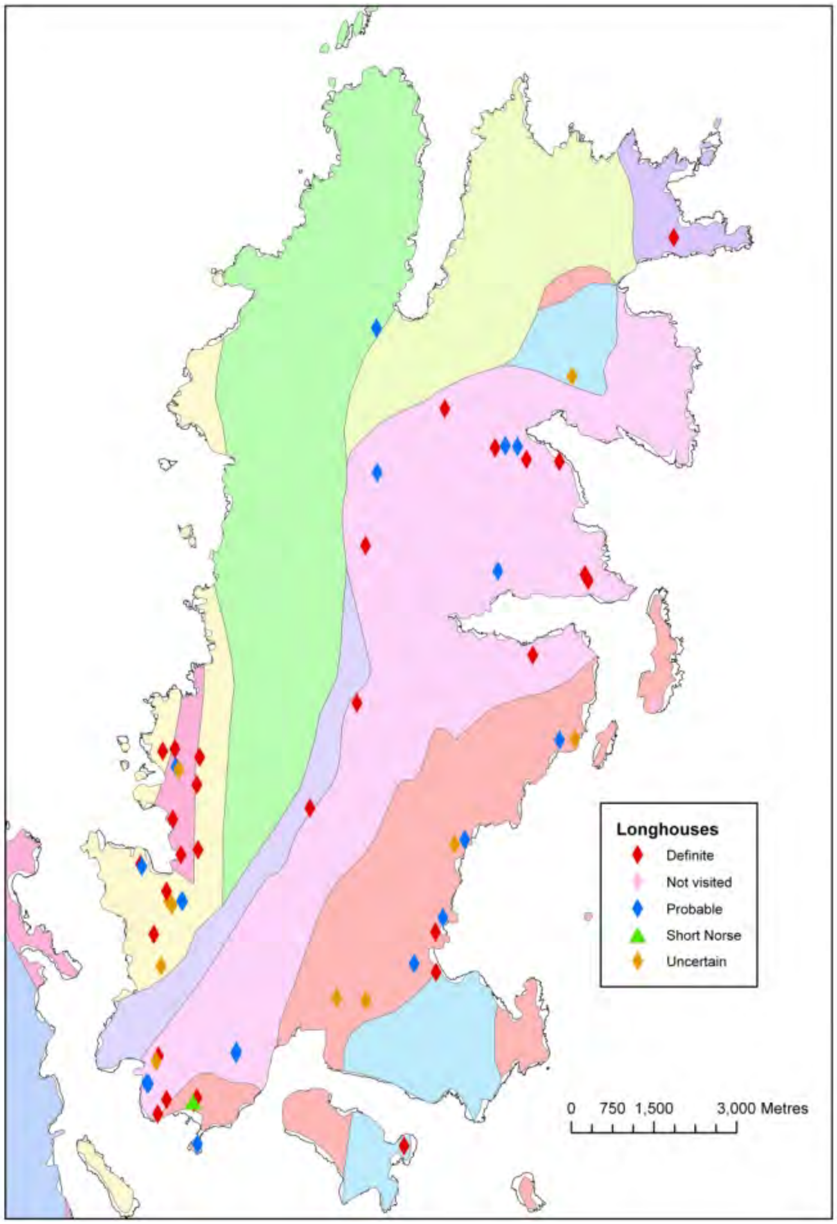


Fig 4.1 Unst longhouses and their relationship to the solid geology of Unst (British Geological Survey © Crown Copyright/EDINA right 2010. An EDINA supplied service).

Key, left-right: yellow, pelitic, calcareous and horneblende gneiss including limestone rich in calc and silicate; bright pink, schist, gneiss, phyllite; green, permeation gneiss (biotite, horneblende, schist, staurolite-kyanite-garnet gneiss; light purple, schistose sillimanite-kyanite-staurolite-chloritoid-garnet pelite with quartzite bands and horneblende schist; pink, serpentenitite; brown, greenstone; blue, pyllite; purple (north) granite.

This demonstrates that the surviving longhouses cluster in groups, avoiding the Vallafield permeation gneiss and the Saxa Vord schists and flags which form the highest parts of the island. These higher areas have glaciolacustrine delta drift: the lower land is covered with glacial drift (British Geological Survey 1:50,000 Geology Series). The majority of the longhouses are located in coastal locations, however there are notable exceptions, including Watlie which is situated beside a loch. The greatest density of longhouses is in the southwest (14 definite, 5 probable, 4 uncertain) which corresponds with the area where the coast is sheltered by the island of Yell. Belmont, Underhoull and Quoy all lie within this area. The rest of Unst is more exposed, which may have been a factor in favour of southwest Unst.

Excavation at Belmont has demonstrated that the manufacture of steatite objects was very important to the economy of that particular upland farm, where the land quality is today poor. Soapstone outcrops, now completely worked out, occur immediately east of the site, and may have sustained a long-lived Norse farm in a marginal location, outside the later township boundary (Larsen *et al.,* 2004).

HEIGHT ABOVE ORDNANCE DATUM

The height above Ordnance Datum (AOD) may have influenced field system locations since altitude potentially impacts on climate and the length of the growing season. The altitude of the Enclosures range between Vassa (3-13m AOD) to Croag Lea (38-42m AOD). The Multiple Field Systems have an even wider range: Pinhoulland starts close to sea level (3m AOD) but the core area of the site rises to 39m AOD. Clevigarth is set at the edge of the cliff, and is on the flattest land of any of the sites (13-21m AOD, including the rise on which the broch is located) while the field systems at Gallow Hill and the Scord of Brouster rise to heights of 50 and 51m AOD respectively. Broch builders generally selected high points

(Tumblin, 84m AOD; Sae Breck 61m AOD): it appears more significant that brochs were locally prominent with good inter-visibility. Clevigarth, is situated at the cliff edge, on a low rise, at 21m AOD, Old Scatness is 10m AOD. The altitudes of the Norse fields vary considerably: Belmont has the widest range, with the infields enclosing sloping ground between 10-50m AOD. The placement of elements in the Norse field systems is not consistent. With the exception of Eastshore, a long wall of the longhouse is incorporated into the yard boundary; part of the yard boundary is also shared with the infield. At Gardie and Watlie the infield is situated below the longhouse and yard, whereas at Stove and Belmont the infield is situated above the yard and longhouse. The heights of the longhouses themselves range between Eastshore at 5m AOD to Quoy and Upper Hamar, at 50m and 55m AOD respectively. Whilst height may be an advantage in the location of brochs, height alone does not appear to determine the location of any of the categories of field system under consideration.

It is generally believed that the upland sites were inhabited at times when the climate was better, combined with pressure on the amount of land available. Whittle (1989) argues that increasing peat-growth was a major factor in the abandonment of the Scord of Brouster and might have been climatically induced. Rising sea level and encroaching upland peat would have increased the pressure on the land (Fojut 1993: 32-33). Changes in the climate in Greenland have been identified from the Greenland ice-cores. These indicate that the climate there improved steadily between 650-1425AD, then became increasingly stormy (Dugmore *et al.,* 2006). This is consistent with changes inferred from Faroese palaeo-environmental cores and fits with the Norse pattern of land use visible in Shetland. Of the Norse sites in the study, Gardie, Quoy, Eastshore and Stove are situated on land which is currently enclosed, although at Gardie the infield land is very poor quality (thin, wet and peaty); Watlie is on rough grazings; and Hamar and Belmont both lie outside the post-medieval enclosed townships.

Complex societies are thought to have some resilience to inter-annual or even inter-decadal climatic variation, but will demonstrate a variety of responses to stresses which occur over multiple decades and centuries. This may result in collapse, migration or adapting to subsistence (de Menocal, 2001). A community might be able to withstand the occasional bad year by broadening their resource base and falling back on seafood, but constantly declining yields must eventually lead to abandonment.

SITE ALIGNMENT

The Homestead Enclosures are small and sub-circular and therefore have no alignment. The field boundaries associated with brochs broadly follow contours. The Norse sites differ from one to another: the Gardie and Stove yards and infields, and the Hamar and Watlie yards, are aligned along the slope. All the Belmont fields and the Watlie infields are aligned down the slope.

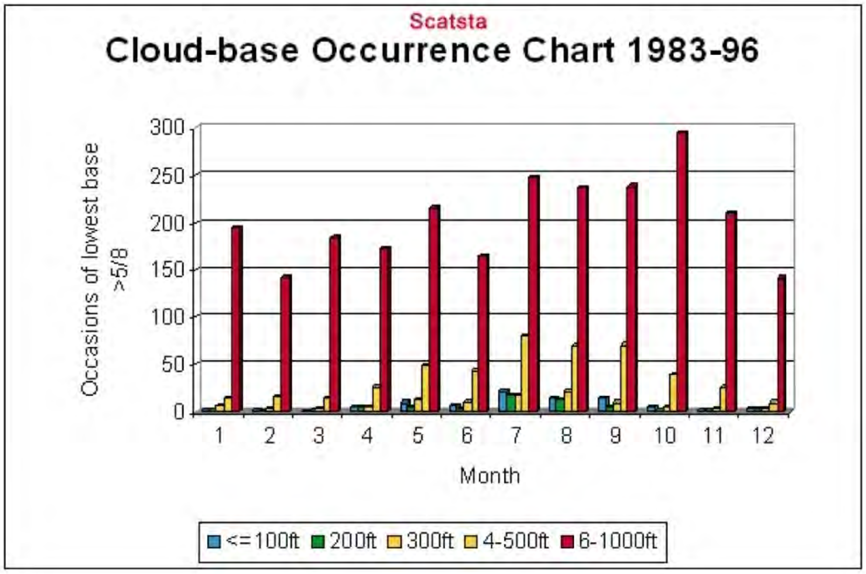
In contrast, the Multiple Field Systems are elongated with identifiable alignments, both individually and as an aggregate. Five of the six field systems are clearly aligned along the slope. The steepness and extent of slope vary in each case: Clevigarth is almost flat, with a maximum height difference of 7m across the site; the Scord of Brouster has a height difference of 24m across the width of the site although in the field, it appears relatively flat. At Sumburgh Head, the field system has a strong relationship with the contours, following the curvature of the hill. The height differences at Gallow Hill, the Ness of Gruting and the core of the field system at Sumburgh Head, are 15m across the widths of the field systems. At Gallow Hill, the field system is located on flatter land than that immediately below it. Pinhoulland is the exception, but even here the compact central area of the Multiple Field System has a similar height range, fits the same pattern and, locally, the individual fields are relatively flat. At Pinhoulland, the lower fields to the northeast extend down-slope to 3m AOD and alter the overall alignment of the site. These fields, which are detached from the core area, were omitted from Whittle's survey (1986:4).

If the Multiple Field Systems accreted over time rather than being created as a single event, it appears that as a Multiple Field System expanded, or the focus relocated, it incorporated land at a similar height, along the slope, rather than above or below. This is consistent with the excavated evidence from the Scord of Brouster (Whittle, 1986), where the earliest and second house sites both lie on the 40m contour. The final house at the Scord of Brouster was located slightly lower down-slope. Whether lower lying land was in use when the Multiple Field Systems were established (thereby preventing a downward expansion) or whether expansion along the slope was a positive choice, cannot be determined with certainty. Individual fields would be easier to work if they were aligned along the slope, particularly if they were being ploughed. Cultivation down the slope would exacerbate the migration of soil down the hill. At Sumburgh Head, the land below the field system is significantly flatter and today appears more attractive for cultivation, suggesting that it was already occupied. Elsewhere, if the soils had good potential, and if the growing season was not significantly impaired by a slightly higher altitude, the acquisition of the flattest neighbouring land could have advantages over cultivating steeper, but lower, slopes.

Site Aspect/Sunshine

Aspect affects the amount of sun, and therefore warmth, which the land receives. A southerly aspect maximises the amount of sun, which could be significant to agriculture and may determine the viability of a site. The amount of sun which a field receives becomes increasingly significant with latitude. By the 17th century AD (and probably considerably before this) the Faroese had developed a system where strips three metres broad, known as "teigar", were usually half a metre higher on one long side than the other, in order to improve both drainage and to maximise the heat available from the sun (Arge, 2005: 29).

Shetland Mainland is divided E-W by a ridge of hills running N-S through the centre. Experience demonstrates that, today, the west of Shetland is sunnier than the east, which is more prone to fog. This is supported by Cloud-base Occurrence Data and Visibility Percentage Charts for Sumburgh 1986-1995 and Scatsta 1991-2000 (UK Met Office Data, 2010). Scatsta, North Mainland, has weather systems which are more akin to the west side of Shetland; Sumburgh Head shares its weather systems with the east (Dave Wheeler, North Isles Weather, pers. comm.). Five of the six Homestead Enclosures are in the east of Shetland, Croag Lea being the exception whereas four of the six Multiple Field Systems are located on the West Side, with two in the South Mainland. If the amount of sun, represented by a high cloud base and good visibility, followed a similar pattern in the prehistoric period as at present, this may have been a factor for the development of Multiple Field Systems on the West Side with undeveloped Homestead Enclosures located on the east. The tendency of the Enclosure sites to favour a southerly aspect might represent an attempt to compensate.



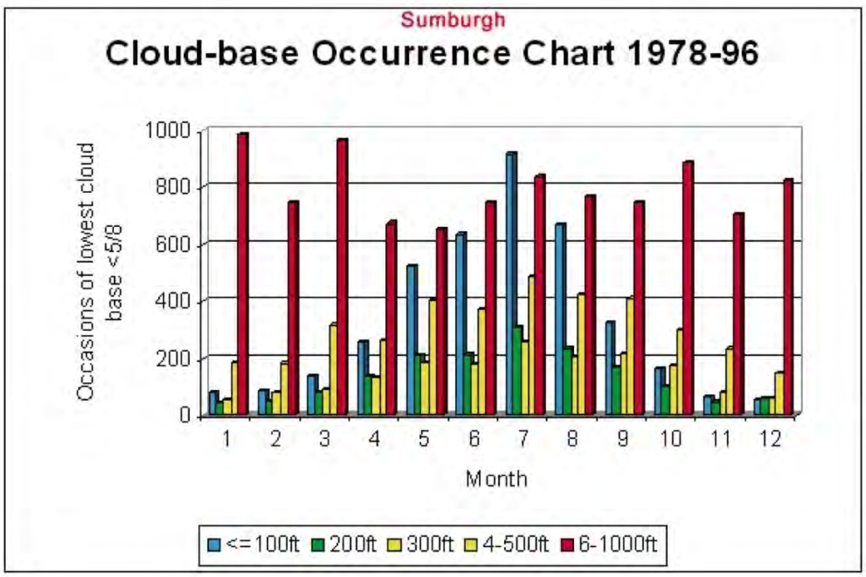
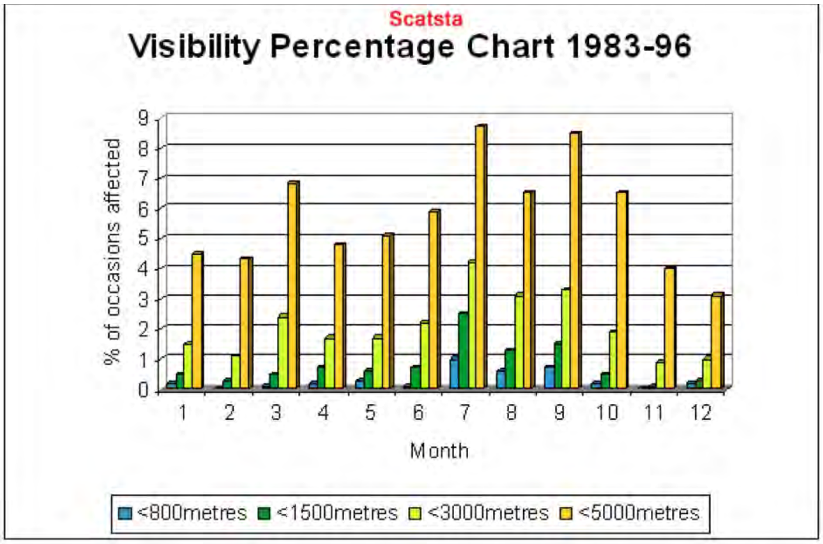


Fig. 4. 2a &b Cloud-base Occurrence Charts for Sumburgh and Scatsta (UK Met Office Data, 2010, courtesy of D. Wheeler, North Isles Weather). Note the greater number of occasions on which Sumburgh has a lower cloud-base than Scatsta.



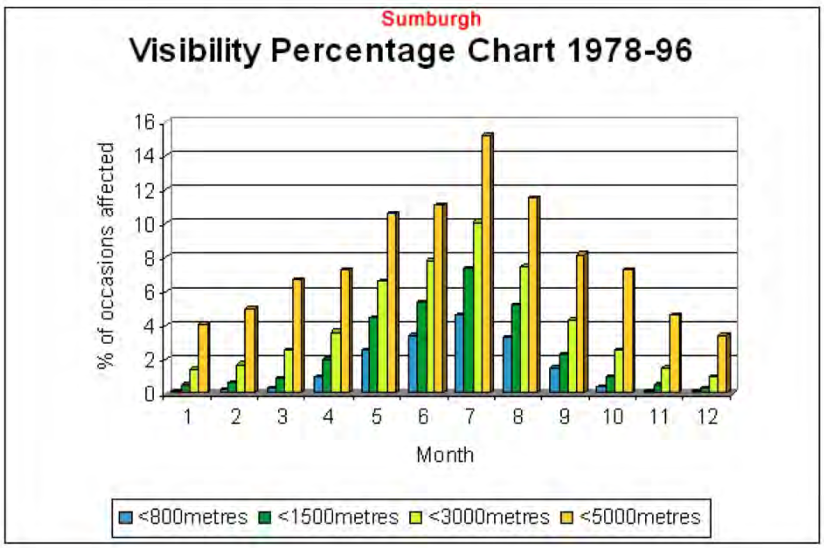


Fig. 4.3a & b. Visibility Percentage Charts for Sumburgh and Scatsta (UK Met Office Data, 2010, courtesy of D. Wheeler, North Isles Weather). Note the greater number of occasions on which Sumburgh has a lower visibility than Scatsta.

In order to test the degree to which there is an east/west divide between the locations of Enclosures and Multiple Field Systems throughout Shetland, all prehistoric house sites and field systems recorded on the Sites and Monuments Record have been mapped. Where the SMR record was ambiguous, this was resolved with reference to vertical aerial photographs. The results demonstrate a clear concentration of Multiple Field Systems located in the west of Shetland, particularly on the West Side, where recent field work

(Cowley *et al.,* RCAHMS, pers. comm.) suggests this is likely to be an under-recording. The examples to the south and east either correspond with areas which are today still fertile (e.g. Fetlar and Whalsay) or are located in the South Mainland. They are largely coastal and most are close to stretches of water which face south. Sunlight reflected from the sea would have a localised impact in increasing temperature. In contrast, the single house sites, with or without surviving Enclosures around them, occur more uniformly throughout Shetland. The amount of sun received at the macro level therefore appears to have been a significant in determining which Enclosure sites developed into Multiple Field Systems, the local aspect being important.

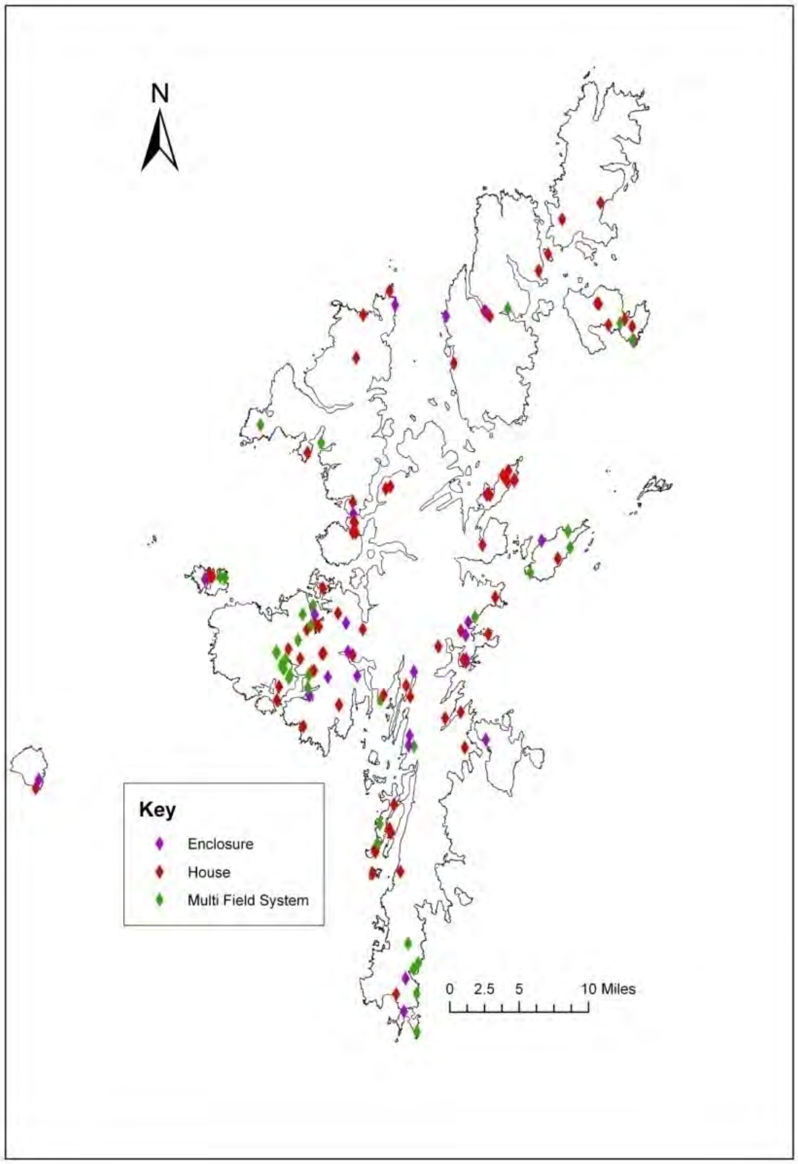


Fig 4.4 Locations of Houses, Enclosures and Multiple Field Systems recorded in Shetland. (Data taken from Shetland Sites and Monuments Record, Shetland Amenity Trust)

In Shetland today, the prevailing wind comes is west-southeast (Windroses for Sumburgh 1986-1995; and Scatsta 1991-2000, UK Met Office Data, 2010). This might suggest that shelter from the west and south would be desirable. It was therefore not possible to use aspect to protect a field system from the wind and maximise the benefits of facing the sun at the same time. Neolithic/Bronze Age field systems show that facing the sun was more important than protection from the prevailing wind: in spite of the wind chill factor, it would be easier to mitigate for wind at the local level than to compensate for the loss of warmth from the sun.

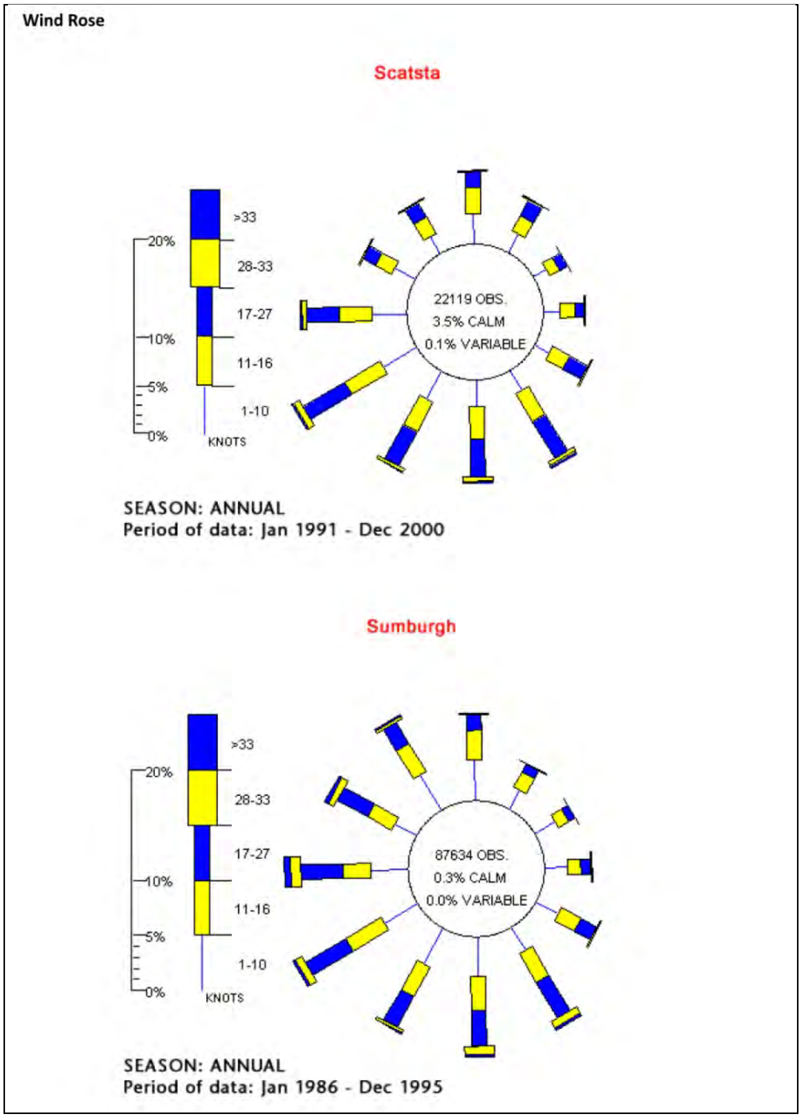


Fig. 4.5 Windroses for Sumburgh and Scatsta (UK Met Office Data, 2010, courtesy of D. Wheeler, North Isles Weather). The prevailing direction of wind is broadly consistent, although Scatsta is rather more sheltered to the northwest and experiences slightly (3.2%) calmer weather than Sumburgh.

The aspect of the sites in the study was considered in two ways: field observation and GIS. The two methods have returned different results (table 4.1), largely because GIS Spatial Analyst relies on the underlying mapping, in this case Ordnance Survey profile 1:10,000, where each pixel represents 10m²; the field observations were more localised. An extreme example of the difference can be seen at Houlland, where the Homestead Enclosure is situated within a bowl in the hill which slopes gently to the north, resulting in a field observation of north, although the general trend of the hillslope in the area is south/southwest: the result returned by GIS mapping.

Table 4.1 Aspects derived from GIS and from Field Observation

Field System	*GIS Aspect*	*Field Observation*
Croag Lea	SW/W	SE
Exnaboe	SE	SE
Hill of the Taing	S/SW	E
Houlland	S/SW	N
S Newing	S/SW	SSE
Vassa	W	S
Scord of Brouster	SW	SW/E
Clevigarth	SE	E
Gallow Hill	N/NE	SE
Gruting	SE/SW	SE
Pinhoulland	NE/E	NE
Sumburgh	W	W
Belmont	NW	W
Eastshore	S	NE
Gardie	S/SW	NE
Hamar	S/SW	S
Quoy	NW	NW
Stove	N/NE	S
Underhoull	S/SW	SW
Watlie	NW	NW

Other than Houlland, the Enclosure sites have a localised site aspect of between south and east: the general trend shown by the GIS is south-west other than at Exnaboe. Three of the Multiple Field Systems share similar localised aspects: two sites face southeast, one faces southwest/east; the others face east, northeast and west. The brochs occur on high points and neither Sae Breck nor Tumblin has a clear aspect. The aspects of the Norse sites have the least consistent direction of aspect. Of all the sites, the Enclosures show the strongest preference for sun: this does not appear to have been significant to either the Broch or Norse field systems.

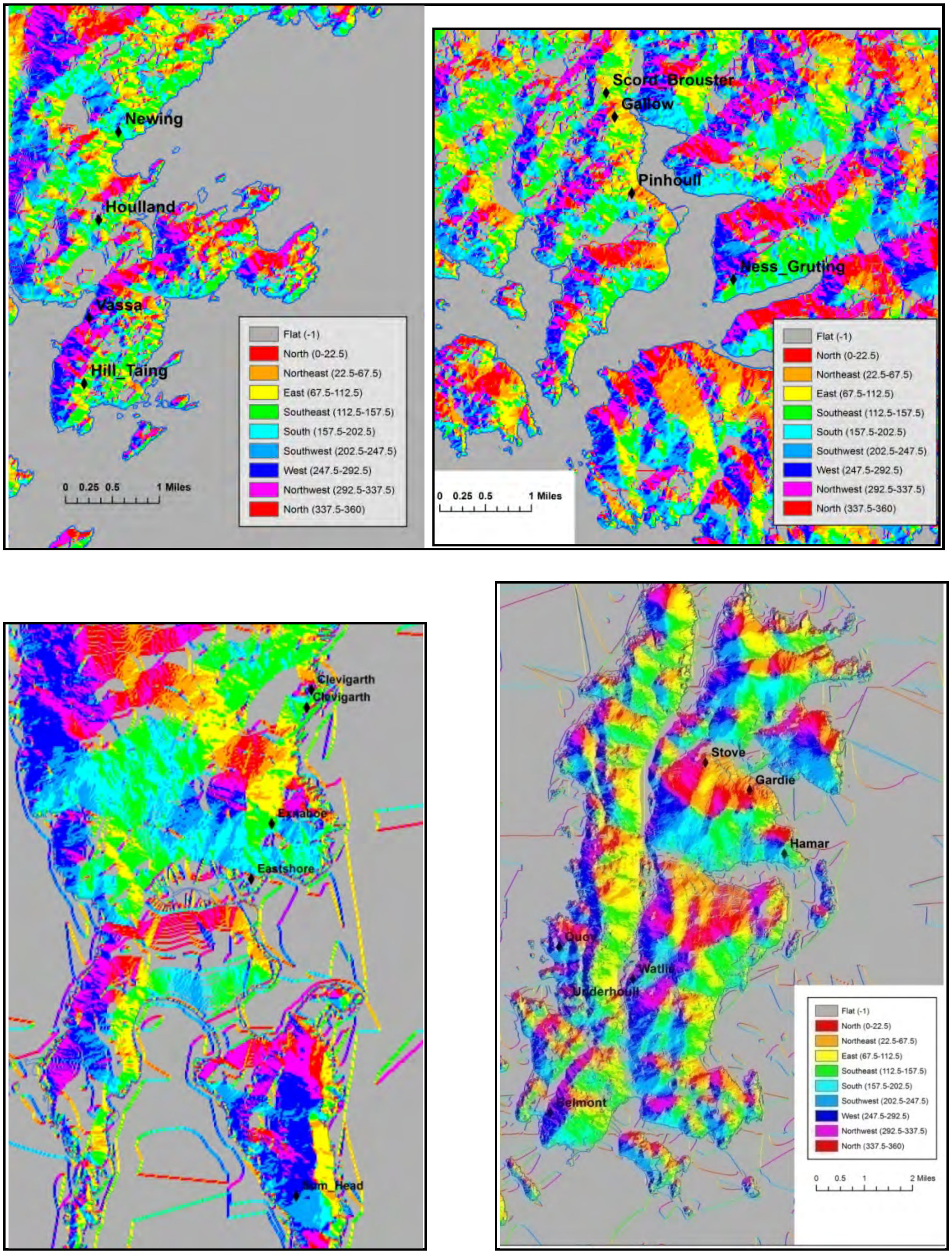


Fig 4.6 Aspects of Field Systems derived from GIS: a. East Mainland, b. West Side c. South Mainland , d. Unst.

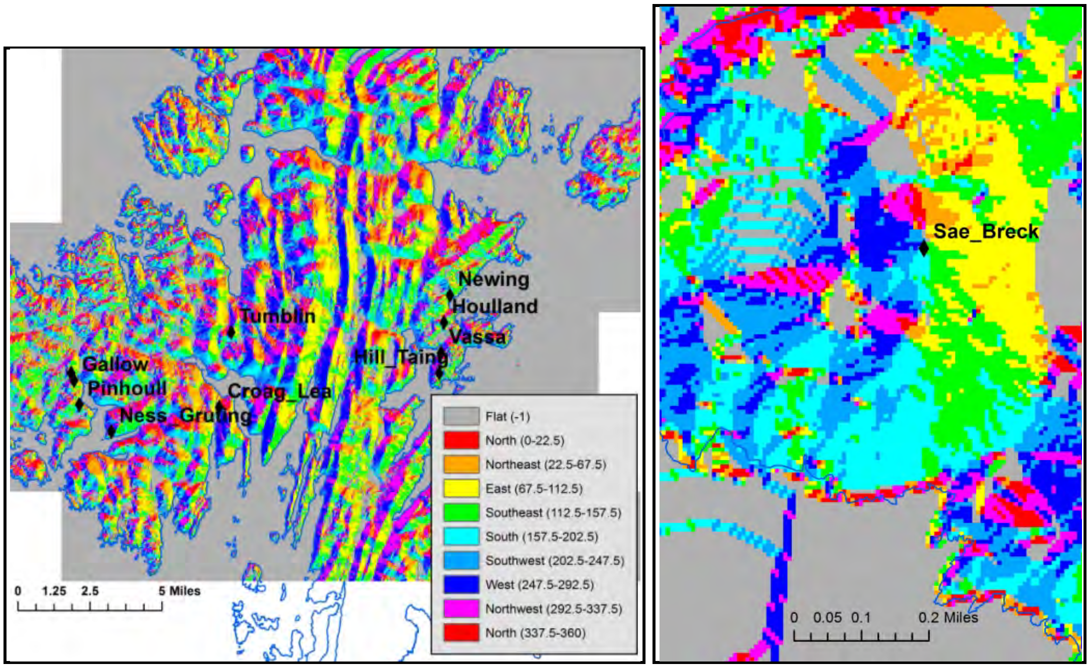


Fig 4.6 Aspects of Field Systems derived from GIS: f. Central Mainland showing strong north-south topographical alignment; g. Sae Breck, North Mainland.

VIEWSHEDS

It is increasingly being observed that Shetland brochs have intervisible lines of sight, sometimes being placed very carefully in order to secure views of brochs at considerable distances (Smith and Johnson, work in progress; Turner and Fojut, in press). This is generally accepted as being for defensive purposes. Whether viewsheds have significance for other classes of site has not previously been investigated in Shetland, and has rarely been considered more widely. Viewsheds would be affected by other "obstacles" in the landscape: woodland in particular would impair visibility. It is possible that good sight lines might explain the choice of high altitudes of some field systems. The Spatial Analyst function of GIS facilitates the creation of maps displaying viewsheds.

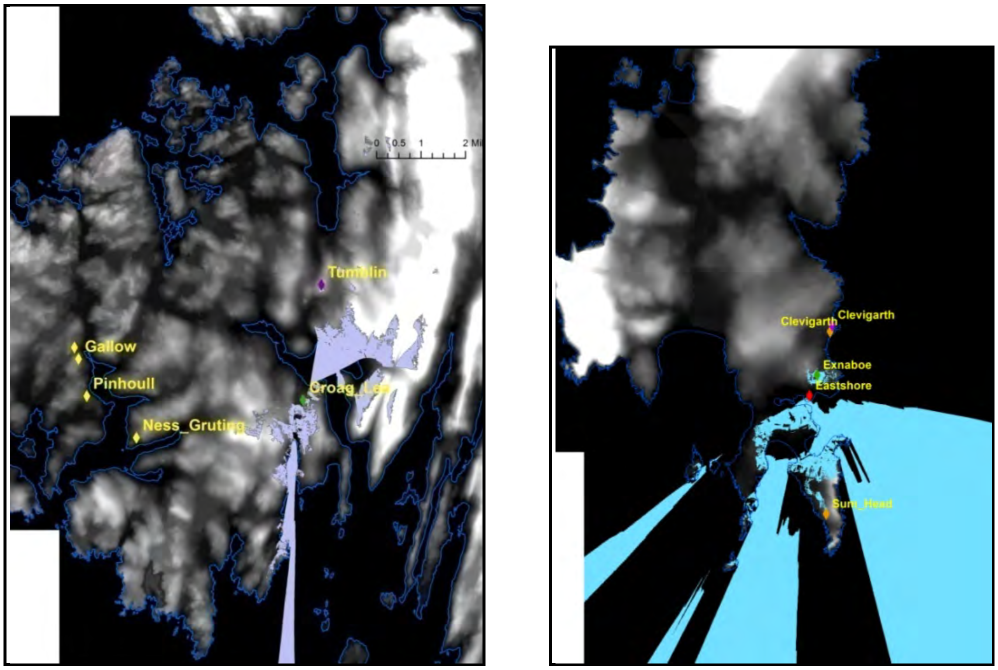


Fig 4.7 Viewsheds from Homestead Enclosures at: a. Croag Lea, b. Exnaboe (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

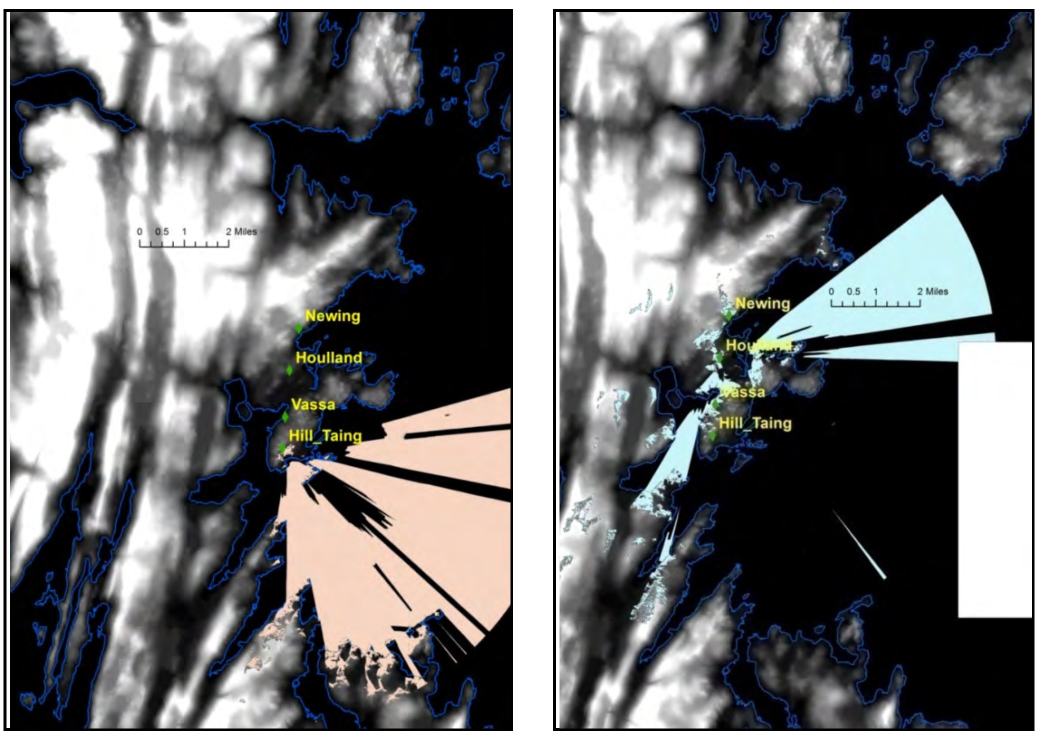


Fig 4.7 Viewsheds from Homestead Enclosures at: c. Hill of the Taing, d. Houlland (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

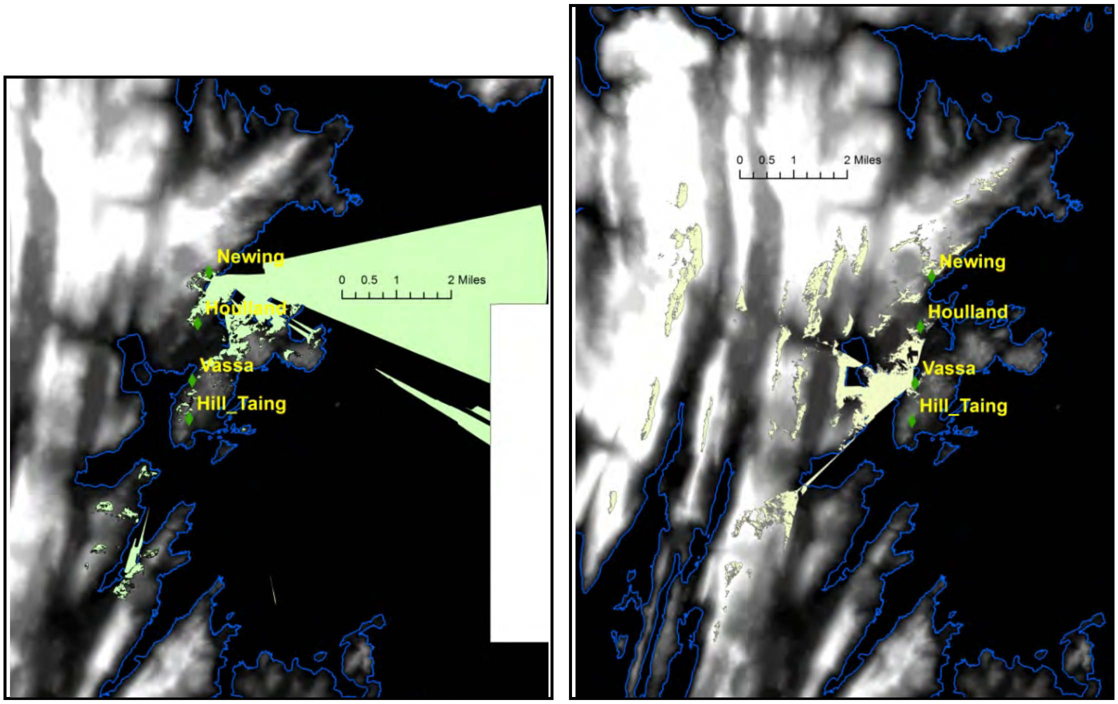


Fig 4.7 Viewsheds from Homestead Enclosures at: e. South Newing, f. Vassa (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

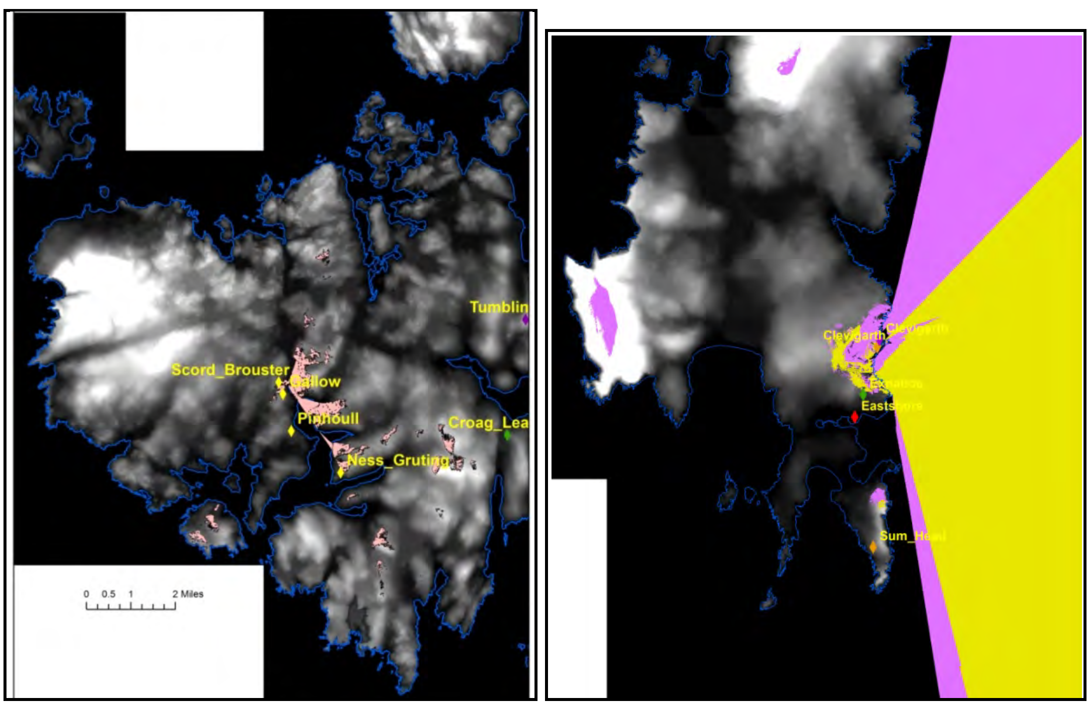


Fig 4.8 Viewsheds from Multiple Field Systems at: a. Scord of Brouster, b. Clevigarth – yellow (purple is the broch viewshed) (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

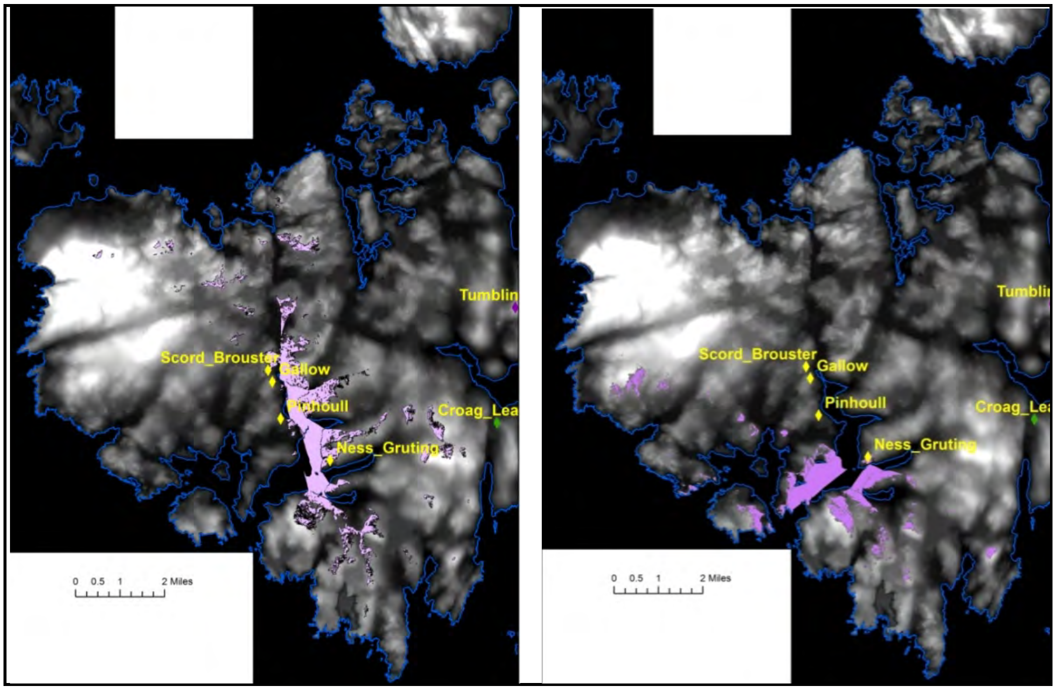


Fig 4.8 Viewsheds from Multiple Field Systems at: e. Gallow Hill, d. Ness of Gruting (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

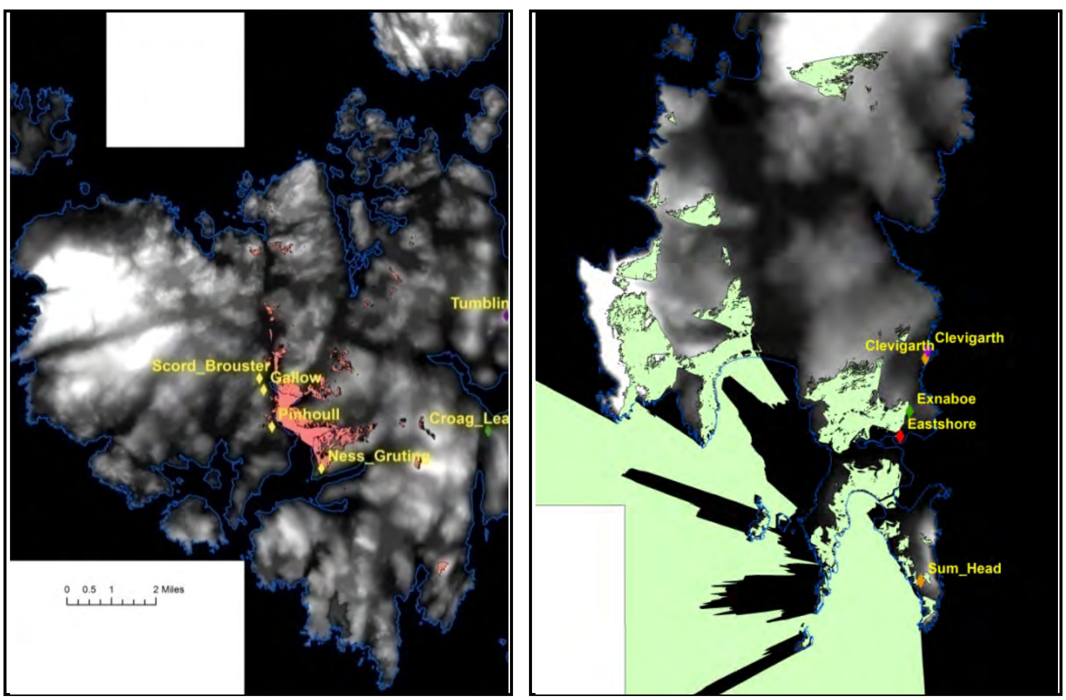


Fig 4.8 Viewsheds from Multiple Field Systems at: e. Pinhoulland, f. Sumburgh Head (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

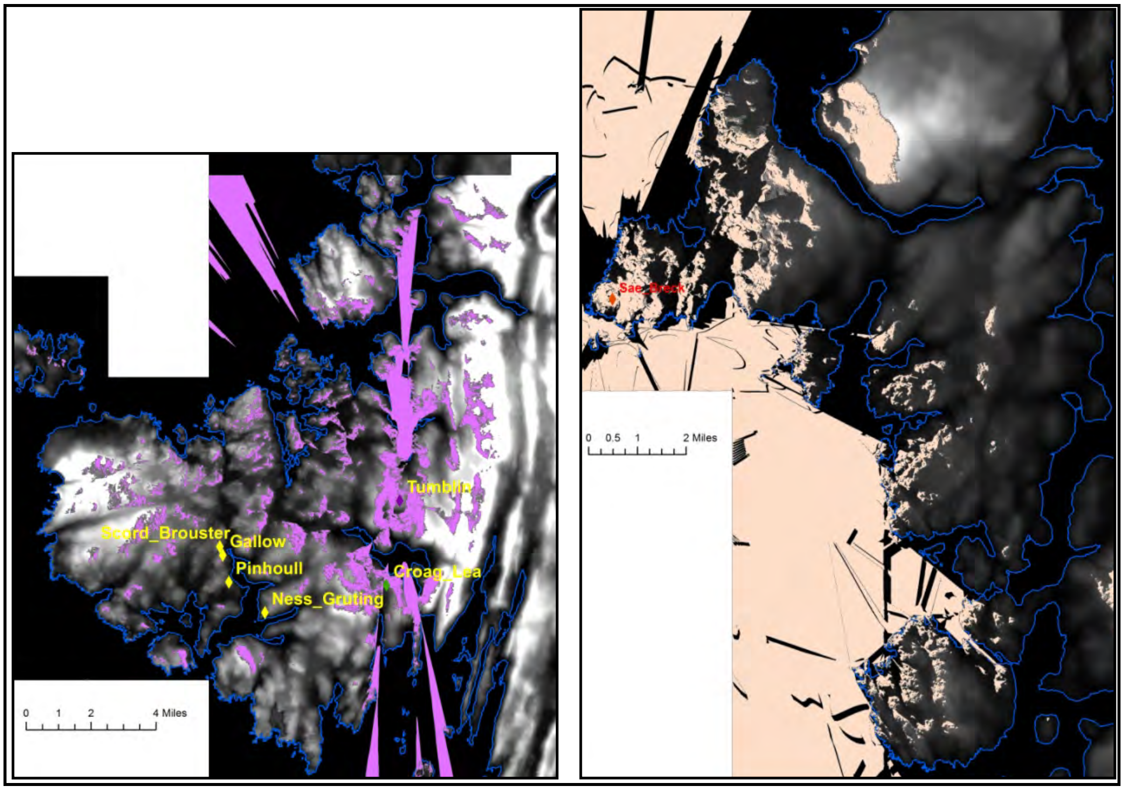


Fig 4.9 Viewsheds from Brochs: a. Tumblin, b. Sae Breck (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

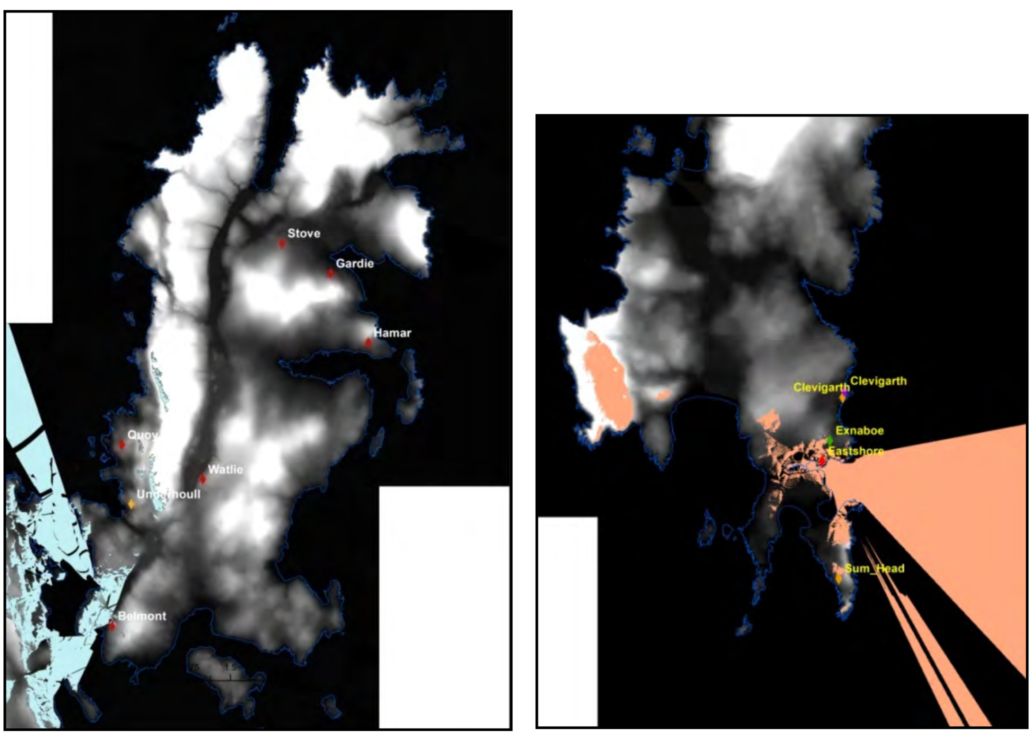


Fig 4.10 Viewsheds from Norse sites at: a. Belmont, b. Eastshore (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

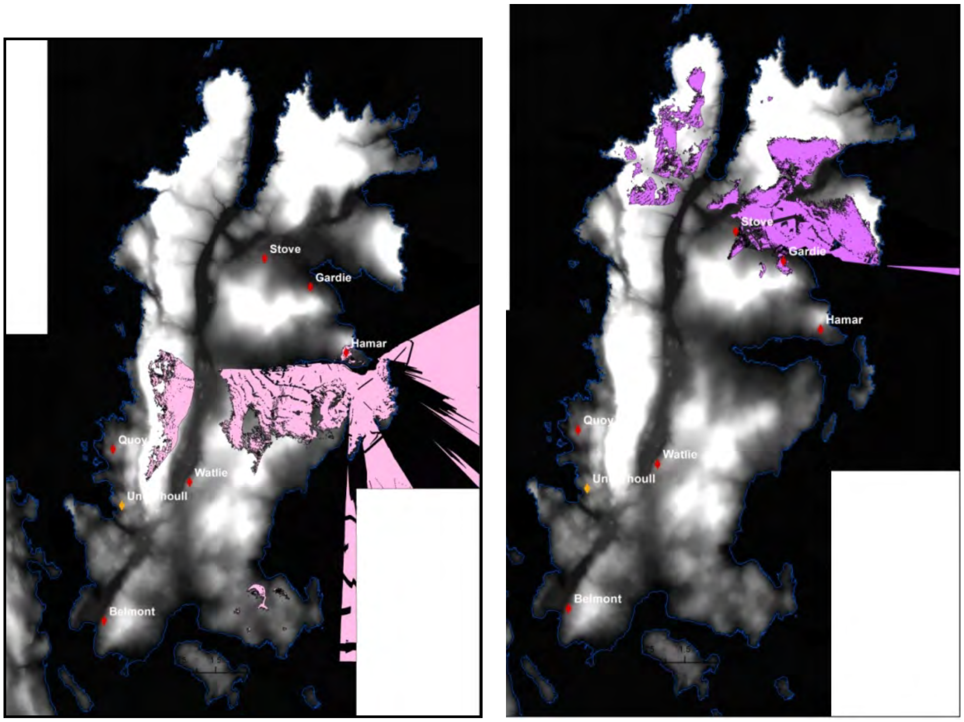


Fig 4.10 Viewsheds from Norse sites at: c. Hamar, d. Gardie (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

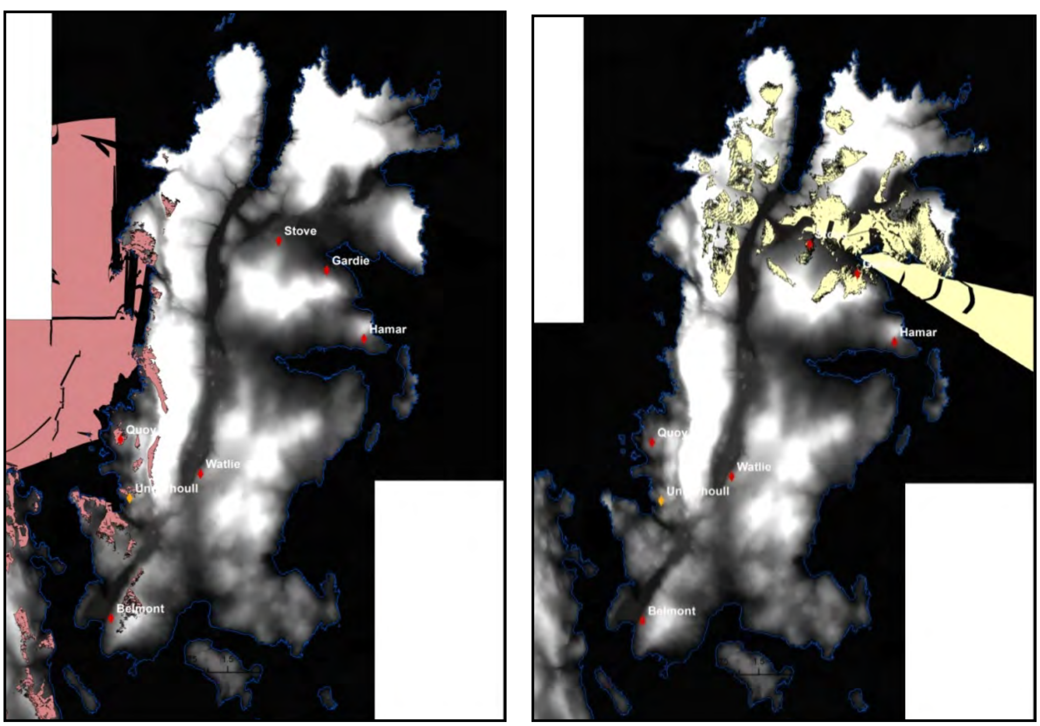


Fig 4.10 Viewsheds from Norse sites at: e. Quoy, f. Stove (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

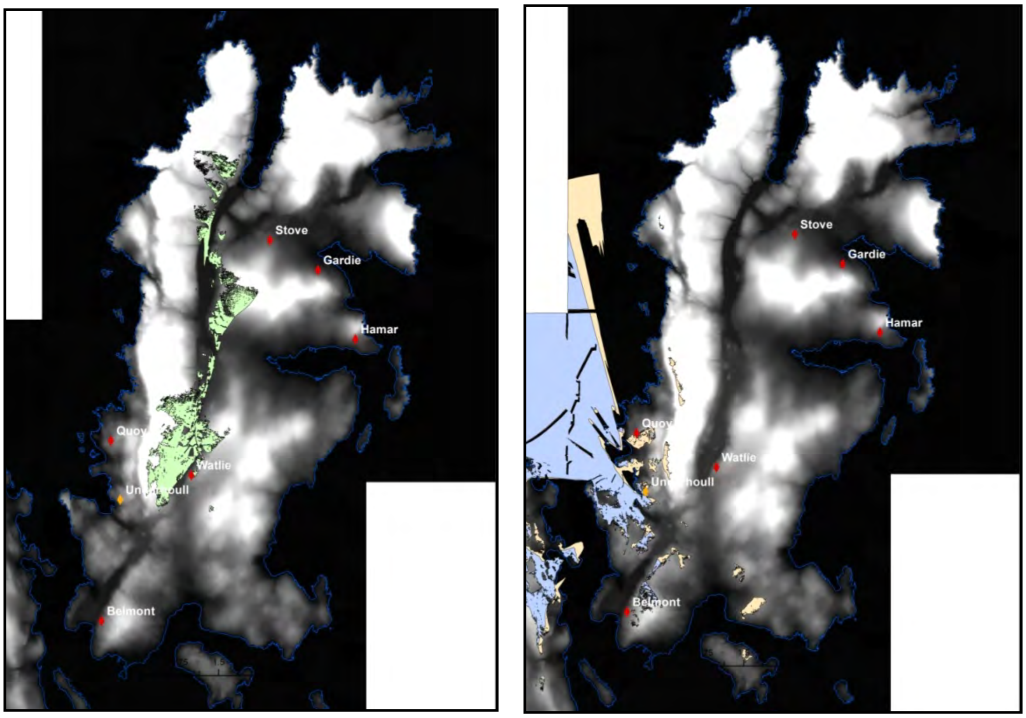


Fig 4.10 Viewsheds from Norse sites at: g. Watlie, h. Underhoull (over Ordnance Survey Profile 1:10,000; EDINA right 2010. An EDINA supplied service).

All six Homestead Enclosures have a view of the sea, the most restricted of these being Vassa and Croag Lea. In mitigation, Vassa is on the side of a voe, the head of the voe being visible and Croag Lea is close to a loch. Houlland and Hill of the Taing are the furthest inland but both have views of some, although limited, lengths of coastline. The Enclosures do not have views of each another, although four of them are close together.

The Multiple Field Systems have far more restricted views, including of the sea, with a greater bias towards inland areas. Sumburgh Head is the exception, with extensive coastal views, as well as good views of land to the north.

The Brochs have extensive views, not least because they are taller. In this study, the GIS viewsheds have assumed a height of 10m, unlike the field systems which have been ascribed given a height of 2m (a little taller than a person). This study only includes four brochs, however, the results reveal some surprises: Tumblin broch is so located that, unexpectedly, the broch at Aith is visible (recently noted by Smith, pers. comm.); that at Clevigarth could see the fort at Sumburgh Head (in addition to the broch at Eastshore).

The Norse fields have the most varied set of results: Hamar has good views of Baltasound and the island of Balta, the location may have been designed to achieve that; Eastshore also has good seaviews. Watlie is entirely land locked (although beside a loch) and Gardie is surprisingly landward looking, the view to the south being restricted by the rise of the land.

This examination of viewsheds indicates that Homestead Enclosures valued a view of the sea, or possibly the coastline, which could have important resource implications. Stranded whales or other cetaceans would be a particularly valuable resource, and staking an early claim might be important. Driftwood was another resource which might arrive unpredictably. It would be less important to see coastal resources which were more predictable, where access could be planned. Croag Lea had the poorest coastal views, although it overlooked two voes, and fish stocks in the adjacent fresh water loch may have reduced the need to watch the coast. The more inland aspects of the Multiple Field Systems might reflect a change in values: the sea would have had economic importance but rules about resources may have been more clearly defined, territory being more organised. Interestingly Stanydale "temple", the oversized structure at the centre of a Multiple Field System (Calder, 1949-50) is one of the few places in Shetland which is entirely landlocked, with no view of the sea (Turner, 1998:48).

The four broch viewsheds support results of work in progress, establishing that broch sites chose locations on grounds of visibility (Smith and Johnson). The Multiple Field Systems look inland and the Norse sites appear to be located without regard for views. The apparent requirement for Homestead Enclosures to see the coastline has not previously been identified. It is even possible that upland locations may have been favoured in order to avoid woodland impairing visibility.

RESULTS OF PLACE ANALYSIS

	Geology: Fertility Potential	Geology: Building	Geology: Tools	Height AOD	Alignment	Aspect	Viewsheds
Homestead Enclosures	Moderate			3-42m		sun	Coast, sea important
Multiple Field Systems	Moderate		All	10-51m	along	50% sun	Inland/ no significance
Iron Age Boundaries	Good-Moderate	All		21 – 84m		none	Intervisible, sea
Norse Field Systems	Avoids worst		Belmont	5-55m		random	Variable

Table 4.2 Summary of the results of factors which appear to be significant to the location of field systems over time which result from Place Analysis

Chapter 5: Results and Discussions 3- Shape Analysis

Introduction

Shape Analysis is a tool more usually applied to examine and compare particles microscopically. However it appeared to offer a potential mechanism for examining and comparing the shape properties of field systems objectively and scientifically. This study will therefore serve as a test of the application of Shape Analysis in a novel context.

The primary purpose in carrying out Shape Analysis was to establish whether there are characteristics relating to field form or function which could subsequently be used to identify or define the period or category of an enclosure objectively. If so, Shape Analysis could potentially classify field boundaries within in a multi-period, or poorly surviving, landscape. Shape Analysis was applied to the Homestead Enclosures, Multiple Fields, the Norse yards and Norse infields. It was not possible to carry out Shape Analysis for the Iron Age sites since the lengths of surviving boundary did not create a sufficiently closed shape for meaningful analysis.

METHODOLOGY

Polyline Shape files were created within Arc View for all the field boundary elements. Where the surviving boundaries were not completely closed, the polyshape was closed across the closest points with a straight line. This introduces a degree of inaccuracy since no prehistoric boundary included straight lines within their makeup. The polygons for each site were then processed in turn using "analySIS". The results were saved into Excel spread sheets (Appendix A). The information is displayed below as a series of maps to scale, and a series of graphs which enable easier visual comparison.

Prior to embarking on Shape Analysis it was necessary to select the most useful parameters: those selected are listed in Table 5.1. It was immediately apparent, both from field observation and the resultant survey maps, that there were significant differences in the sizes of some of the elements of the field systems. It was possible that an analysis of basic descriptors, including Area and Perimeter, would reveal more subtle differences between field systems.

The study also included measurements of shape. Shape Factor was calculated in order to determine whether apparently distinctive, irregular, shapes visible in the field could be quantified or further refined. Minimum and Maximum Feret values were selected as indicators of the proportions of the field shapes, a factor which could be obscured by the Feret Mean. Convexity was included as an expression of how smooth or irregular the edges of a field were. Although gaps in the field boundaries were closed using straight lines, all but the very fragmentary infield at Stove returned results which were consistent with others within their field class.

Parameter	**Unit**	**Definition**	
Area	m^2	The exact area of the field as defined by the number of pixels	A
Perimeter	m	The perimeter as defined by the edge of the pixels that form the boundary. Diagonal pixel linkages were included which is not a problem due to the large number of pixels.	A
Shape Factor	none	Measurement of the compactness of the shape of the field. It can be expressed as $\frac{4\pi \text{ area}}{\text{perimeter}^2}$	D
Convex Area	m^2	The area of an n-sided polygon created around the shape of the field which defines the minimum area of a convex shape which will	A

		incorporate the whole field. The convex cover, or hull, has no concave edges. This has the effect of smoothing out the feature shape	
Convex Perimeter	m	The edge of this shape	A
Convexity	none	An expression of the area of the feature divided by the area of the convex hull where 1 is the value for a smooth sided object with no indentations (eg: circles or rectangles)	D
Max Feret's diameter	m	The line between two parallel tangents on either side of the periphery that are farthest apart	A
Min Feret's diameter	m	The line between two parallel tangents on either side of the periphery that are closest together	A
Mean Feret's diameter	m	The mean of 360 separate Feret measurements made at one degree rotation intervals around the object centre.	A
Rectangular Minimum Area	m^2	The area of the smallest possible bounding rectangle which has sides tangential to the feature boundary edges.	A

Table 5.1 Table of parameters considered for Shape Analysis which also indicates whether the measurement is absolute (A) or derived (D) (based on Adderley, pers. comm.; Russ, 1998; Adderley, 2001.)

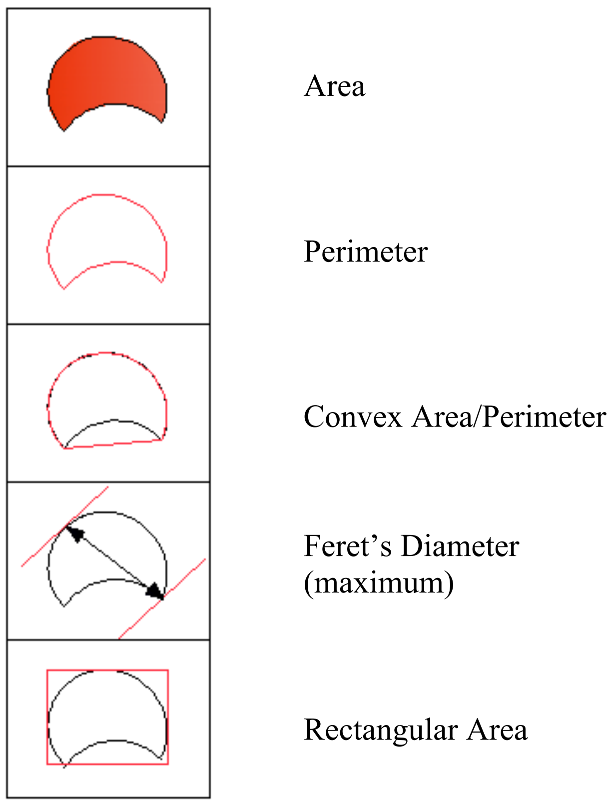


Fig 5.1. Explanatory diagram of the parameters considered for Shape Analysis

<u>RESULTS</u>

The polymaps for each site are presented below. The differences in size between some classes e.g. Homestead Enclosures, at the smaller end of the spectrum, and Norse Infields at the opposite end, means that different classes of field systems are shown at different scales. However, the maps are below are presented at a single scale within each category in order to enable a degree of visual comparison.

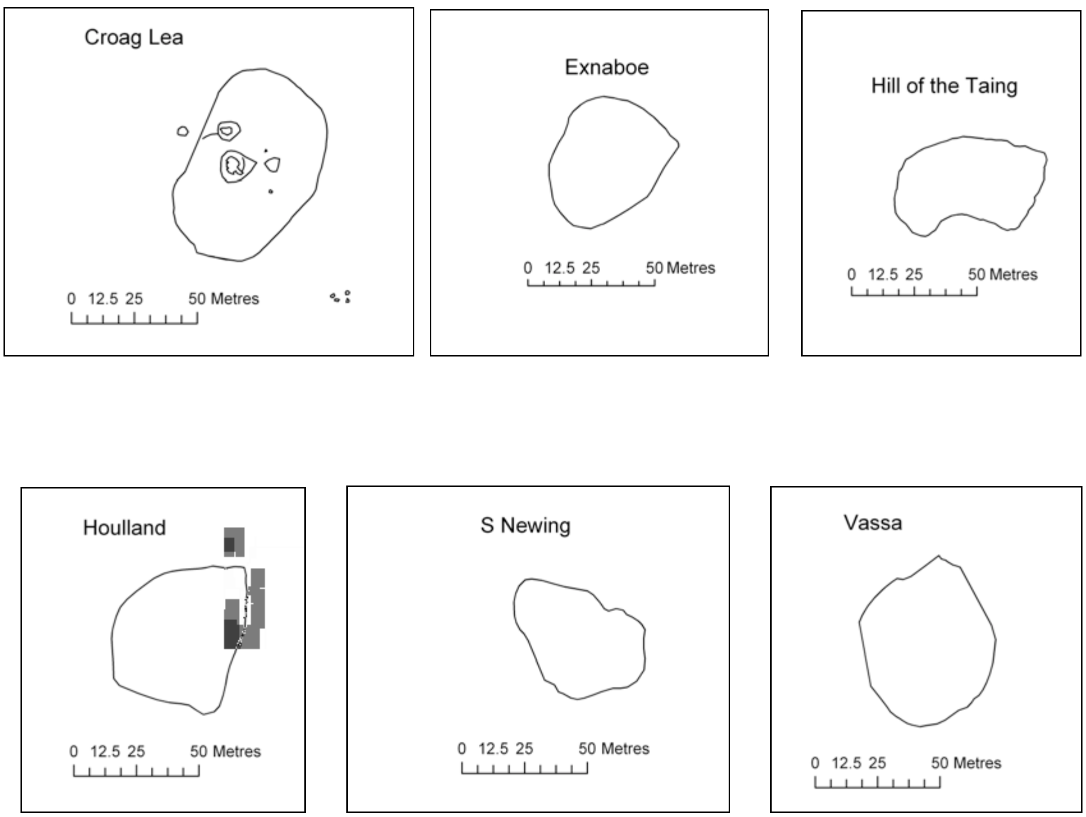


Fig 5.2a-e. Polyline Shape Files for the "Neolithic" Homestead Enclosures (Croag Lea, Exnaboe, Hill of the Taing, Houlland, South Newing, Vassa)

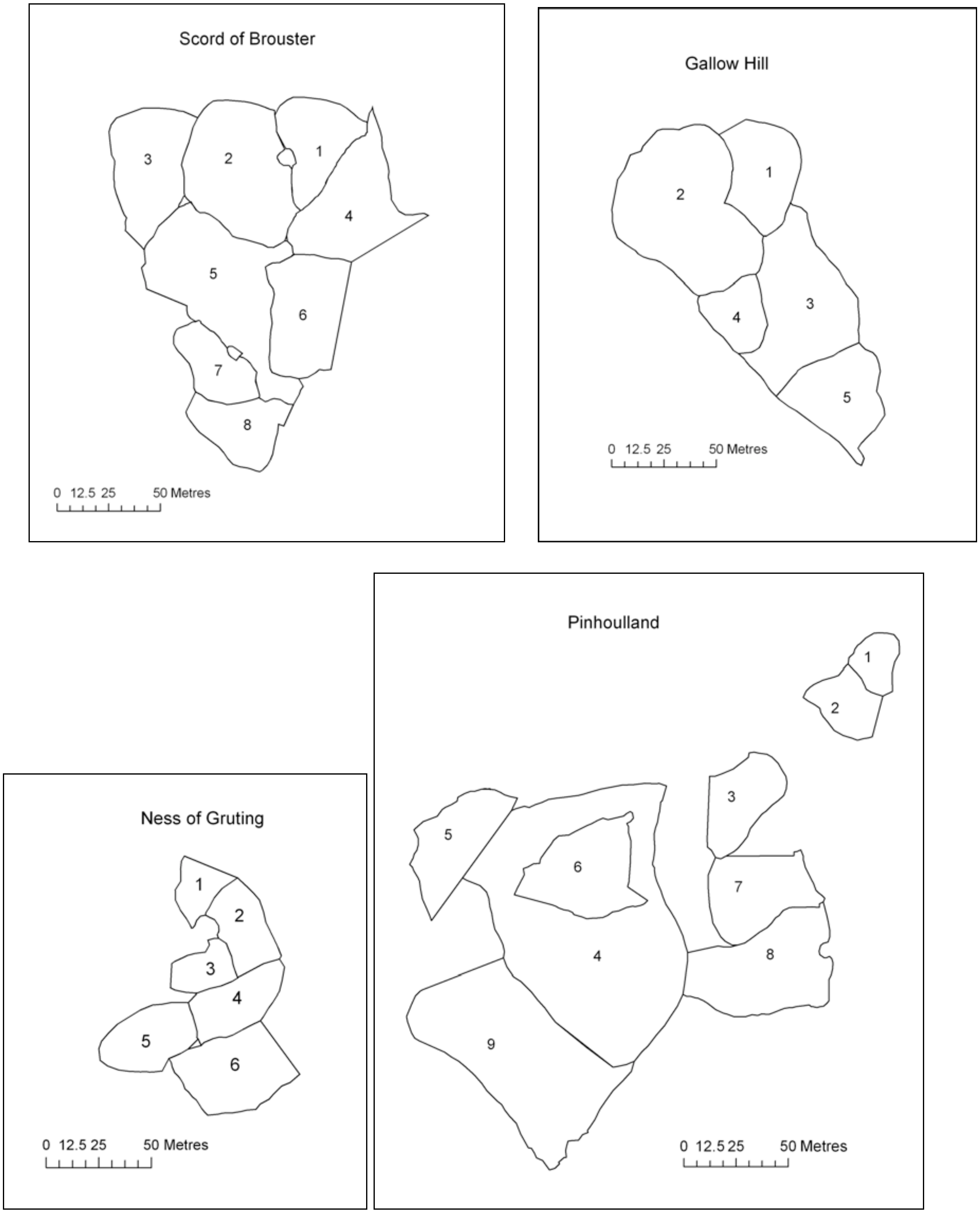


Fig 5.3 a-d. Polyline Shape Files for the Multiple Field Systems (Scord of Brouster, Gallow Hill, Ness of Gruting, Pinhoulland)

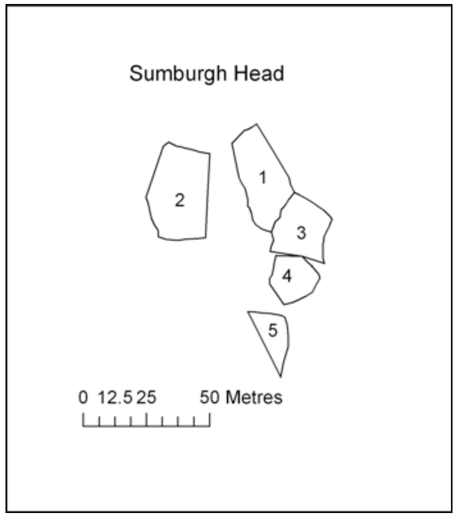


Fig 5.3e. Polyline Shape File for the Sumburgh Head Multiple Field System

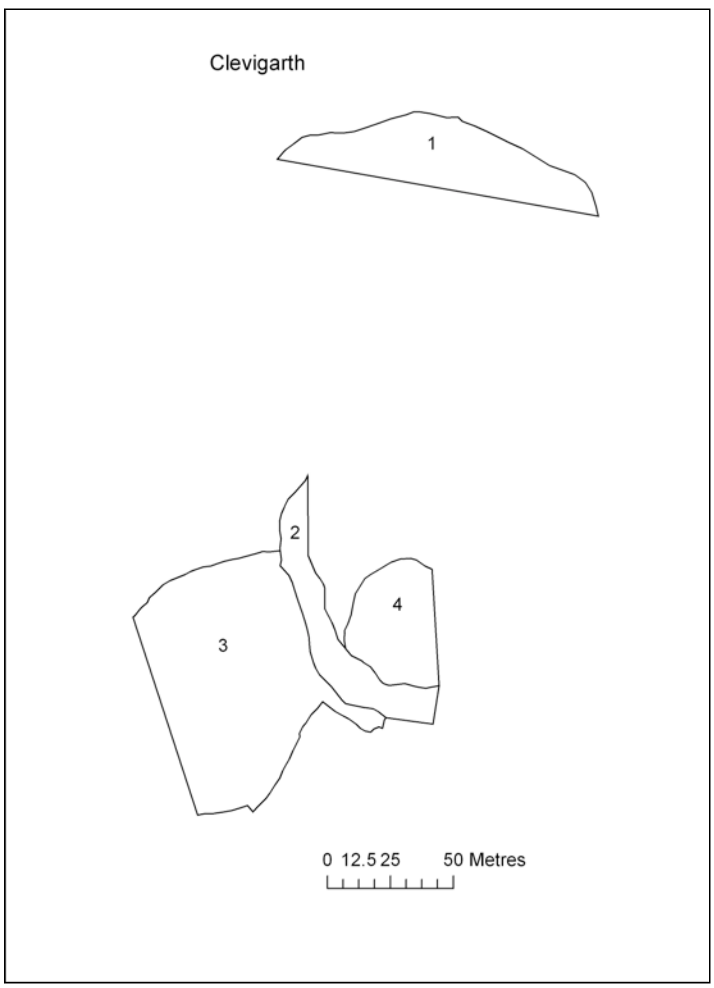


Fig 5.3f Polyline Shape Files for the Multiple Field System at Clevigarth (fields 2-4; field 1 is a segment of broch boundary)

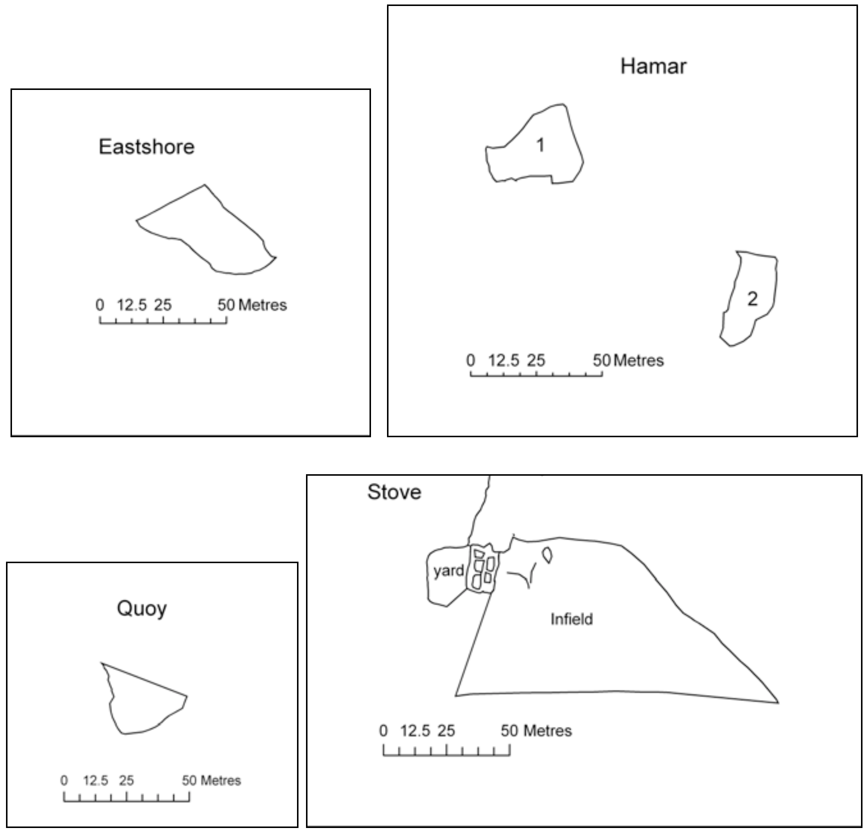


Fig 5.4 a-d. Polyline Shape Files for Norse yards at Eastshore and Hamar (above) and Quoy and Stove (below).

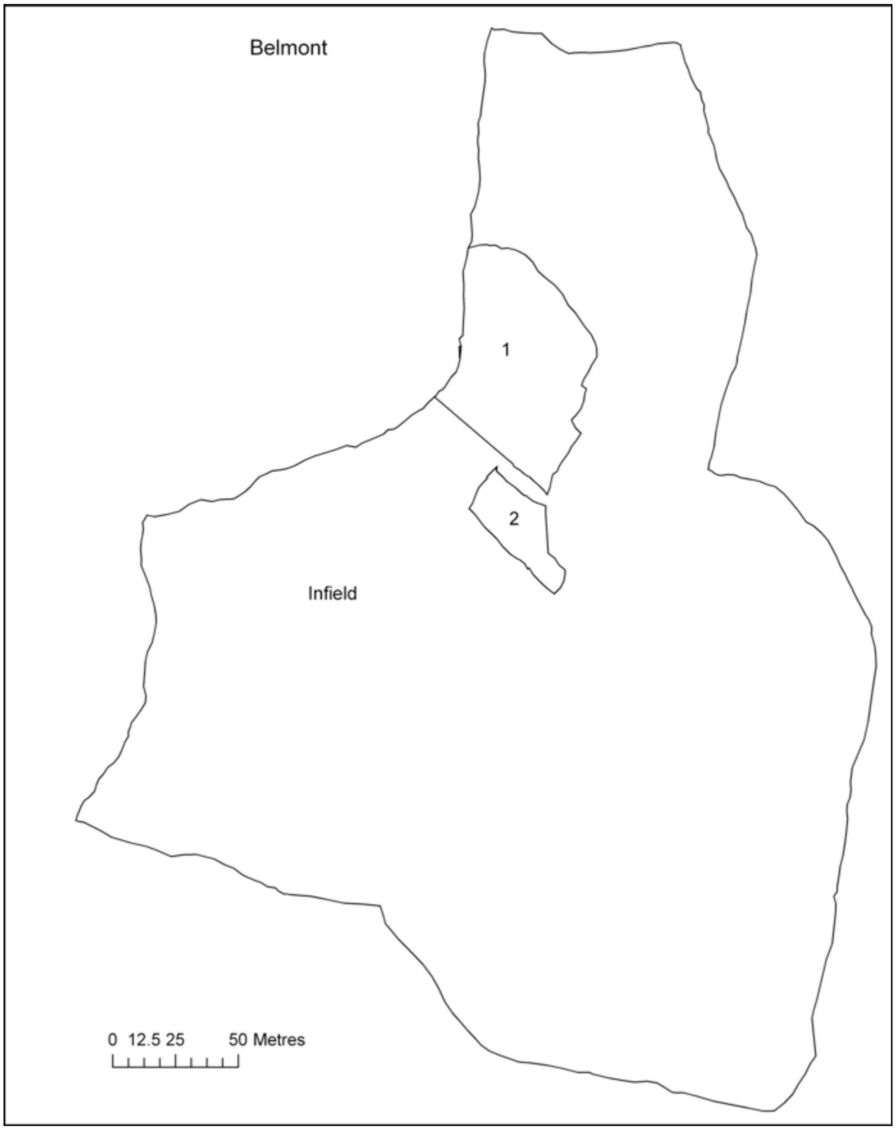


Fig 5.4 e Polyline Shape Files for Norse field systems at Belmont

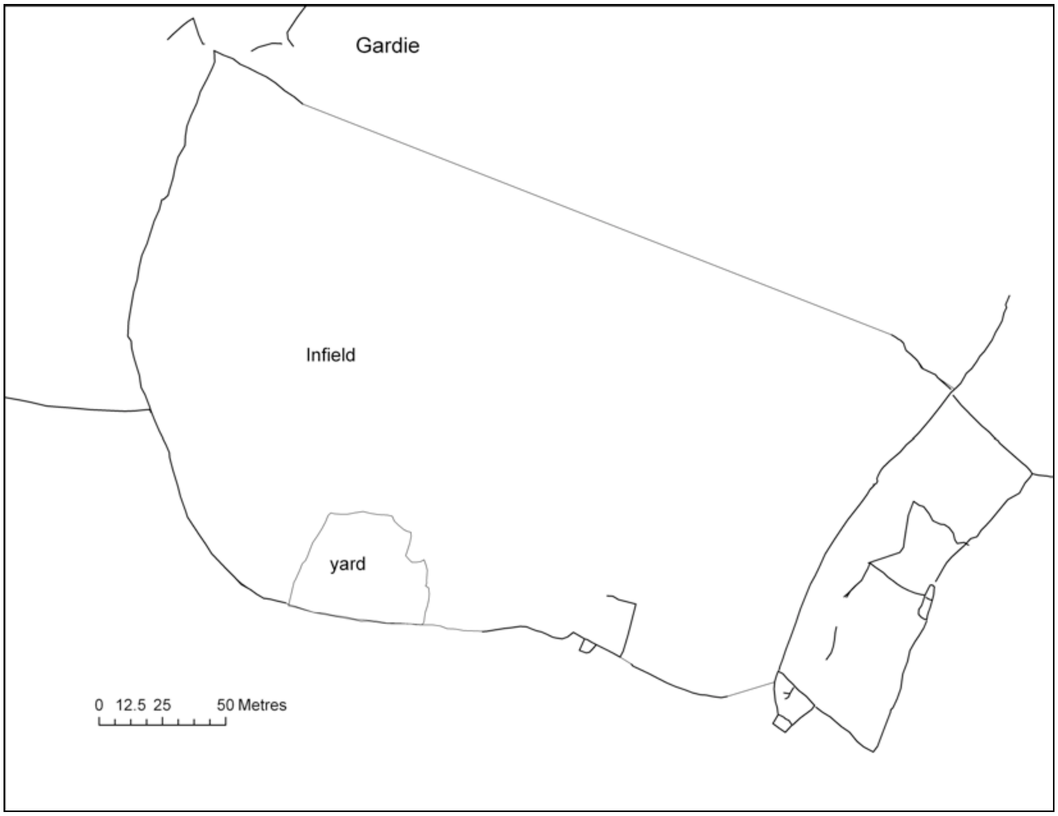
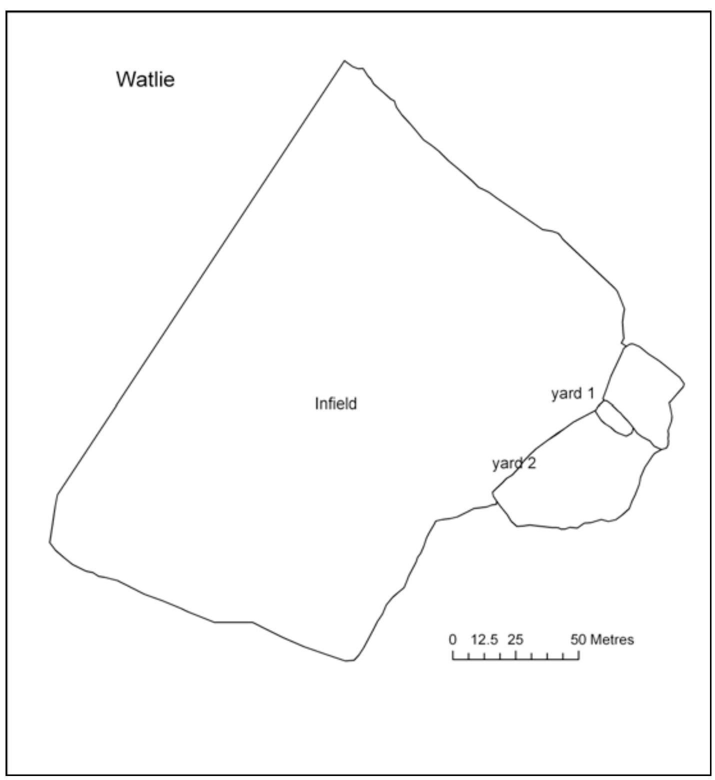


Fig 5.4 f-g. Polyline Shape Files for the Norse field systems (yards and infields) at Gardie (above) and Watlie (below).



Area

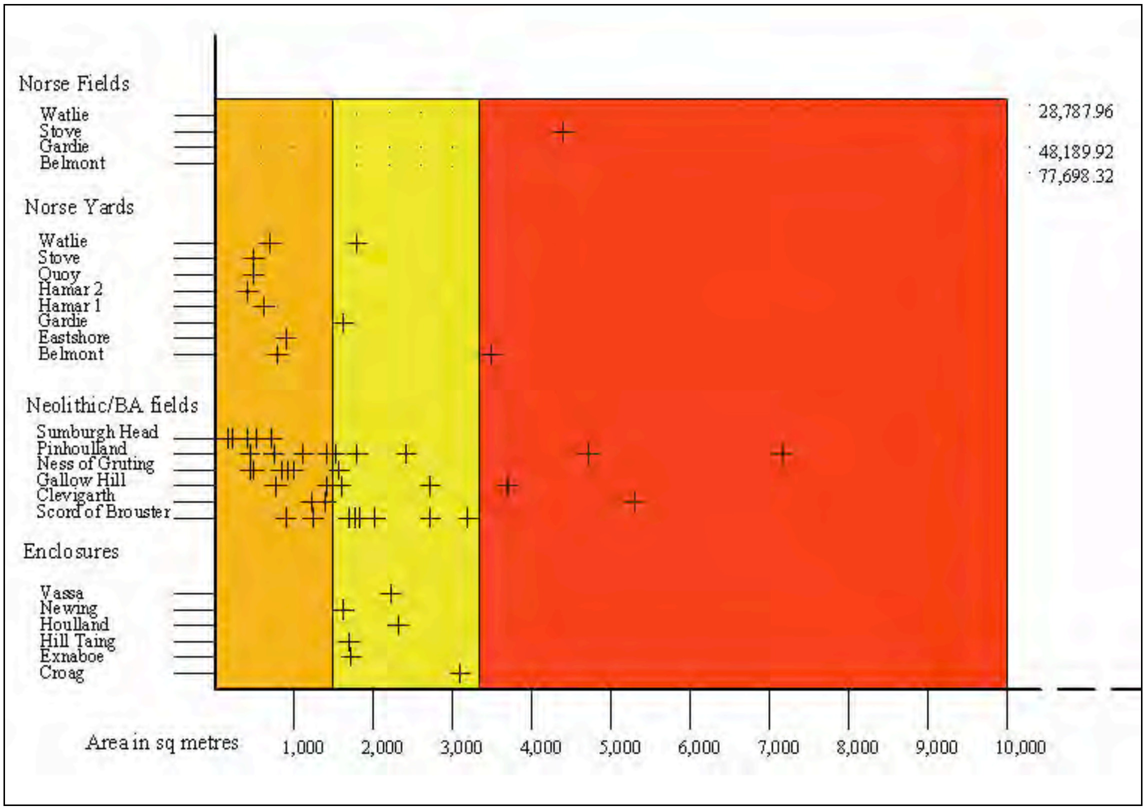


Fig.5.5 Area of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System. The yellow shading highlights the values of the Homestead Enclosures, as the most discrete, and also the earliest, form of field system.

The Homestead Enclosures display the narrowest range of results relating to Area: 1660.68m² at Newing to 3135.36m² at Croag Lea, almost twice the size. The area calculation for the Homestead Enclosures includes the area of the house, situated in the centre of the enclosure, other than Vassa, where the house is on the external northern edge of the enclosure.

The Multiple Field Systems had a wider variation in area, both within individual field systems and between them. At each site other than Sumburgh Head, some fields contain house sites, in which case their area is included. The majority of the Multiple Fields contained clearance cairns within their area, although this was not the case in the South Mainland (Sumburgh Head and Clevigarth). The most extensive range of measurements within a single field system came from Pinhoulland, with areas between 456m² and 7,198m². The smallest fields were found at Sumburgh Head, where all fell at the lower end of the range (182 – 734m²) and included the two smallest examples.

The measurements of the Norse yards did not include the area of the associated longhouses, although apart from Eastshore, the yard and long-house shared a long-wall. At both Belmont and Watlie two yards were attached to one house. The two yards at Hamar belonged to two different houses.

The ten Norse yards had the smallest areas of any field type: only three exceeded 1,000m. Two of the three larger yards were one of a pair of yards attached to a single house. The largest, the northern yard at Belmont (3739m ²) is twice the size of the second largest, Watlie 2 (1779m²). The third largest yard was located at Gardie (1658m ²).

The Norse infields were the biggest units analysed, the largest of which, 77,698m², found at Belmont. The smallest infield, Stove, is fragmentary and this has resulted in a misleading result in terms of area. Many of the longhouses and yards surveyed had no surviving visible remains of associated infields. The infield at Belmont is more than twice the size of Watlie (28,788m²), reflecting the yard results. Both appear to be fairly complete which suggests that the size of the infield could vary significantly. The occurrence of two yards may reflect status and wealth, or relate to land quality, land management practice or use.

The northern limit of the infield at Gardie no longer survives and so the area recorded is less than its maximum extent.

Perimeter

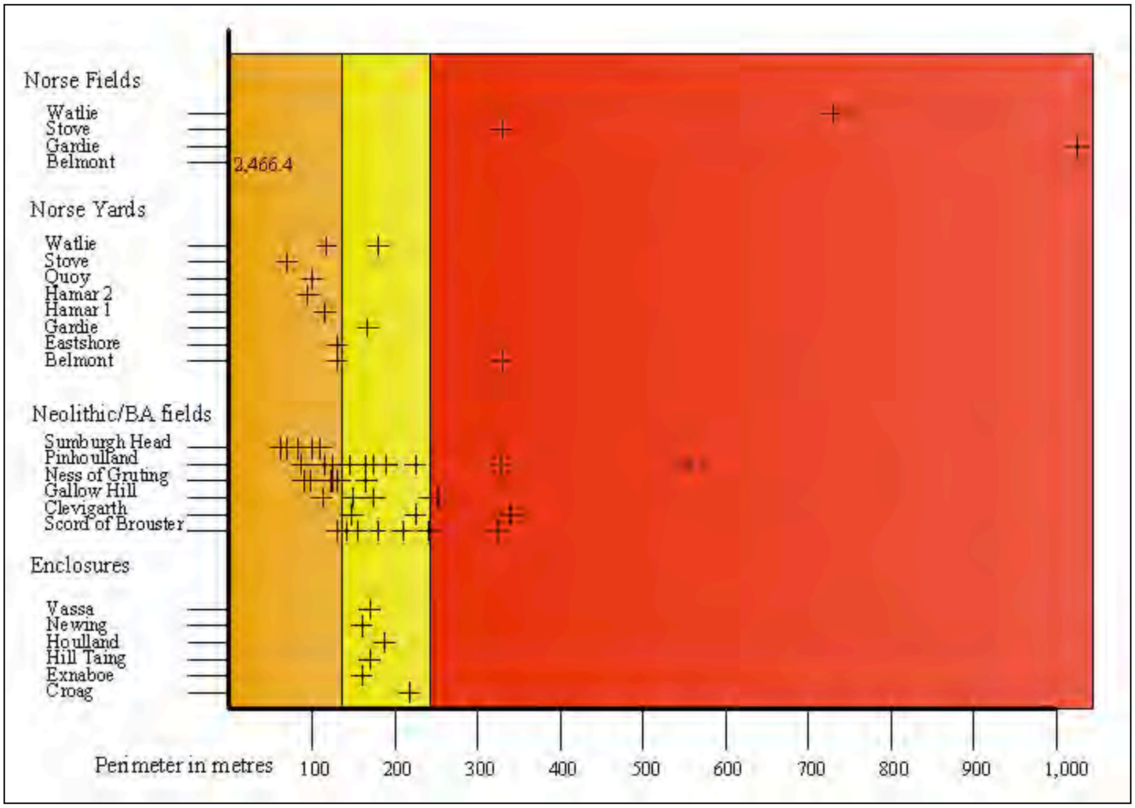


Fig.5.6. Perimeter length of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System. The yellow shading highlights the values of the Homestead Enclosures, as the most discrete, and also the earliest, form of field system.

The perimeters of the Homestead Enclosures show very little variation in length (a maximum difference of 56.5m). This contrasts with the yards which (excluding the larger of each of the paired yards at Belmont and Watlie yards) have a perimeter variation of 100.19m. There is also a wide variation between the perimeter lengths of the Multiple Field fields. The infields have a wide variation in perimeter length: they increase in size in the same order as the area increase, but this is not directly proportional.

Shape Factor

Shape Factor is a numerical value which represents the degree to which a shape is compact: 1.0 represents a circle, which is the most efficient shape, whereas a straight line would have a value of zero. Shape Factor has no relationship to absolute size. Of the eight fields at the Scord of Brouster, the largest field [5] had the smallest Shape Factor whilst the second largest field [2] was the most compact. The Shape Factors were calculated for each field. A value was also calculated for the mean of each class of field.

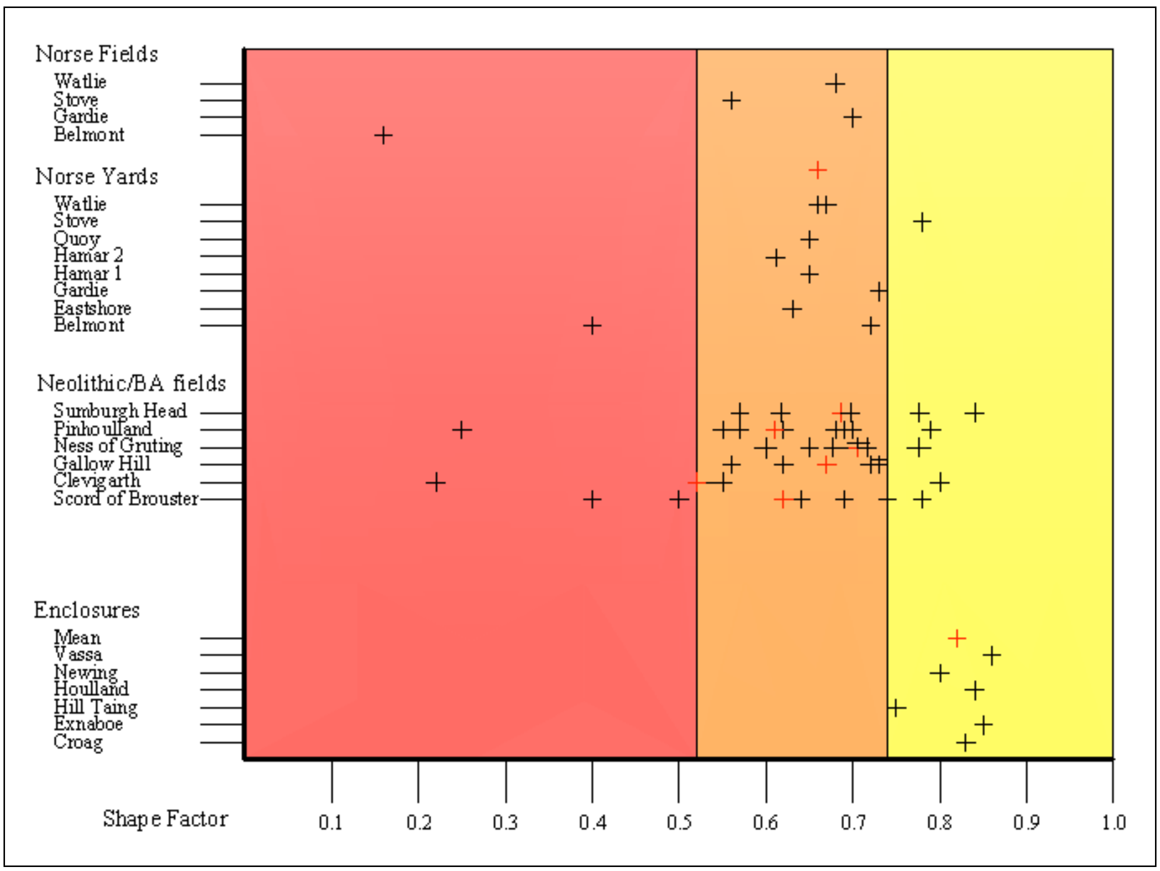


Fig.5.7 Shape Factor of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System. The mean is plotted in red. The yellow shading highlights the values of the Homestead Enclosures, as the most discrete, and also the earliest, form of field system.

The Homestead Enclosures showed the least variation within the range and are relatively compact, with values between 0.75 (Hill of the Taing) – 0.86 (Vassa). The Norse yards have a fairly limited range of values (0.57 – 0.73) with the exception of two outliers: a low value at Belmont (0.4) and a high value at Stove (0.78). Stove, the most compact of the Norse yards, is the only site which overlaps with the Enclosures. The Shape Factors of three of the Norse Infields range between 0.56 – 0.7. Belmont has a much lower value of 0.16.

The Multiple Field Systems have the most extensive range: the majority have a Shape Factor value between 0.5 – 0.8. There are three significant outliers: one at each of Pinhoulland, Scord of Brouster and Clevigarth. The wide range reflects the irregularity and, in some cases the fragmentary, nature of some of the fields of this type. At one end of the scale, the Shape Factor for all five fields at Gallow Hill is fairly consistent, with a maximum variation of 0.17; by contrast, the Shape Factors at Pinhoulland show an overall variation of 0.54.

Convexity

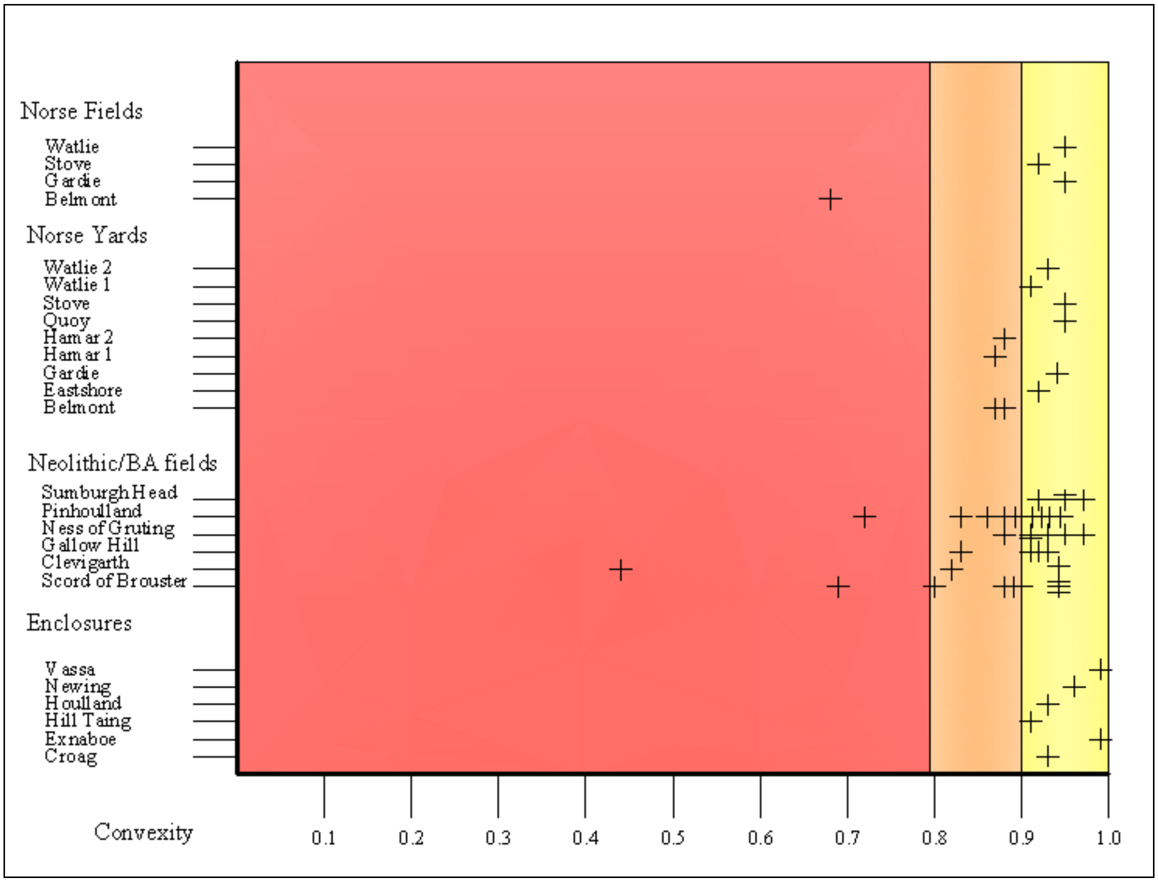


Fig.5.8 Convexity of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System. The yellow shading highlights the values of the Homestead Enclosures, as the most discrete, and also the earliest, form of field system.

The convexity of a shape is a measure of how indented its edge is. Convexity is inversely proportional to the degree of indentation.

The convexity values for the Homestead Enclosures all occur at the top of the range: five of the six fall between 0.96 – 0.99; Hill of the Taing, having a value of 0.91. At the top of their range, the convexity values of the Norse yards (0.87 – 0.95) overlap the convexity values for the Homesteads. The lowest value, 0.87, is shared by both Belmont [1] and Hamar [1].

The majority of the Multiple Field Systems had values between 0.69 – 0.97. Only one field, at Clevigarth, fell outside this range. Again, the Multiple Field Systems have the broadest range of values of any group. They encompass similar values to those found for the yards and at the lower end of the Homestead Enclosure range. The large irregular fields, Pinhoulland [4] and Scord of Brouster [5], as well as a long narrow field, Clevigarth [2], had exceptionally low values. Three of the Norse infields had similar values to one another, as well as to the Homestead Enclosures (0.92 – 0.95). Belmont was the exception with a lower convexity value of 0.68.

<u>Feret ratio (Minimum:Maximum)</u>

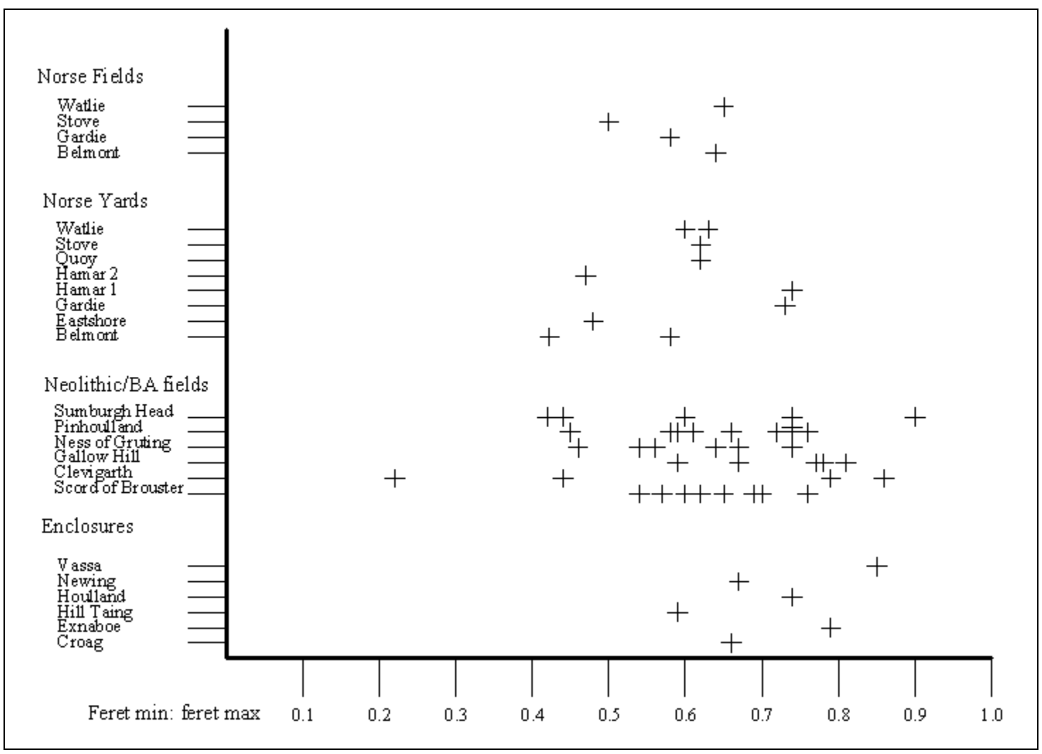


Fig 5.9 Ratio of Feret minimum: Feret maximum diameters of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System.

The ratio of the feret minimum: feret maximum demonstrates how elongated a feature is. An infinitely long feature has a value of 0; a circle or a regular polygon have values of 1. The limitation of this calculated parameter is that an L-shaped feature could return similar values to that of a circle.

The majority of fields of all periods have a feret ratio of more than 0.5. There is a wide range of variation within each field class and also within the component fields of the Multiple Field Systems. Excluding Clevigarth [2], which has an exceptionally low value, the highest and lowest feret ratios are both found at Sumburgh Head [5] and [4] respectively (0.42 and 0.91). The Homestead Enclosures have values of between 0.59 at the Hill of the Taing and 0.85 at Vassa.

The range for the Norse yards is slightly less than that of the Multiple Field Systems: Belmont [1] has a value of 0.43 and Hamar [1] has a value of 0.75, at either ends of the spectrum. The range is most restricted for Norse infields, varying between the partial field at Stove with a value of 0.5 and the two complete infields, Belmont and Watlie having values of 0.64 and 0.65.

Ratio of Area: Minimum Rectangular Area

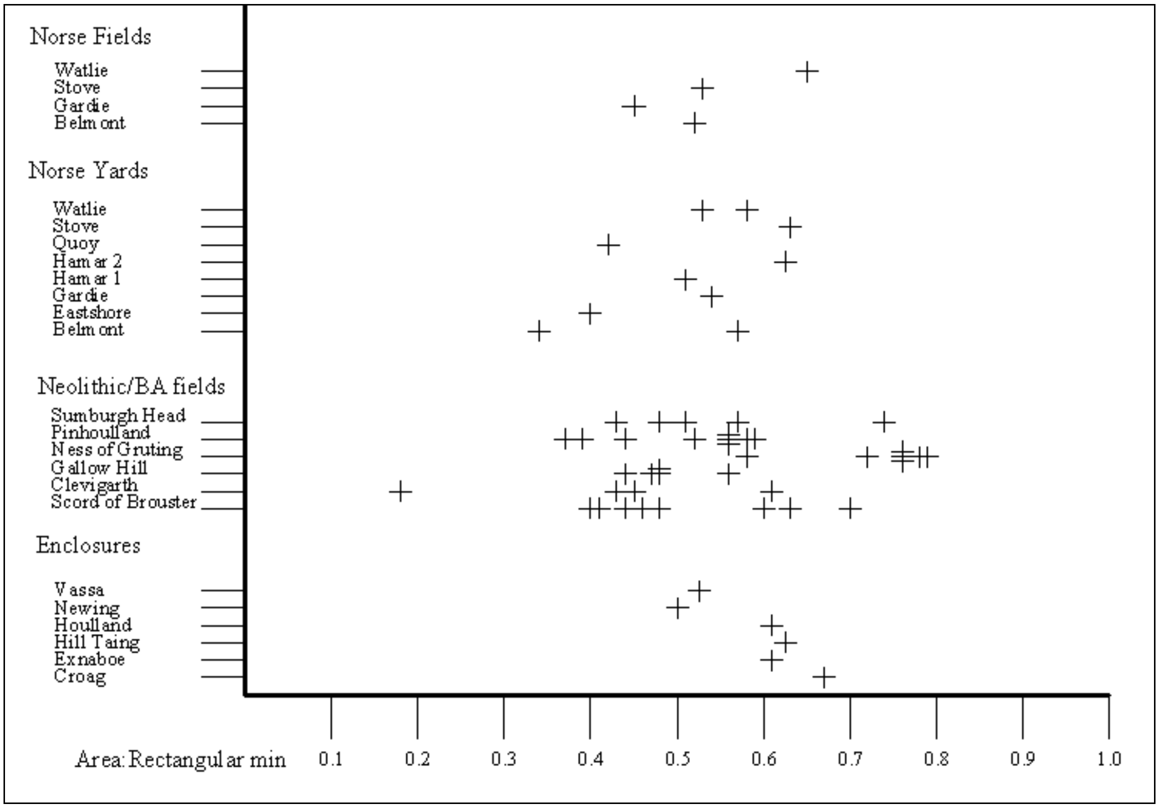


Fig. 5.10 Ratio of Area: Rectangular Area of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System.

The ratio of Area: Minimum Rectangular Area ("smallest bounding box") demonstrates how close a shape is to being rectangular. On this scale a value of 1.0 represents a rectangle (in which the corners are 90°). A rhombus, or other parallelogram, therefore would not have a value of 1.0.

The results of calculating the ratio of Area: Rectangular Area cluster in the middle of the range. The Homestead Enclosures are the most closely grouped category, having a range of 0.5 – 0.67. The range of the Multiple Field Systems is between Pinhoulland [4] (0.39) and Ness of Gruting, where five of six fields have values between 0.72 – 0.79. These results exclude Clevigarth [2], which has a value of 0.18. The values for the Norse yards are similar to those of the Enclosures although not as high, the top of the range being represented by Stove (0.63) and Hamar[2] (0.65). The Norse infields also fall in the mid range.

Ratio of Area: Convex Area

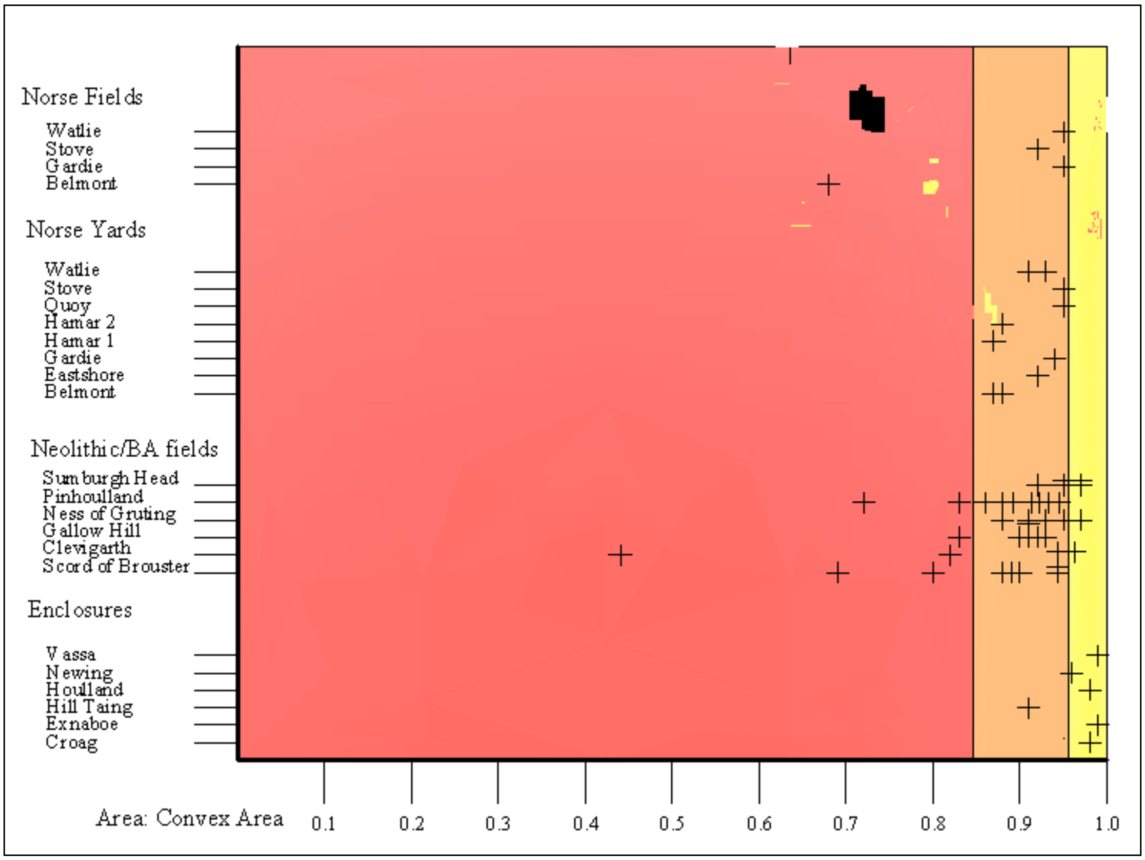


Fig. 5.11 Ratio of Area: Convex Area of fields (derived from Shape Analysis). Each cross relates to either a single field or an individual unit within a Multiple Field System. The orange shading highlights the Norse Yards which form a discrete group. The yellow shading, which is of values greater than the Norse yards includes 5 of the 6 Homestead Enclosures.

The Ratio of Area: Convex Area is termed "Solidity" by Russ (1999). The convex area is the area that the feature would have if all its edges were smoothed out, removing any concave or serrated surfaces. Comparing this area to the actual area of the feature demonstrates the degree to which the feature is convex or “solid”. The results were very similar to those for Convexity values, although there were differences.

The Homestead Enclosures are all very solid, having values of 0.91 (Hill of the Taing) to 0.99 at both Exnaboe and Vassa. The Multiple Field Systems have a wider range although (excluding Clevigarth [2] at 0.4) the lowest value is at Scord of Brouster [5] at 0.69. The highest values for fields in the range are at the Ness of Gruting [5] with a value of 0.98. The Norse yards have a slightly larger range than the Homestead Enclosures, with values from 0.87 and 0.88 at Belmont [1] and [2] through to 0.95 at both Quoy and Stove. Of the Norse infields, Gardie and Watlie both also had values of 0.95, with Belmont returning a value of 0.68.

Sinuosity

Sinuosity is a measurement of the extent to which a line diverges from the most direct route between two points. It is normally applied to flowing water within a landscape, in order to assess the degree to which it meanders. Field observation and survey indicate that some classes of field system boundary meander more than others, therefore this was tested in relation to field systems. Calculating the Sinuosity Index is an add-on function of GIS, results being derived from the attributes table (see Appendix B). The “expected length” (the direct line) is compared with the “observed length” (the survey measurement) in order to produce the “Sinuosity Index” which will therefore always have a value of more than 1. Initially the method was applied to one of the Multiple Field Systems and appeared to have potential. Difficulties were encountered when the method was applied to the Homestead Enclosures which are closed, or almost closed shapes: instead of taking the circuit into account the “expected length” was calculated between the start and finish points of the survey (in the region of 0.5m). In order to further explore the use of Sinuosity, it was then applied to lengths of boundary where the start and finish points turned through angles of less than 90°. When boundaries did this, a new reading was started, introducing a degree of subjectivity. The methodology was initially applied to the Homestead Enclosures and the Multiple Field Systems in order to determine whether the results would reflect the differences visible in the field.

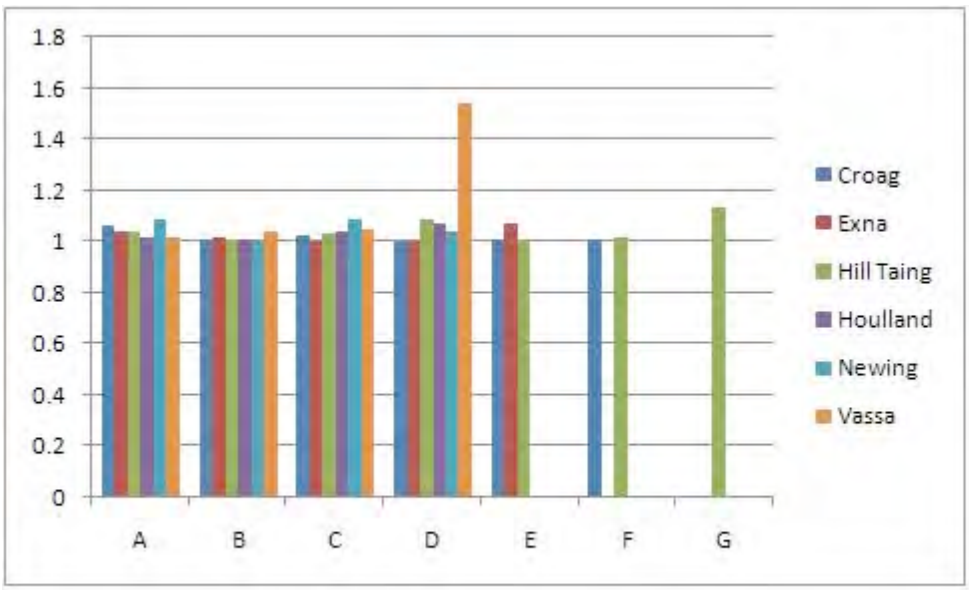


Fig 5.12a Sinuosity Index results of the Homestead Enclosures.

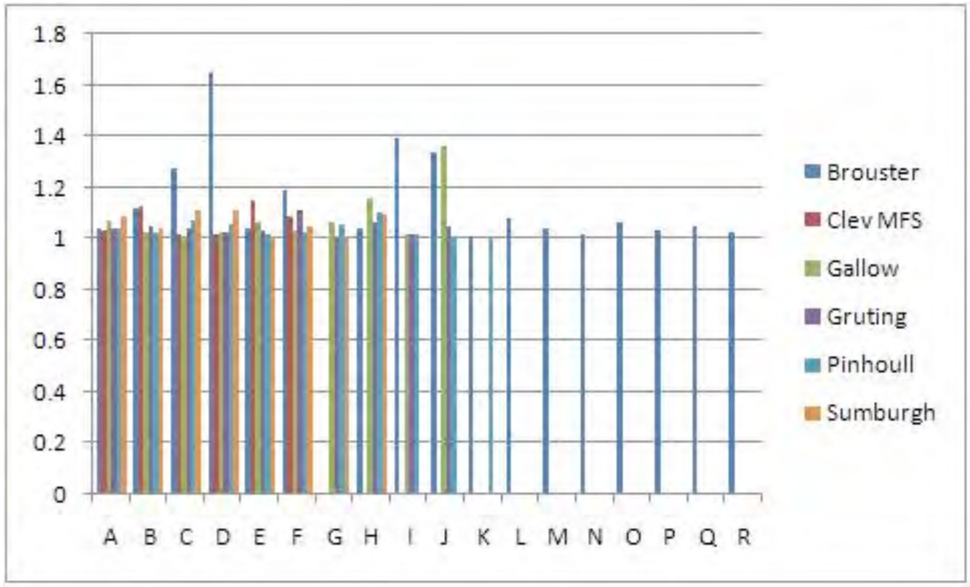


Fig 5.12b Sinuosity Index results of the Multiple Field Systems (a single high result from Brouster removed for ease of comparison with the Homestead Enclosures – see fig 6.38c below).

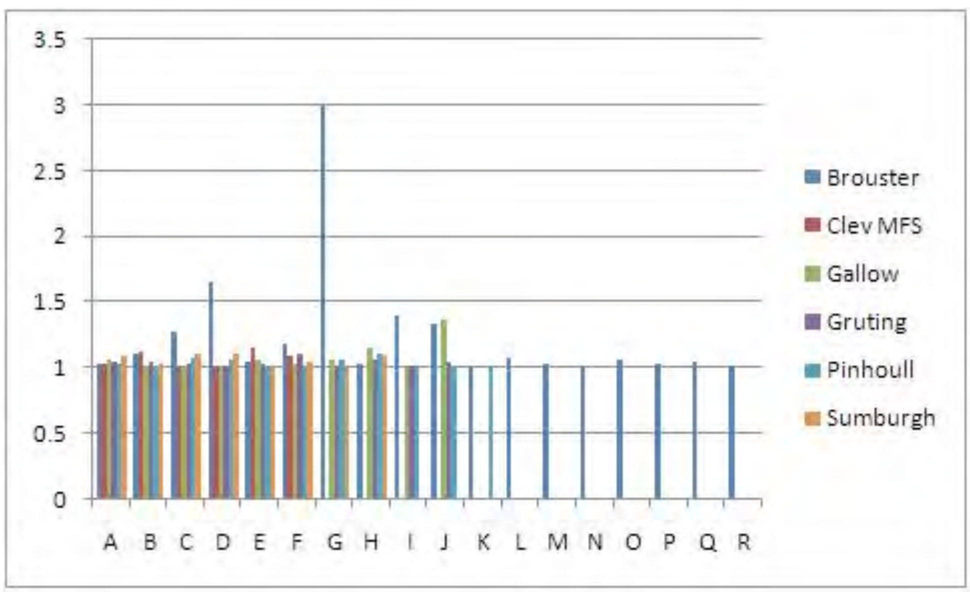


Fig 5.12c All Sinuosity Index results of the Multiple Field Systems.

The results from the Multiple Field Systems include readings from the Scord of Brouster which are higher than those from the Homestead Enclosures, but this was examined before the 90° rule was applied. The conclusion drawn from this experiment was that Sinuosity was not a suitable tool to be applied to field boundaries, being more applicable to linear features rather than curvilinear objects.

DISCUSSION

This discussion will use the results of Shape Analysis to compare and contrast the Homestead Enclosures, Multiple Field Systems and Norse Yards. It will also explore whether field systems show any indications of inheritance/sustainability. The possibilities for using Shape Analysis to determine a relative chronology within the Multiple Field Systems will also be considered. The discussion will also compare the Homestead Enclosures and Norse Yards, which may have had similar uses.

Area

The Homestead Enclosures form the most coherent group in terms of area and none appear to be exceptional or different to any of the others in the class. The Multiple Field System display the greatest diversity in terms of area. All of the fields situated between Sumburgh Head and Compass Head ("Sumburgh Head") are small in area: two of the five are the smallest in the range. Of these the smallest, [5], at 182m² survives only partially, closed for the purposes of Shape Analysis with a straight line, and therefore larger when in use. This raises questions as to whether the field system at Sumburgh Head was atypical. Visually, the field system fits comfortably within the class of Multiple Field Systems. The Sumburgh Head system is located on sloping ground with few flat areas. It is steeper than that of any of the other Multiple Field Systems. Where flat areas exist it was due to the creation of terraces and platforms, either during or as a result of, cultivation. Field [1] was extensively modified, creating an artificial terrace. The smaller field areas can therefore be interpreted as the result of maximizing the available land. There was much flatter land below the field system to the west; it is probable that this was already in use, although no surface traces survive. This land was used more intensively in later periods, including the present and the whole area appears to have been stripped. Today the land at Sumburgh is well drained in contrast to the other sites within this class. The land may have been more productive, despite the slope, with smaller fields rendering similar yields to larger ones elsewhere. However, it seems more probable that this field system needed to cultivate every ledge and terrace.

There are four fields which appear to be exceptionally large: Pinhoulland [4] and [9], Clevigarth [3] and Gallow Hill [3]. At Pinhoulland the largest field [4] surrounds field [6] which incorporates an exceptionally large, well-preserved, house: the dimensions suggest that it might be comparable with Stanydale “temple”. The survey plan indicates that Pinhoulland [9] was either secondary, or an adjunct to, field [4]: the northern boundary (which the two fields share) is convex to [9] and concave to [4]. Clevigarth [3] on the west, landward, edge of the field system, appears to respect the adjacent boundary of Clevigarth [2].

At Gallow Hill, field [2] has the largest area, however its relationship to the surrounding fields and its convex edges give it the appearance of being primary in the field system. From the survey plan it appears that this field may have originated as two fields, the internal division having disappeared. It is possible that the boundary between the two was less durable than earthworks, perhaps stakes, brushwood or fencing. Alternatively it is possible that two fields were deliberately amalgamated while in use, whether due to changing function or working practice.

Gallow Hill [3] has the second biggest area. It has a very irregular, concave shape and is situated amidst other, more convex, fields. Visual inspection suggests that Gallow Hill [3] is secondary, taking in the land between other, pre-existing, fields.

With the exception of Gallow Hill [2], the four fields with the largest areas all appear to be secondary, or in the case of Pinhoulland [9], tertiary, to other fields. This raises the question as to whether the fields with the largest areas within the other Multiple Field Systems were secondary.

At Gruting the field with the greatest area [6] is situated at the lower edge of the system, which today is wetter, more boggy ground. It may always have been less well drained than the land above it, which is gently sloping. At Sumburgh Head the field with the greatest area [2] is detached from the others; therefore there is no indication of chronology.

The field with the greatest area at the Scord of Brouster [5] is situated in the centre of the field system and includes the house site which is known from excavation (Whittle, 1986) to be the second stone-built house in a sequence of three.

The larger Norse yard at Belmont is bounded on the west side by a boundary, interpreted as the infield dyke. This may have been reused as a later township dyke, although there is no longer evidence of a township having existed in the flatter, coastal, land below it. Excavation at Belmont (Larsen *et al.*, 2012) demonstrates that at least three longhouses were built on top of one another and that there were another three major phases of alterations to the buildings: the site was therefore in use for a prolonged period.

The second yard at Watlie lies to the south. It is defined by lynchets to the south and east, situated at the foot of a steep rocky outcrop, several metres high. In both cases of two yards, Belmont and Watlie, it is possible that the yards were not contemporaneous, but related to different phases. Alternatively, the larger yards may have had a different function to the others. This potentially raises questions about the yard at Gardie which, in terms of area, would fit more comfortably with these two. The areas of the infields vary enormously. Of the four infields surveyed, only two appear complete: Belmont and Watlie. The infield at Watlie is extremely small (28,787.96m^2) in contrast to that at Belmont (77,698.32m^2).

<u>Perimeter Length</u>

In general, the variation in perimeter length of the fields in all categories showed a close correlation with area. The exception were the Homestead Enclosures. These show remarkably little variation in perimeter length, the smallest two, Exnaboe (with an area of 1766.62m^2) and Newing (with an area of 1660.68m^2), being only 0.41m different in length. The percentage difference in area is 6.4% while the percentage perimeter length difference is 0.3%,; however it is the field with the larger area, Exnaboe, which has the shorter perimeter. Of all the Enclosures, the difference in perimeter length between the longest and the shortest was 56.5m. This contrasted with the Norse yards, which were slightly smaller in area. If the largest of each of the paired yards at Belmont and Watlie were excluded, Gardie is the Norse yard with the longest perimeter. Gardie was 2.46 times longer than the smallest yard, Stove. The perimeter at the largest, Belmont [1], is 4.8 times longer than that at Stove.

Of the Multiple Field Systems, the perimeter of the largest field, Pinhoulland [4], is 7.5 times longer than that of the smallest, Sumburgh Head [4]; the difference between them in area is 39.62. The difference between the fields within each individual field systems is smaller: between 1.76 (Sumburgh Head) and 2.35 (Clevigarth). However, at Pinhoulland, the longest perimeter is 7.09 times the shortest.

Of the two complete Norse infields, Belmont has a perimeter 3.38 times that at Watlie. The difference in area is only 2.7 times. The greater difference in the perimeter length reflects the very irregular boundary at Belmont.

<u>Shape Factor</u>

The Homestead Enclosures have consistently compact Shape Factors (0.75 – 0.86). This indicates a maximisation of area to perimeter length, a circle having a Shape Factor of 1, being the most efficient shape.

Of the Multiple Field Systems under consideration, each has a single field (or at Sumburgh Head two) with a shape factor which falls within the same compact range as the Enclosures. This suggests that there might be an overlap in either time or function between the Homestead Enclosures and the Multiple Field Systems.

The Scord of Brouster [2] has a Shape Factor of 0.77, has an area of 2750m² and a perimeter length of 211.84m and fits comfortably within the upper range of the Homestead Enclosure category. The house site associated with this field is situated at the edge of the field rather than in the centre, however it has been proved to be the earliest stone built house in the field system (Whittle, 1986). The boundary between field [1] and field [2] is convex to field [1] and concave to field [2]. This would suggest that either field [1] predates field [2] or, alternatively, the east side of field [2] was remodeled when field [1] was added later. Of the Homestead Enclosures considered in this study, at five the house site is located in the center of the Enclosure; at Vassa the house site is immediately outside the boundary. Therefore, the location of the house site along the boundary of the fields [1] and [2] at the Scord of Brouster does not preclude it from having begun as a Homestead Enclosure. The interpretation that the field edge was remodelled on a different line when the second field was added would also explain why the house at the Scord of Brouster was situated at the edge of field [2].

Clevigarth [4] has a shape factor of 0.8, an area of 1393m² and a perimeter of 147.49m but is incomplete, having been subject to coastal erosion on the east side. The field has a house situated within it. The other elements of the field system appear to respect the shape of the field, adding to the impression that Clevigarth [4] was primary in the field system. The remaining fields at Clevigarth appear to be exceptional; e.g. the shape factor of 0.22 at Clevigarth [2], which also appears to respect the concave boundary of Clevigarth [4], suggesting that it is earlier.

At Gallow Hill, fields [1], [2] and [4] all have shape factors which are slightly below those of the Homestead Enclosures (0.73, 0.72, 0.73 respectively). Of these, field [2] is slightly anomalous. There is a house site within it but, as already observed, it may comprise an amalgam of 2 fields with a division no longer observable above ground. The area of the field is larger (3676m²) and the perimeter length is 252.89m. Gallow Hill [1] and [4] fit more comfortably into the Homestead Enclosure category. These both contain mounds and clearance cairns but have no obvious house remains. Nevertheless, in archaeology an absence of observable evidence is not evidence of absence.

The most compact field at the Ness of Gruting is field [5] with a Shape Factor of 0.78, an area of 985m² and a perimeter length of 126m. The area and the perimeter length are smaller than those of the Homestead Enclosures and there is no visible house site within it.

At Pinhoulland, field [1] has a Shape Factor of 0.79, but again the area (456m²) and the perimeter length (85m) are smaller than the Homestead Enclosures and the field has no visible house site within it (although there are at least four visible houses elsewhere in the field system).

At Sumburgh Head fields [2] and [4] are the most compact with Shape Factors of 0.8 and 0.84 respectively. However, the areas and perimeters are significantly smaller than those of the Homestead Enclosures. The only visible house site which relates to the field system is situated north of the field system and is not physically attached, although there may be an earlier, timber built, structure within the field system with no visible remains. Earlier timber buildings at the Scord of Brouster were only discovered because they lay beneath later stone built ones (Whittle, 1986). Additional timber buildings may have existed there (and also at other sites under discussion), not located due to a lack of visible surface evidence.

The Shape Factor values for the Norse yards, with the exception of Stove, fall just below those of the Homestead Enclosures. Belmont [1], the larger yard, has an exceptionally low value, 0.4 which adds weight to the theory that it served a different purpose to the single yards. The Shape Factors of the infields have a large range. A possible explanation as to why the infield at Belmont is so far from being compact is that it had to fit into a landscape where the lower lying land to the south and west was already occupied.

Convexity

The Homestead Enclosures have a very limited variation in convexity, with five of the six sites falling between 0.96 – 0.99. The convexity values for the Norse yards overlap these at the top of the range. The Multiple Field Systems encompass a wide range of values: the large irregular fields, Pinhoulland [4] and Scord of Brouster [5], as well as the elongated field, Clevigarth [2] have exceptionally low values, as does the Belmont infield.

Feret Ratio

With the exception of Clevigarth [2] all the fields under consideration have feret ratios of above 0.4 and up to 0.91. The fields demonstrate a tendency towards more compact shapes at all periods. Rigs and strip fields, which would have a low feret ratio, were adopted in later periods as a means of maximising the arable use of the land in a period where ploughing and low level mechanisation was becoming increasingly important. The feret ratios indicate that agriculture operated in a very different manner during the prehistoric and Norse periods, suggesting either grazing or digging by hand during the prehistoric period. The prehistoric fields also have a tendency to contain numbers of clearance cairns which, whilst they helped manage the stoniness of the fields, would have presented an obstacle to ploughing. The numbers of broken ard points found during excavation at the Scord of Brouster (Whittle, 1986) is at odds with evidence for hand digging and grazing. A possible explanation is the longevity of the site (more than 1,000 years): evidence may relate to more than one type of land use. Unenclosed or fenced arable areas might predate a more enclosed system, as the land deteriorated under the pressure of cultivation and climatic deterioration, and clearance cairns were created in response to increasing stoniness (Whittle, 1986). However, it is clear that some of the clearance cairns predated the boundaries. Noel Fojut has suggested, perhaps in jest, that the shapes of the fields within the Multiple Field Systems may have been dictated by how far it was possible to throw stones from the centre of a field to its edge, taking slope into account (pers. comm.).

Ratio of Area: Minimum Rectangular Area

There are no observable significant differences in the rectangularity of any class of field system. It is therefore clear that rectangular fields were no significant to agricultural practice throughout the prehistoric and Norse periods, although either rectangular fields or strip cultivation would seem beneficial to ploughing or arable farming.

Ratio of Area: Convex Area

The ratio of Area to Convex Area is a measure of how crenellated the boundaries are. All the fields could be classified as solid, having values of more than 0.7 (with the exception of the unusual field, Clevigarth [2]). The lower values correspond to fields which appear to be secondary, respecting a pre-existing boundary. This appears to be the case at Clevigarth [2] but taken as a whole, shape analysis suggests that this field does not fit comfortably into the Multiple Field System class.

SUMMARY OF RESULTS OF SHAPE ANALYSIS

FORM

The Homestead Enclosures returned the most coherent set of results, particularly in terms of Area, Perimeter, Shape Factor, Convexity, and Area: Convex Area. The Shape Factor results overlapped with one field at each of the Multiple Field Systems, apart from Gallow Hill where two fields fell just outside the category. This raises the possibility that the Multiple Field Systems started as Homestead Enclosures and indicates that Shape Analysis can be used to identify Homestead Enclosures as a distinctive form. (One of the Norse Yards, Stove, also fell within the Shape Factor range, but it was smaller in terms of Area and Perimeter). The results of calculating the Sinuouisty Index did not prove useful in defining form of field types.

Shape Analysis indicates that the form of the field system at Clevigarth is somewhat different from the other field systems within the multi-field category. Clevigarth [4] fits in the category of Homestead Enclosure, even if its function altered over time. Clevigarth [2] stands out as being different from other fields, suggesting that it might have had a different function.

FUNCTION

The Feret ratios and the Area: Rectangular Area demonstrate that all the fields examined are irregular and that their function did not dictate that they be regular strip fields or rigs. This might indicate that digging with a spade was more common than ploughing, although the prevalence of ard points conflicts with this interpretation. The Multiple Fields (such as the Scord of Brouster where quantities of broken ard points were recovered, Whittle, 1986) showed the widest variation in irregularity.

Shape Analysis demonstrates that the Homestead Enclosures were the most efficiently built type of field. Efficiency is defined as being the means of enclosing the maximum amount of area with the minimum resources (labour and materials). The solidity of the areas enclosed, the close relationship between area and perimeter length and shape factor all suggest that efficiency was important.

Convexity is another measure of efficiency: enclosing an area with a straight dyke is most efficient in terms of materials and labour. If the dyke is convex it enables the field to be larger, but requires additional resources. If the dyke is concave it also requires more materials and labour but the amount of land enclosed is reduced. The convexity results from the Shape Analysis highlight fields which were unusual, but has not proved to be a particularly useful diagnostic tool for differentiating between field categories. The desirability of convex boundaries is shown to be well understood throughout the prehistoric and Norse periods.

Chapter 6: Results and Discussion 4 – Boundary Form Analysis

Introduction

It is common practice for archaeologists carrying out topographical survey to record a range of different attributes: from vegetation cover to the properties of the surviving earthworks. These serve a general descriptive function, but have never previously been analysed in their own right. This chapter seeks to explore whether the rigorous recording of the form of surviving field boundaries could establish a set of parameters which relate to date, field function or sustainability. It achieves this by presenting the results of systematic recording, using GIS to present, and Excel to analyse, data collected during the GPS survey.

The aims of the Boundary Form Analysis will be to:

- Identify any diagnostic characteristics relating to chronology/period
- Identify indicators of longevity and adaptability
- Identify factors which influence field morphology
- Test whether it is a useful tool for understanding field systems
- Further the development of a landscape approach to understanding past agricultural practices
- Explore the contribution which it makes to discussion of the inheritance/sustainability of previously been occupied landscapes

The analysis of Shetland field systems is possible due to the range of types and periods of field systems which survive sufficiently clearly above ground for topographical mapping and recording of their characteristics. The form of this survival varies: Whittle noted several differences in construction methods at the Multiple Field System at the Scord of Brouster (Whittle, 1986) a site which radiocarbon dating demonstrates was in use for over 1000 years (Ashmore, 1999). The Multiple Field Systems may have evolved during that period, whereas the other types of site within this study more probably resulted from a single event.

BOUNDARY FORM DATA ANALYSIS

METHODOLOGY

Introduction

In order to compare sites it was necessary to select potentially significant key attributes which could be recorded objectively. Seven attributes were selected: feature type, feature height (both sides of the feature), width of bank, angle of slope, stone size (minimum and maximum), density of visible stone and direction of face. More subjective values, such as the state of preservation were rejected. This resulted in nine values being recorded for each survey point.

Data relating to boundary form were recorded as free text during the instrument survey, which allowed site descriptions to be written. Datasheets of selected attributes were then created for each site, allowing for more detailed data collection. For maximum consistency, data were recorded for each point of the topographic survey: usually intervals of five paces although sometimes closer readings were required in order to reproduce boundary form accurately. More regular boundaries required fewer points to be recorded. In order to avoid bias, the results are presented as percentages. This enables direct comparisons and compensates for differences in size.

Points recorded included those defining the start, finish and changes in direction or character of a particular feature or construction type. It was necessary that the data recorded reflected the overall nature of the feature. This was achieved by incorporating information from a length of the feature extending one metre either side of the recorded point.

It was essential that the tabulated data be as comprehensive, consistent and objective as possible. A variety of factors including light levels, temperature, vegetation length and ground water, all had the potential to influence results. A degree of subjectivity is inevitable as to the precise beginning and ending of earthworks. These factors were mitigated for by carrying out data recording alone and taking regular breaks. Once the attributes of a site were recorded, the data was entered into spreadsheets, assisted by David Marsh. The data were then imported into GIS and converted to images which were initially printed out onto A4 acetates in order to enable a visual comparison between attribute values. Data were also converted into Excel graphs to facilitate examination.

Notes on the Iron Age and Norse boundaries

There are three Iron Age field systems included within the boundary study: with the exception of Underhoull, the multi-period site which is considered separately, these are the only ones where such boundaries were identified during the initial search. Two of these, Tumblin and Sae Breck, have been sub-divided, as they include two distinctive boundaries. At Tumblin one of these corresponds with the later township dyke (1st Edition Ordnance Survey map): possibly a reuse of a dyke originally relating to the broch. At Sae Breck there are two dykes present, crossing at approximately right angles. Only Sae Breck 1 can be contemporary with the broch; Sae Breck 2 clips the broch mound, thereby post-dating it. However, it is very prominent and was therefore also recorded. Each of the Norse yards incorporates the wall of a longhouse. This has been excluded from the boundary analysis.

RESULTS

Feature Type

This provides a description for each element of the site.

	Definition applied
Bank	An earthwork with two visible sides, in which visible stones might or might not be present; where they were present they did not dominate the feature.
Dyke	A boundary which survives as a line of stones. These may protrude from the flat ground surface or from a low earthwork, but the stones are the dominant feature. (The boundary may include orthostats.)
Discontinuous Dyke	A boundary which survives as stones which protrude from a low earthwork or from the flat ground surface intermittently, but at frequent intervals. Vegetation-covered stone may be apparent within the feature.
Lynchet	An single-sided earthwork which, when compared with the surrounding ground level, has a significant height on one side of the feature but very little, or no, difference in height discernible on the other. These are frequently, but not exclusively, the result of cultivation on a slope.
Built Structure	A wall, usually drystone, with coursed stone visible.
Orthostat	A single large stone set up on end (excluding those incorporated in dykes).
Stone Setting	Stones which appear to have been placed to form a function, for example supporting the base of either a post or an orthostat.
Crub (abbrev. of *plantiecrub*)	A small drystone enclosure for planting kale, often found in the hill, sometimes on the site of earlier structures. Usually disused.

Table 6.1 Definitions of Feature Type used in recording Boundary Form.

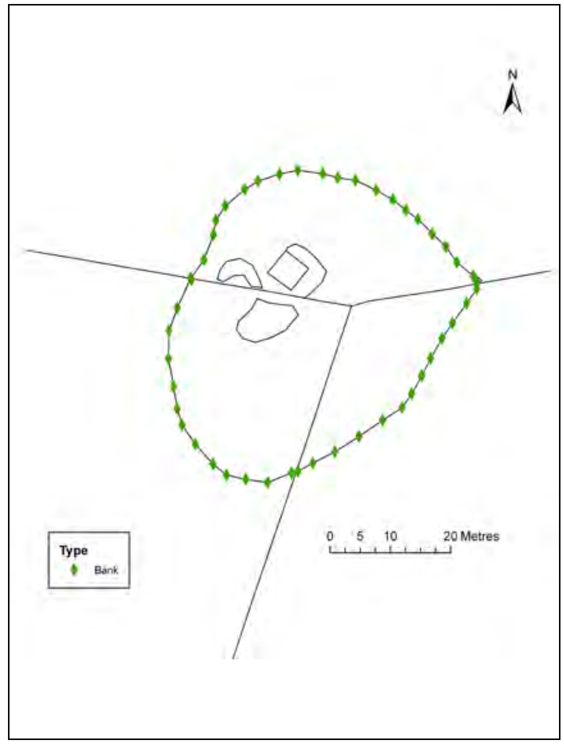
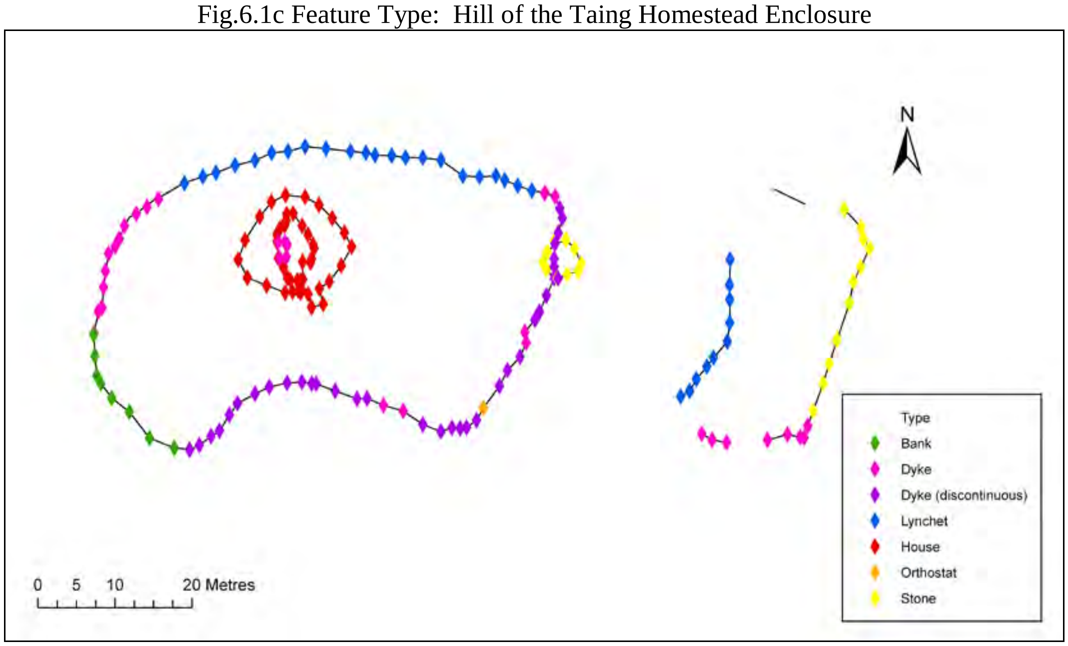


Fig. 6.1a Feature Type: Croag Lea Homestead Enclosure; Fig 6.1b Feature Type: Exnaboe Homestead Enc.

Fig.6.1c Feature Type: Hill of the Taing Homestead Enclosure



(Left) Fig 6.1d Feature Type: Houlland Homestead Enclosure Houlland
(Right) Fig. 6.1e Feature Type: Vassa Homestead Enclosure

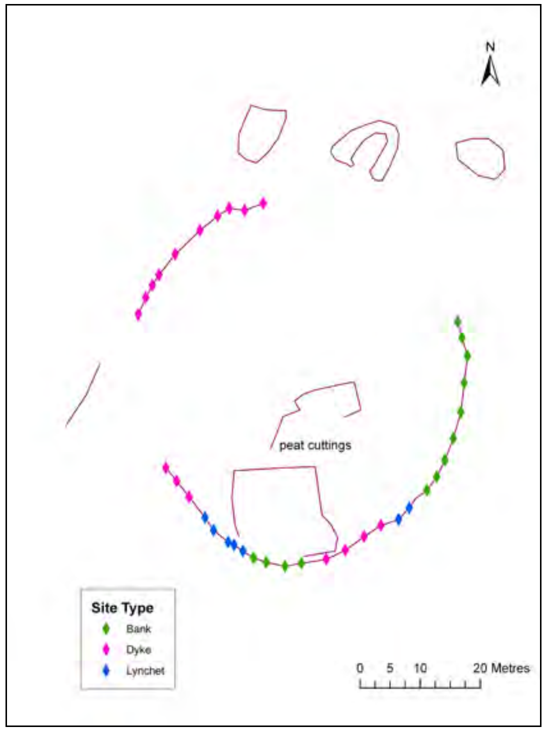
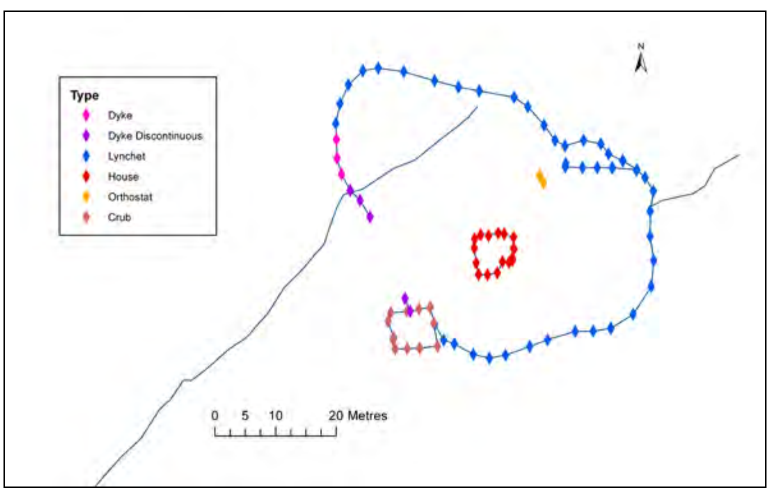
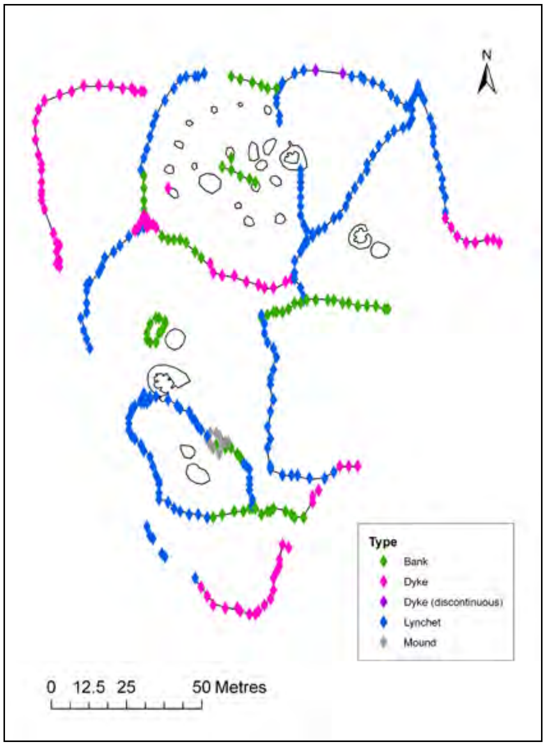


Fig. 6.1f Feature Type: South Newing Homestead Enclosure





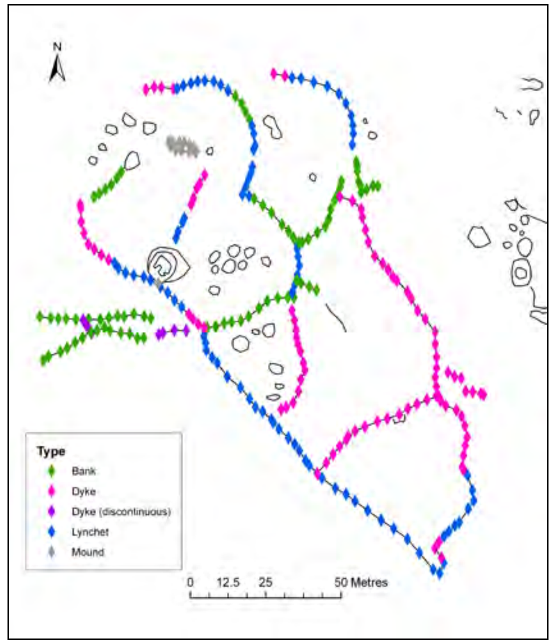


Fig 6.2a (Left) Feature Type: Scord of Brouster Multiple Field System
Fig 6.2b (Right) Feature Type: Gallow Hill Multiple Field System

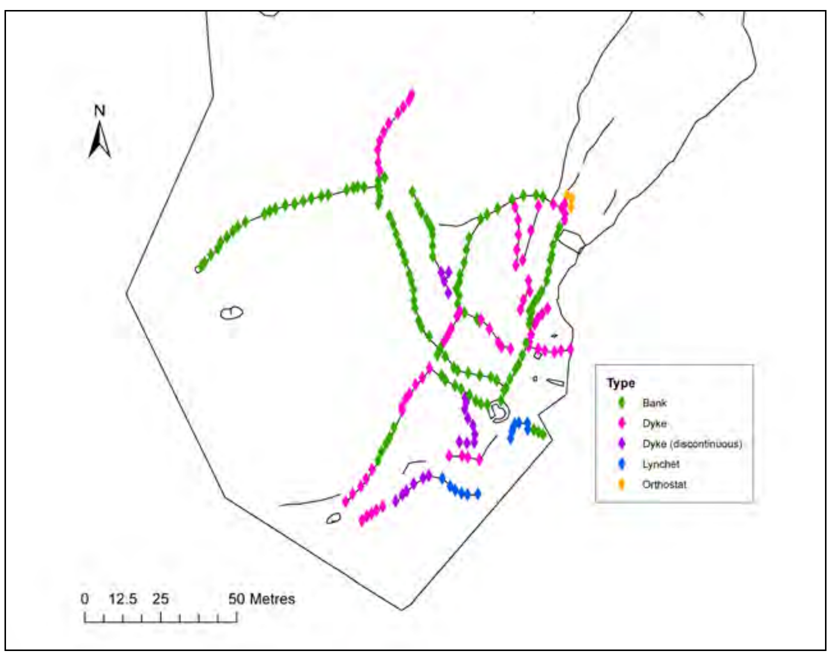
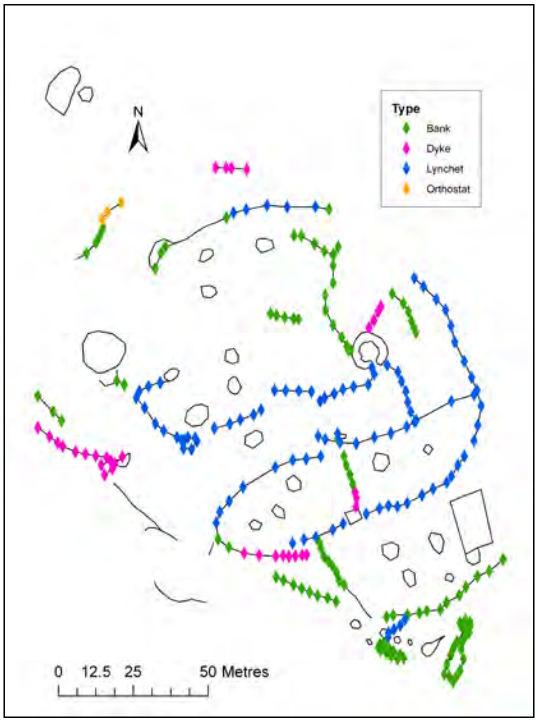


Fig 6.2c Feature Type: Clevigarth Multiple Field System



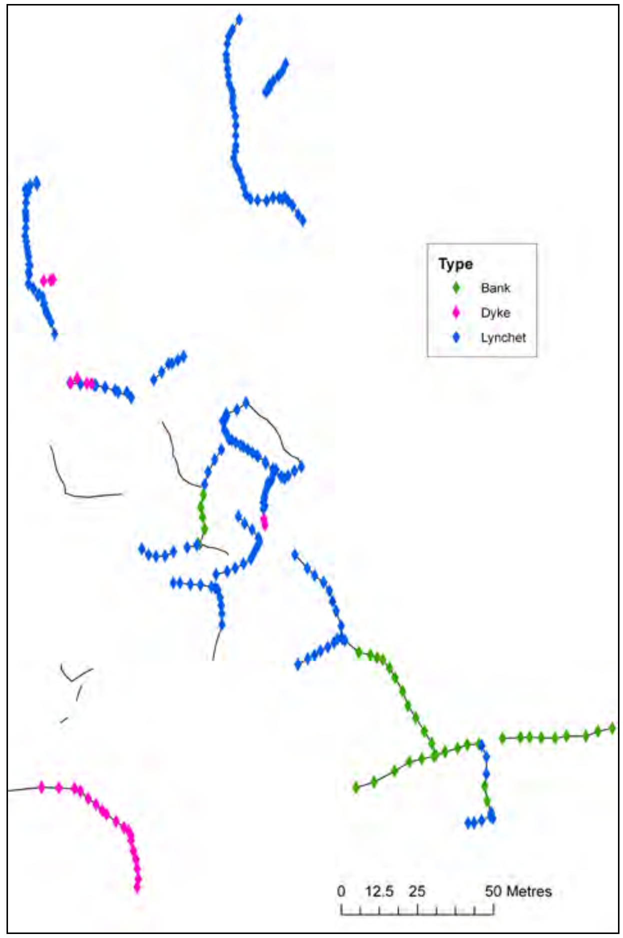
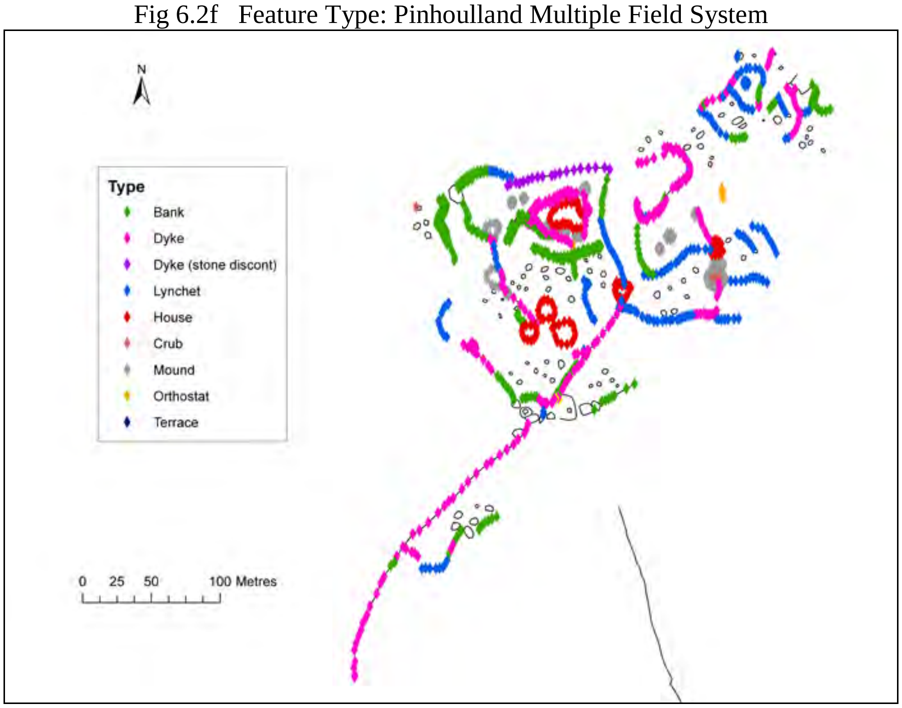
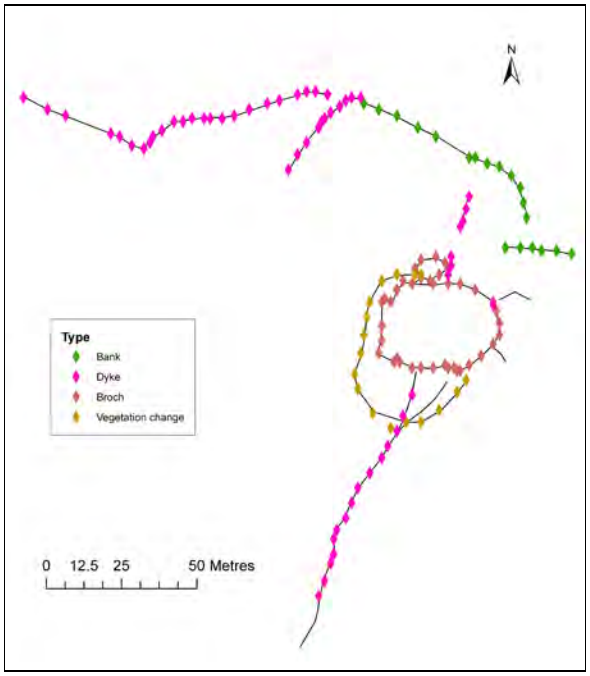


Fig 6.2d (Left) Feature Type: Ness of Gruting Multiple Field System
Fig 6.2e (Right) Feature Type: Sumburgh Head Multiple Field System

Fig 6.2f Feature Type: Pinhoulland Multiple Field System





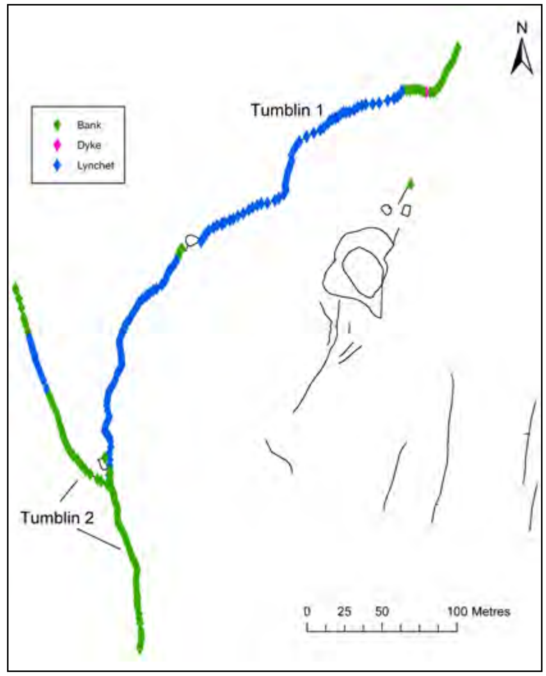


Fig 6.3a (Left) Feature Type: Clevigarth Broch Iron Age Boundaries
Fig 6.3b (Right) Feature Type: Tumblin Broch Iron Age Boundaries

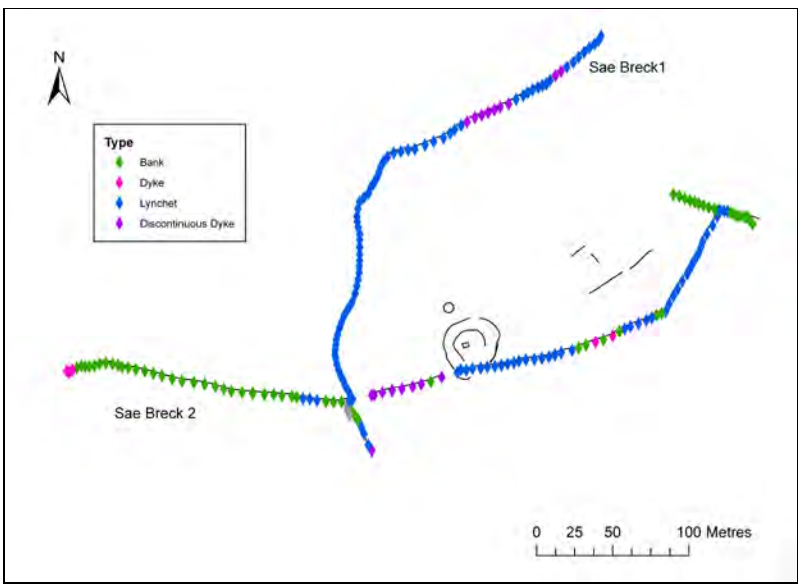


Fig 6.3c Feature Type: Sae Breck Broch Iron Age Boundaries

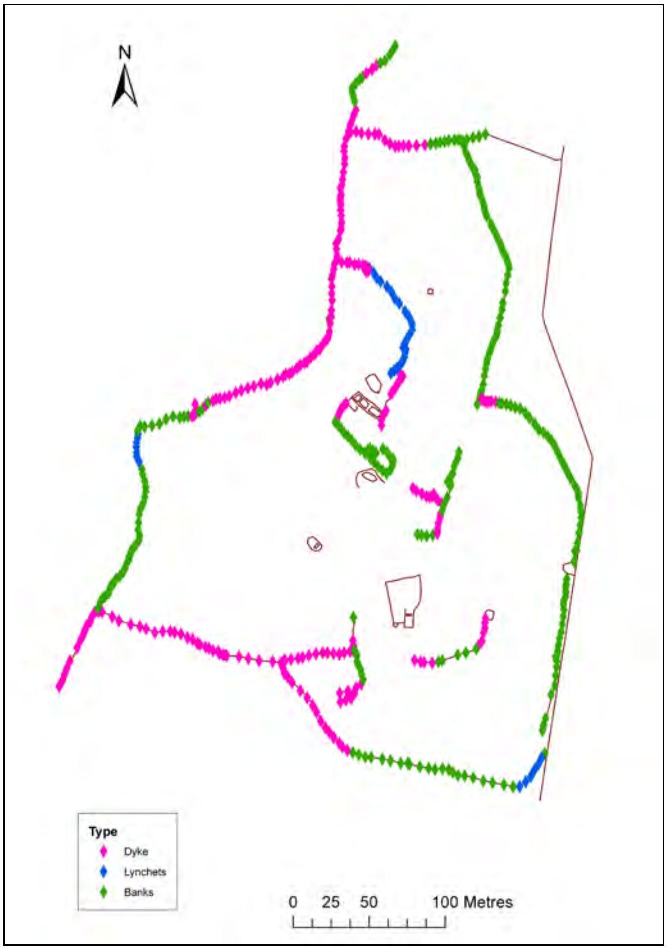
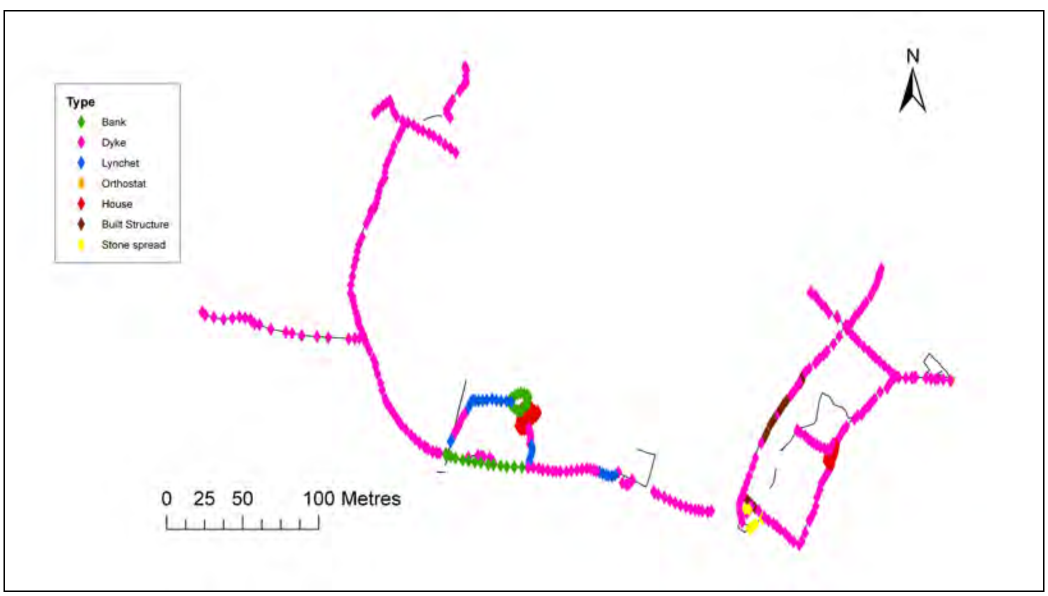


Fig 6.4a Feature Type: Belmont Norse Boundaries

Fig 6.4b Feature Type: Gardie Norse Boundaries



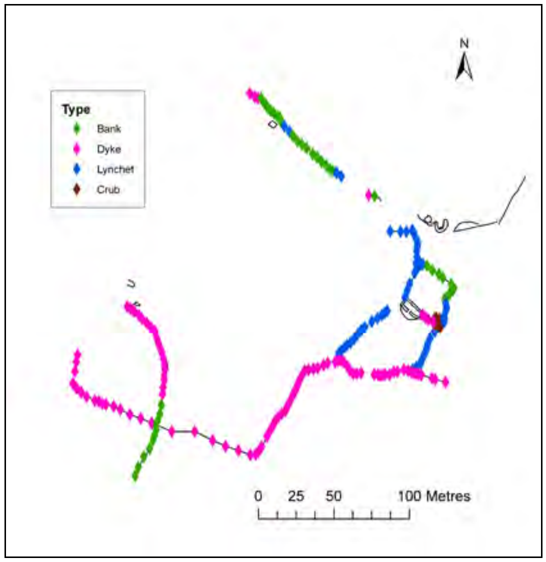


Fig 6.4c Feature Type: Watlie Norse Boundaries

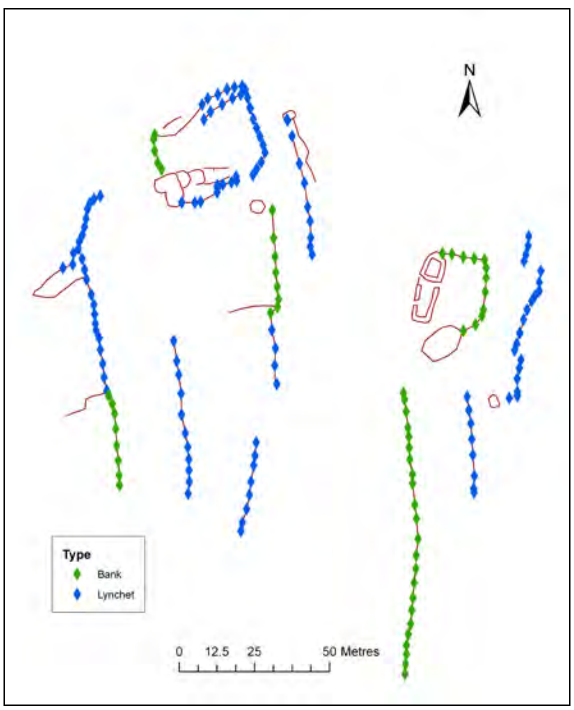


Fig 6.4d Feature Type: Hamar Norse Boundaries

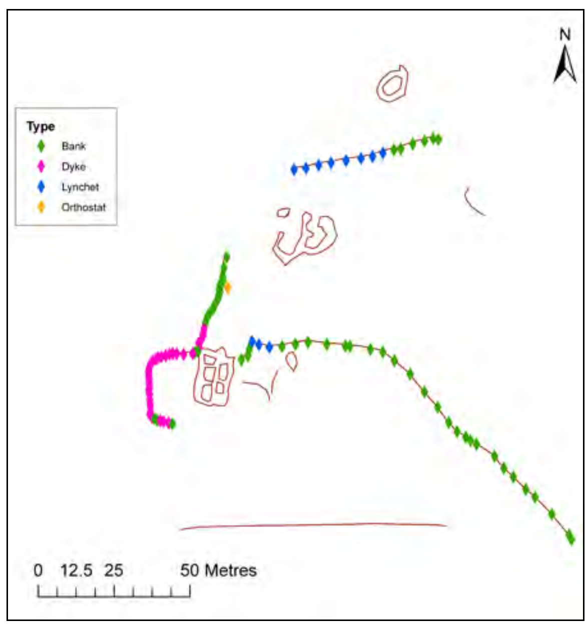


Fig 6.4e Feature Type: Stove Norse Boundaries

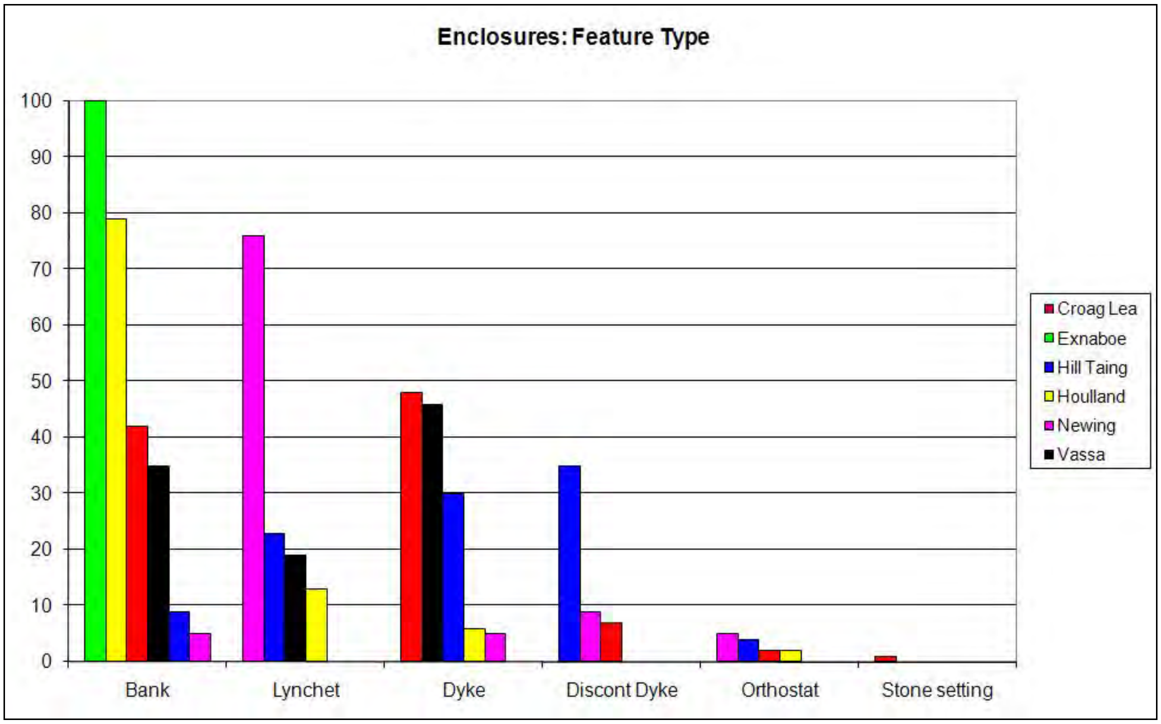


Fig 6.5a Graph showing percentage of points of each Feature Type, recorded per Homestead Enclosure site

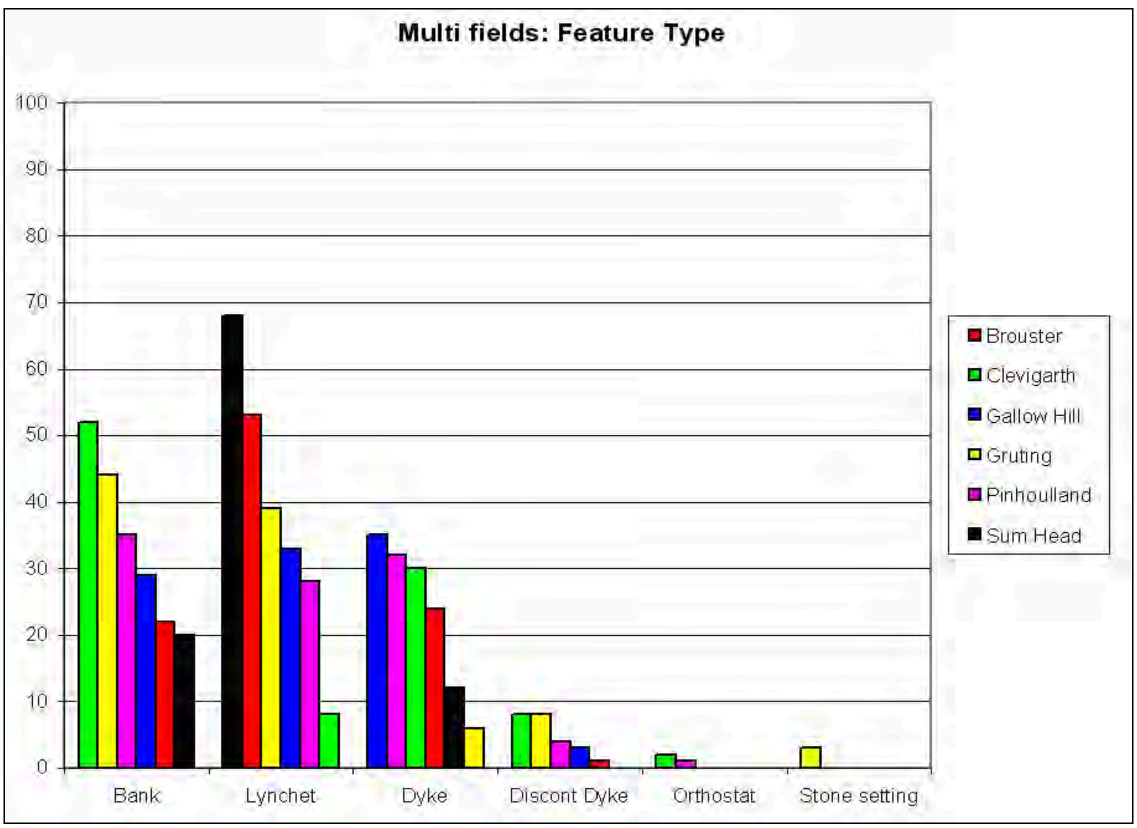


Fig 6.5b Graph showing percentage of points of each Feature Type, recorded per Multiple Field System.

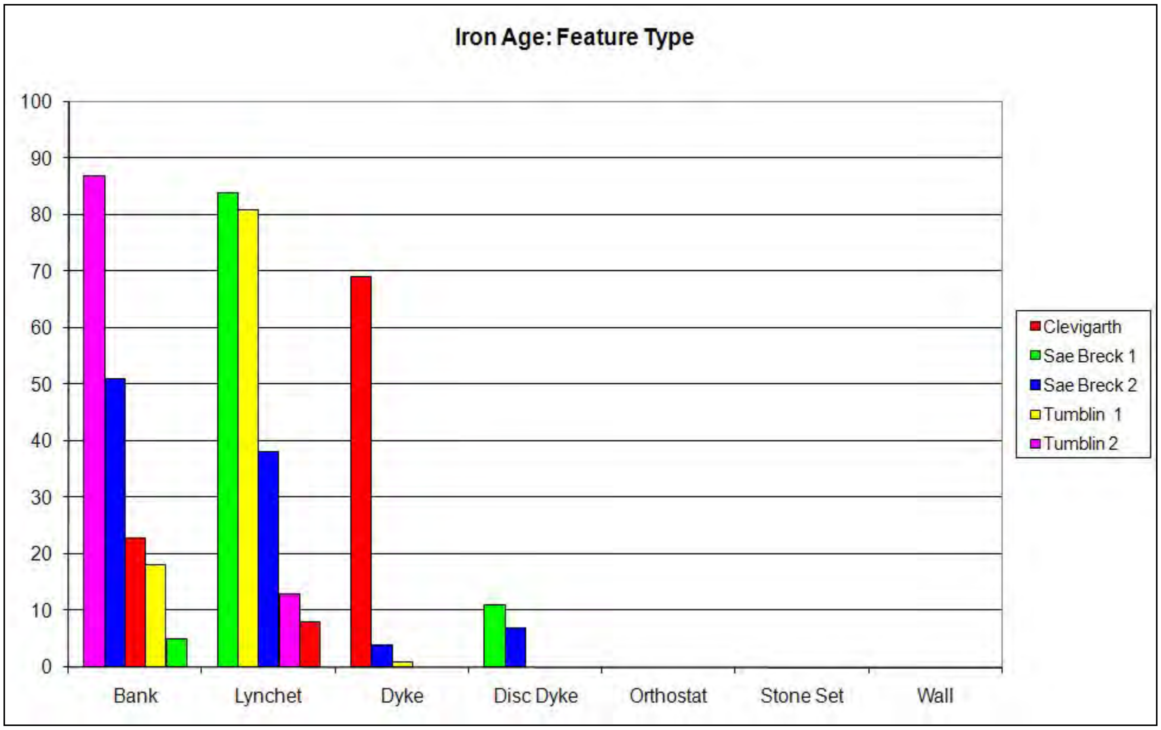


Fig 6.5c Graph showing percentage of points of each Feature Type, recorded per Iron Age Boundary

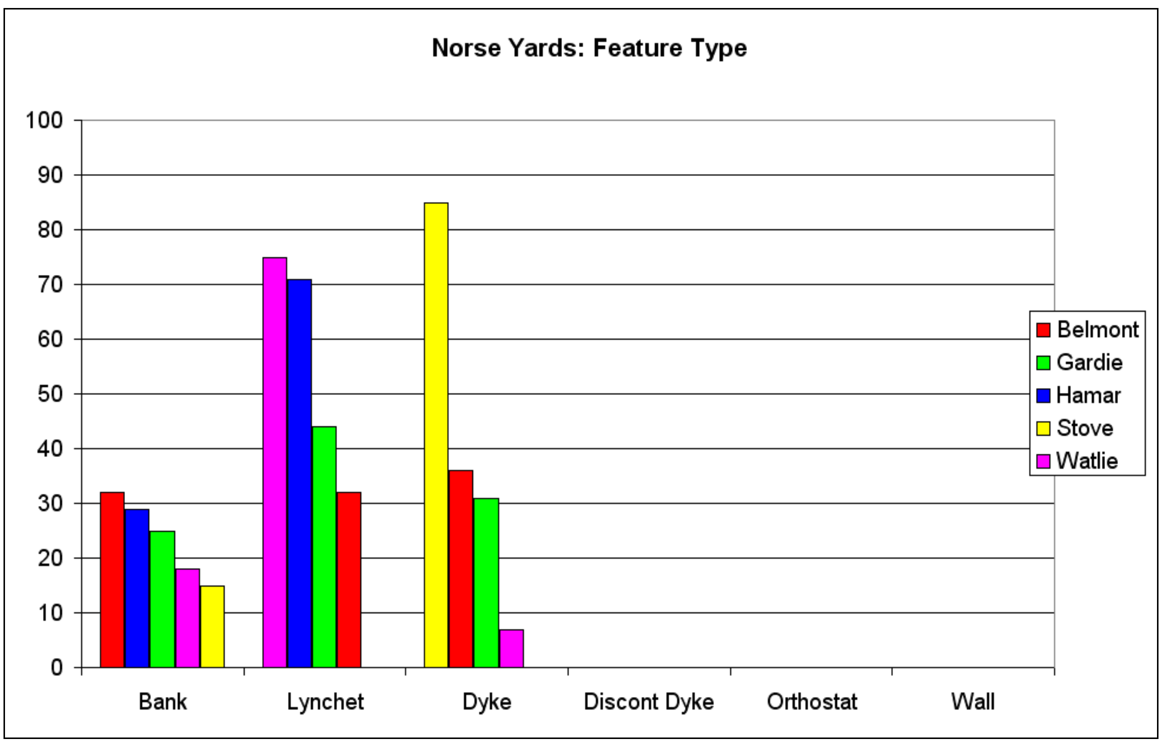


Fig 6.5d Graph showing percentage of points of each Feature Type, recorded per Norse Yard.

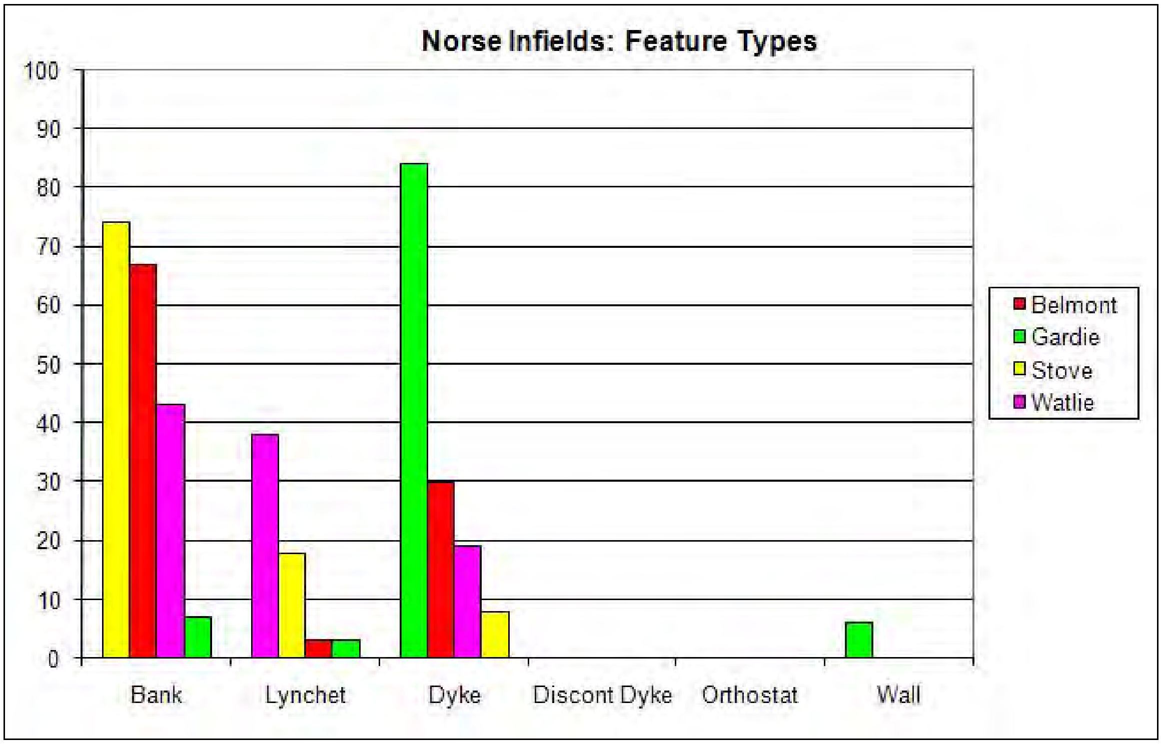


Fig 6.5e Graph showing percentage of points of each Feature Type, recorded per Norse Infield

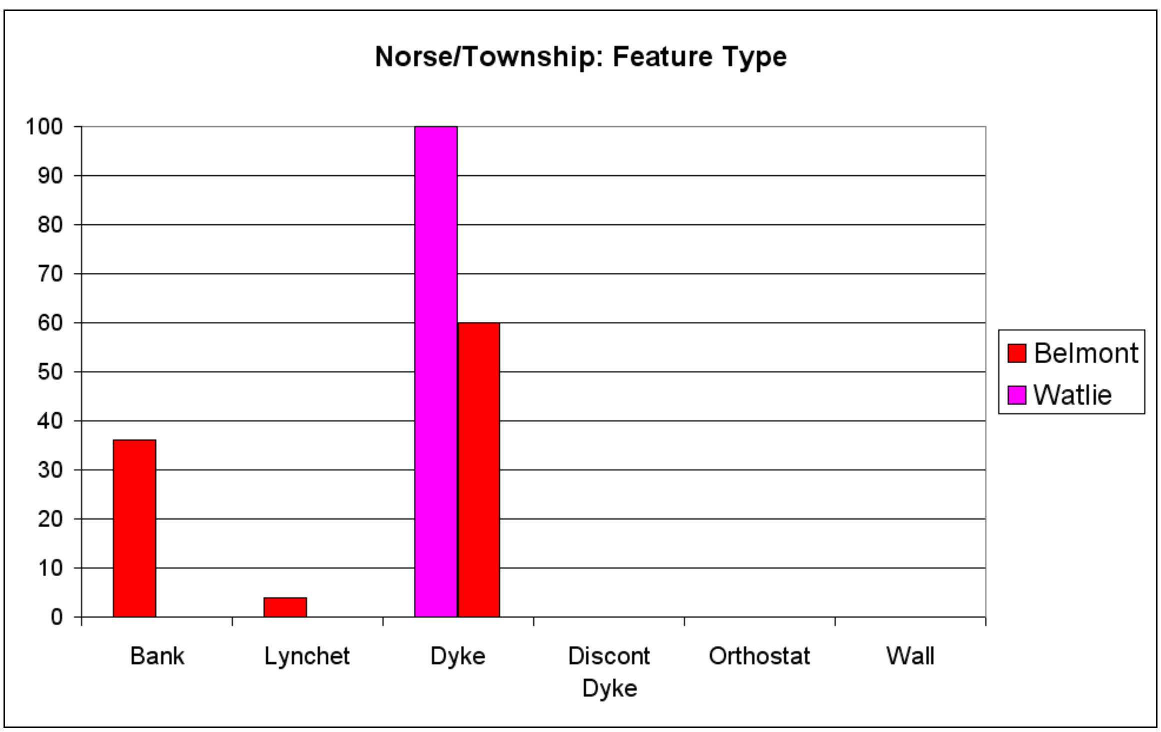
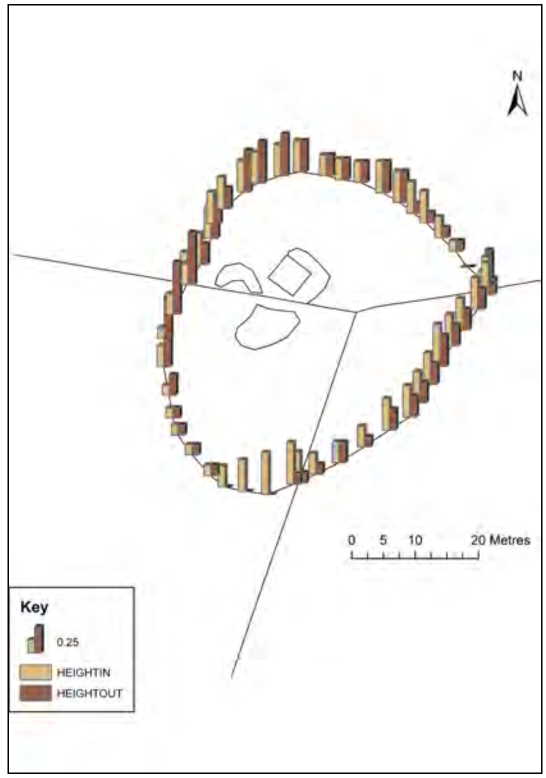


Fig 6.5f Graph showing percentage of points of each Feature Type, recorded per Infield/Township Boundary.

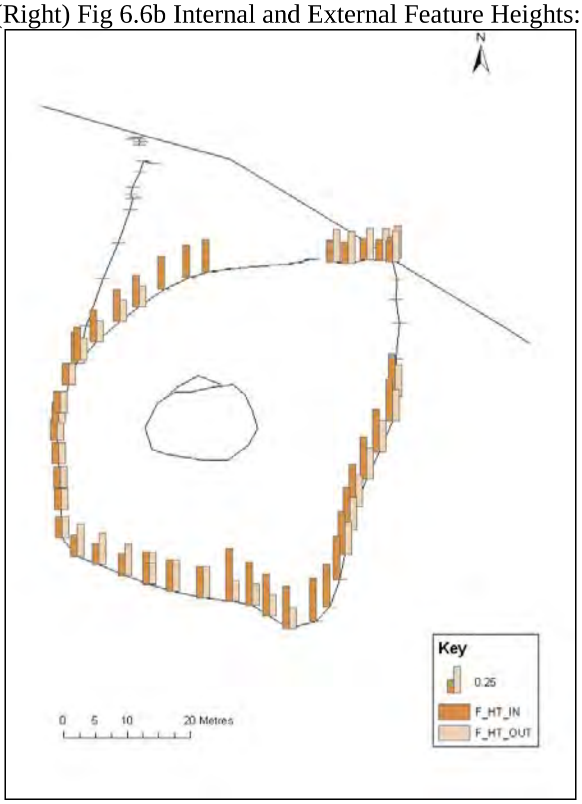
Feature Height

The internal and external feature heights of field boundaries are indicators of the relative ground levels on either side of the boundary. While the ground beneath the boundary itself might slope, this was sufficiently slight to have no discernible impact. The study of feature height applies solely to the earthwork component (i.e. bank and lynchet), only being recorded for a dyke where stones were set into an earthwork, the height applying to the earthwork component. The proportion of boundary measured therefore varied between sites. This does not appear to have impacted on the results. Within the Enclosures, the percentage of earthwork measured varies between 100% and 31%: the results from Houlland (92%) and Vassa (54%) are very similar.

A measurement was recorded on either side of a bank, and one side of a lynchet. The concave, and potentially earlier, face was usually defined as “internal” however the Multiple Field Systems included boundaries shared by more than one field. The proportions of shared boundaries varied between sites. At the two Norse infield boundaries shared with township dykes, the township dykes continued beyond the infield; in both cases the faces were defined as being internal and external with respect to the township to the west. At Watlie the township and the infield areas coincide (west of the boundary) but at Belmont the infield is to the east and the township to the west.

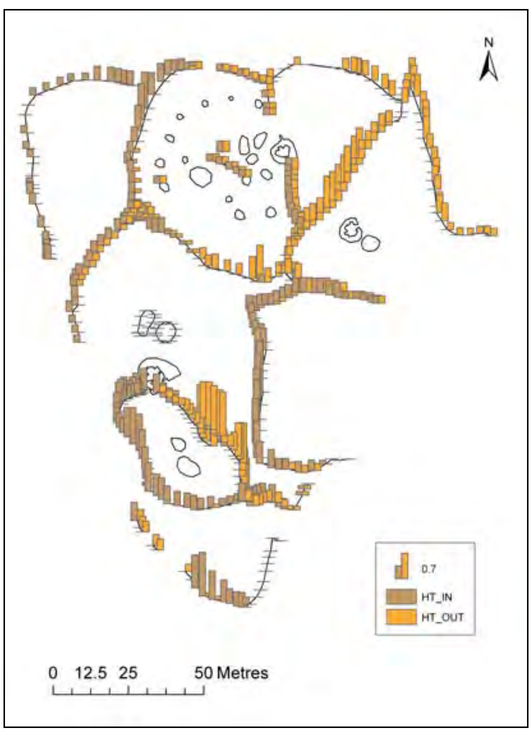


(Left) Fig 6.6a Internal and External Feature Heights: Croag Lea Homestead Enclosure;
(Right) Fig 6.6b Internal and External Feature Heights: Exnaboe Homestead Enclosure



(Left) Fig 6.6c Internal and External Feature Heights: Houlland Homestead Enclosure
(Right) Fig 6.6d Internal and External Feature Heights: Vassa Homestead Enclosure

Fig 6.6e Internal and External Feature Heights: South Newing Homestead Enclosure



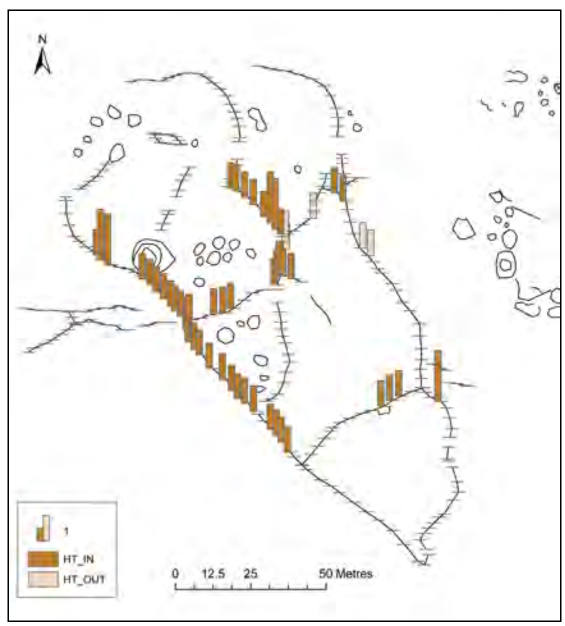
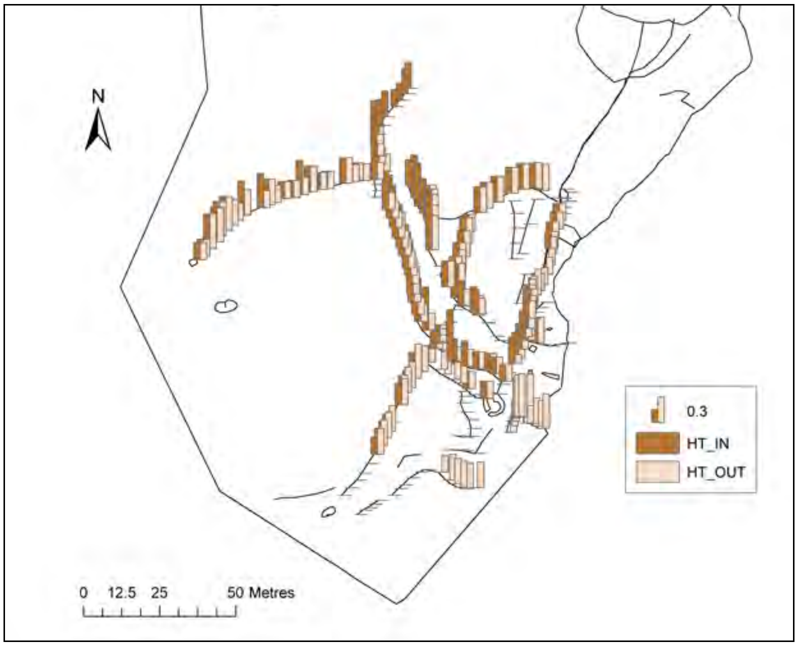


Fig 6.7a (Left) Internal and External Feature Heights: Scord of Brouster Multiple Field Systems
Fig 6.7b (Right) Internal and External Feature Heights: Gallow Hill Multiple Field Systems

Fig 6.7c Internal and External Feature Heights: Clevigarth Multiple Field System



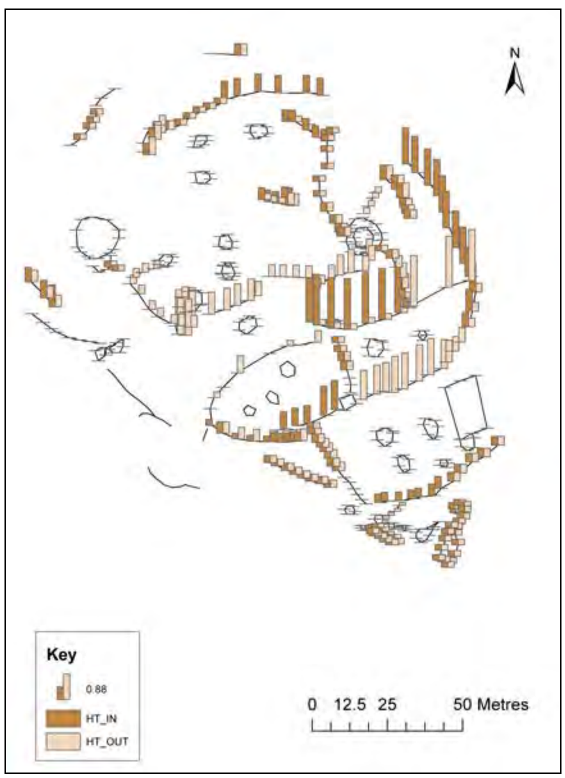


Fig 6.7d Internal and External Feature Heights: Ness of Gruting Multiple Field System

Fig 6.7e Internal and External Feature Heights: Pinhoulland Multiple Field System

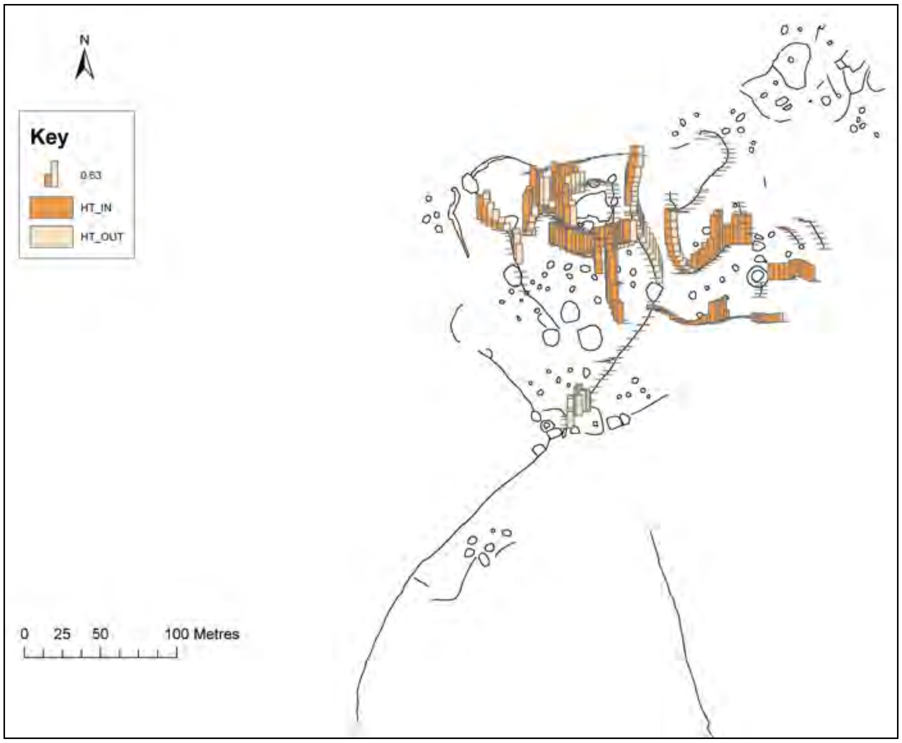
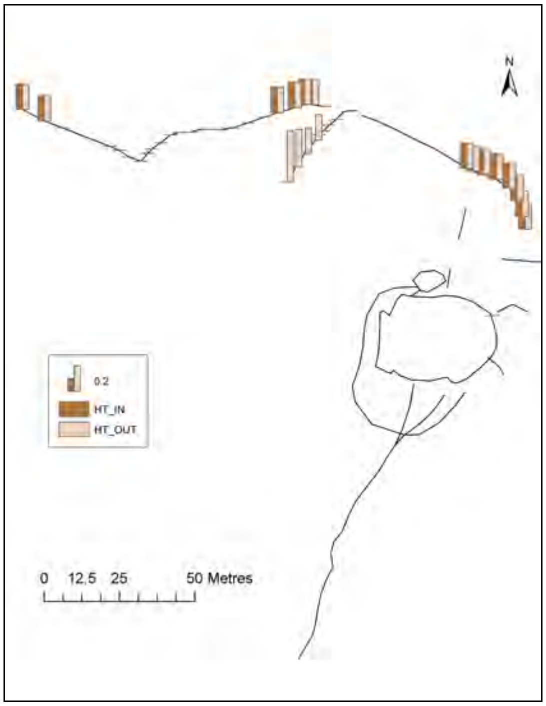


Fig 6.7f Internal and External Feature Heights: Sumburgh Head Multiple Field System



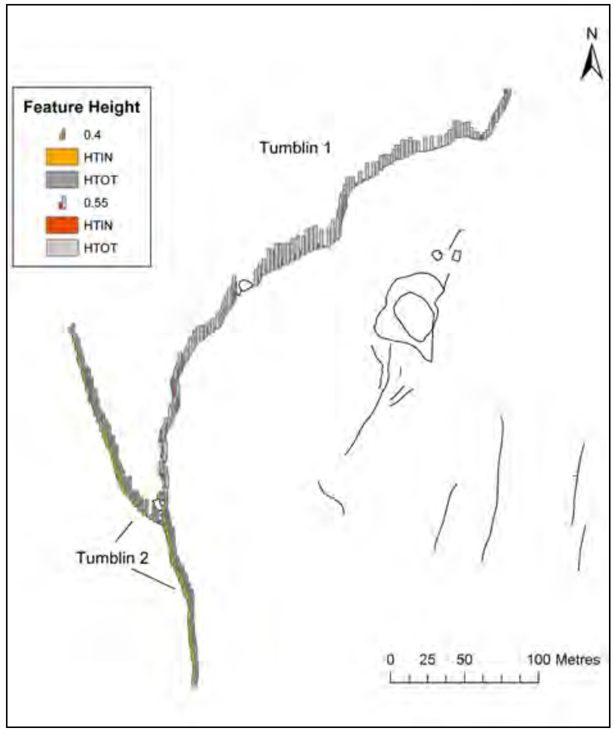


Fig 6.8a (Left) Internal and External Feature Heights: Clevigarth Iron Age Boundary
Fig 6.8b (Right) Internal and External Feature Heights: Tumblin Iron Age Boundary

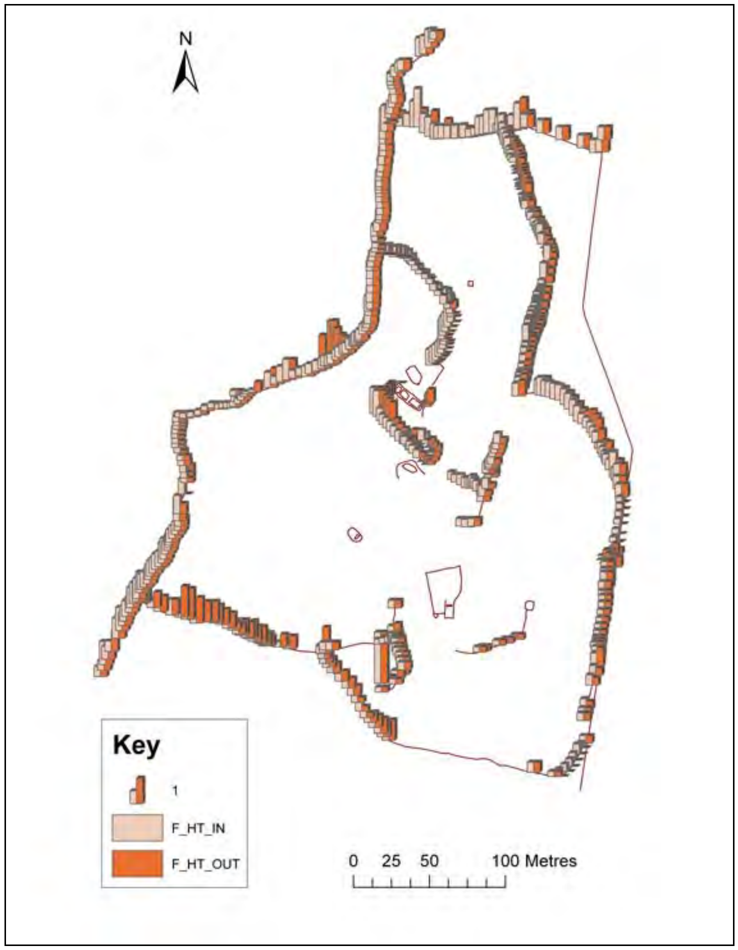


Fig 6.9a Internal and External Feature Heights: Belmont Norse Boundaries

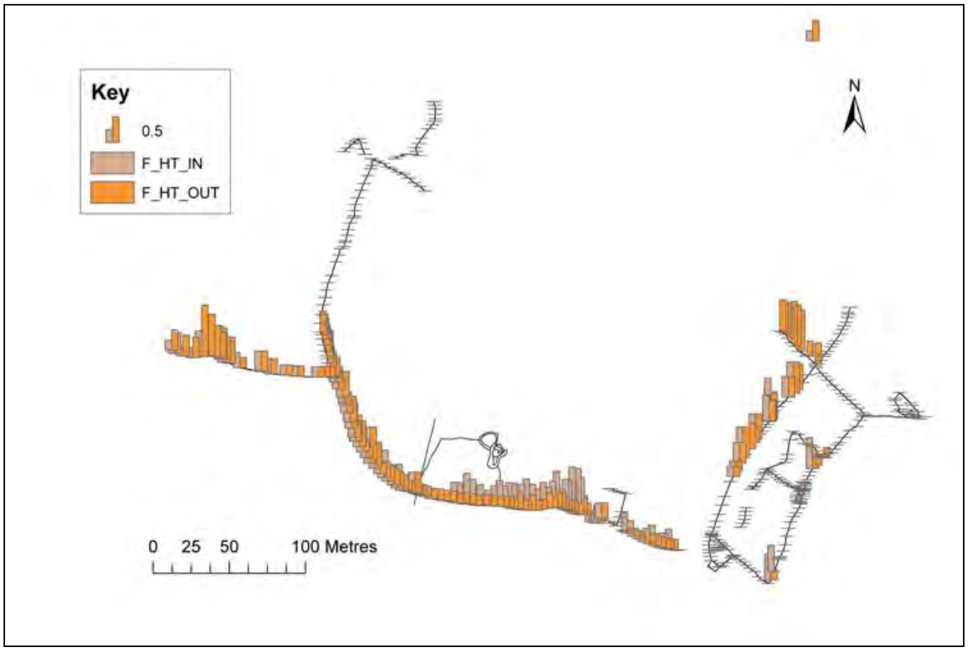
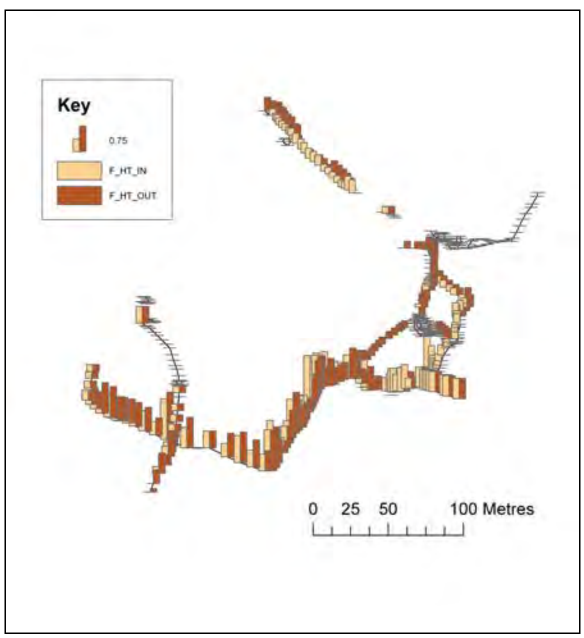
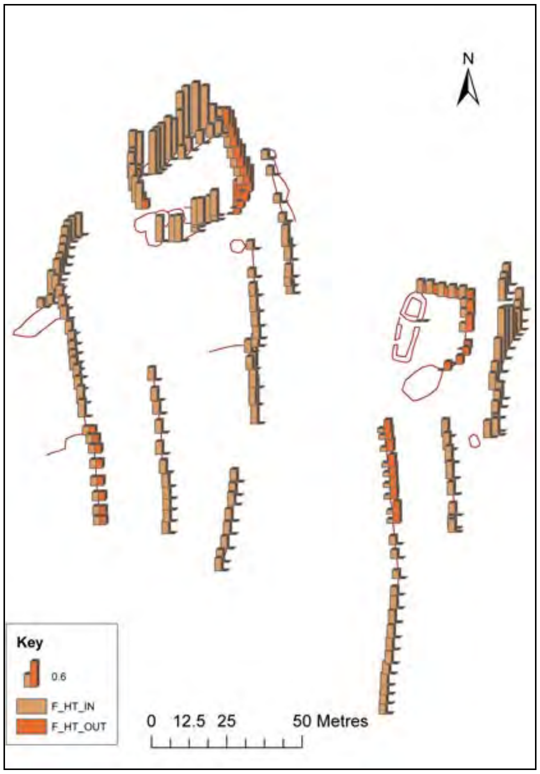


Fig 6.9b Internal and External Feature Heights: Gardie Norse Boundaries

Fig 6.9c Internal and External Feature Heights: Watlie Norse Boundaries





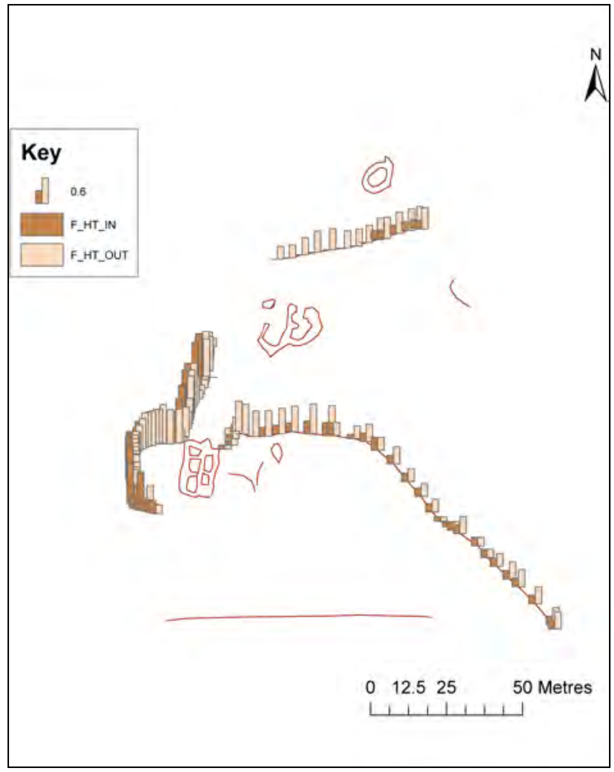


Fig 6.9d (Left) Internal and External Feature Heights: Hamar Norse Boundaries
Fig 6.9e (Right) Internal and External Feature Heights: Stove Norse Boundaries

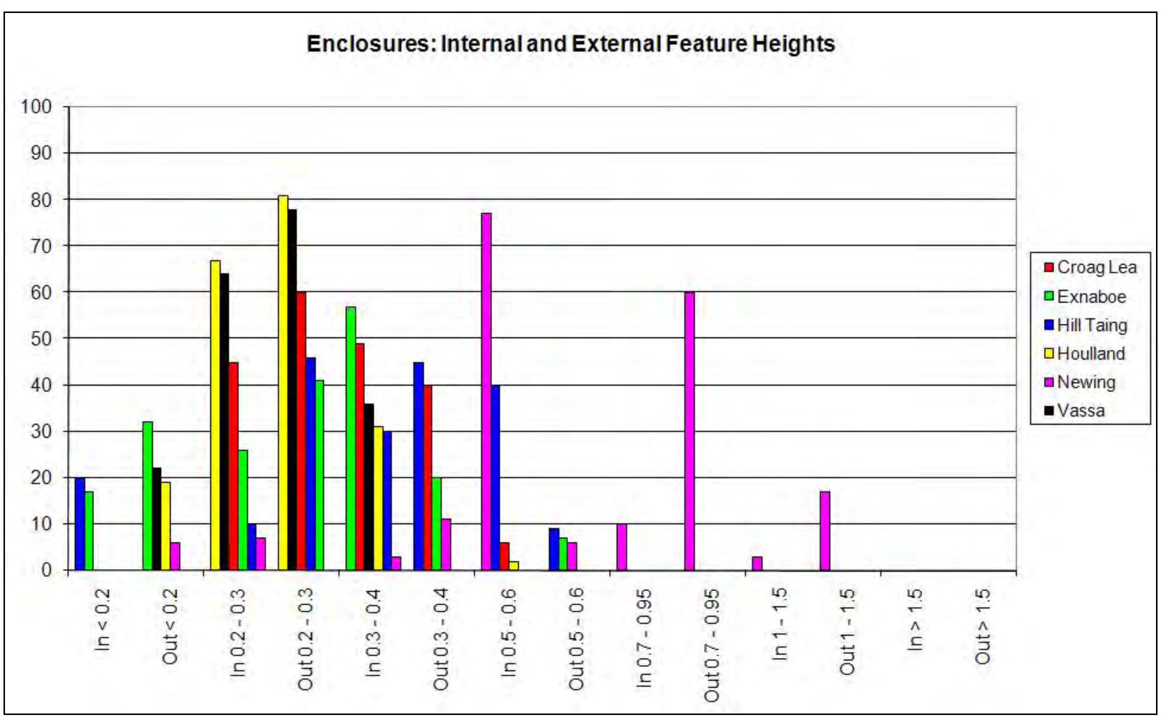


Fig 6.10a Graph showing percentage of points of Internal and External Feature Height recorded per Homestead Enclosure Site

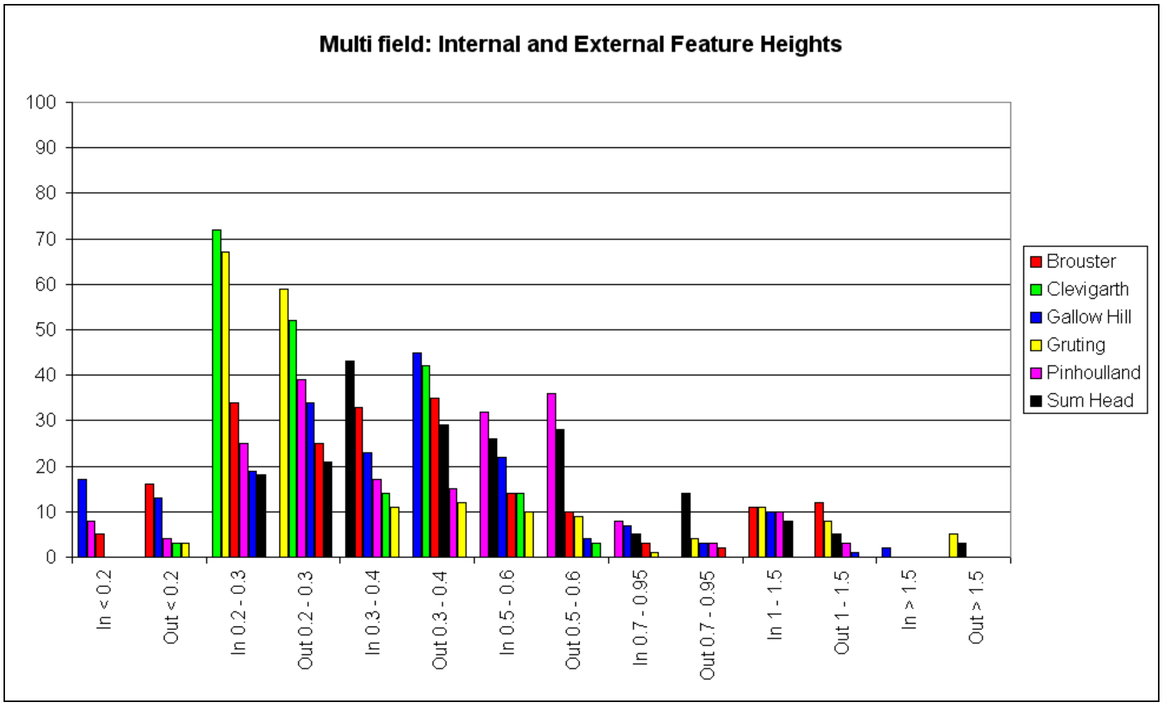


Fig 6.10b Graph showing percentage of points of Internal and External Feature Height recorded per Multiple Field System.

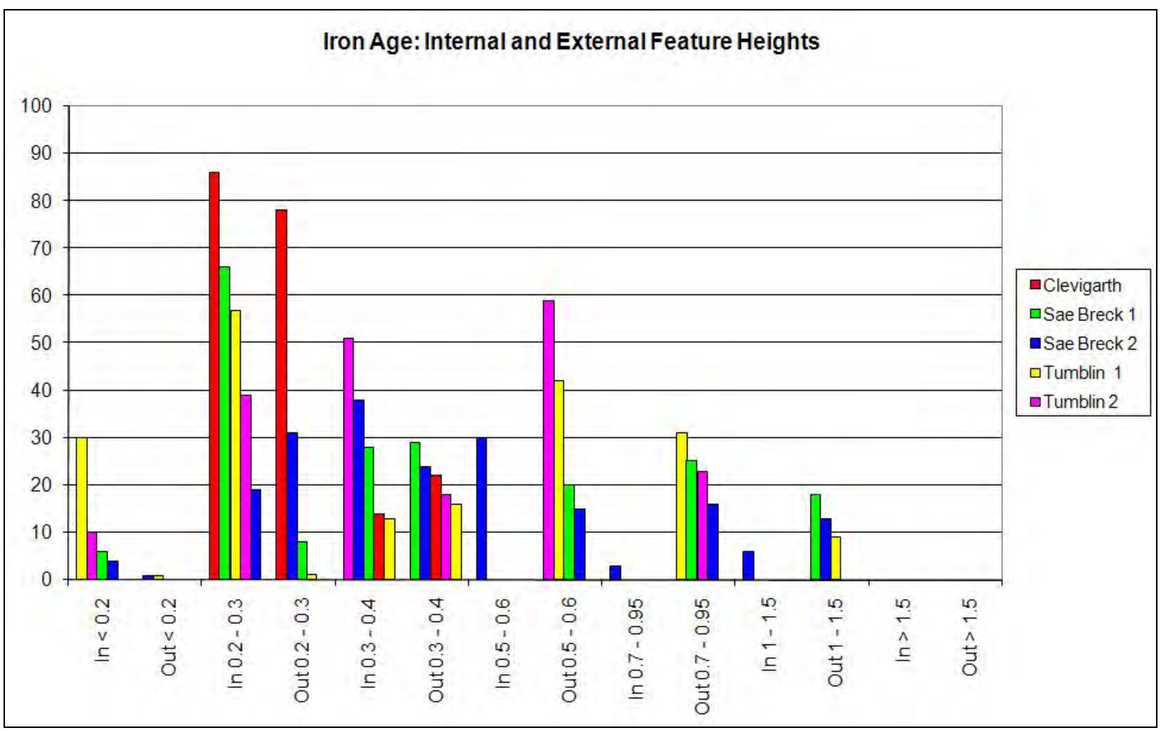


Fig 6.10c Graph showing percentage of points of Internal and External Feature Height recorded per Iron Age site.

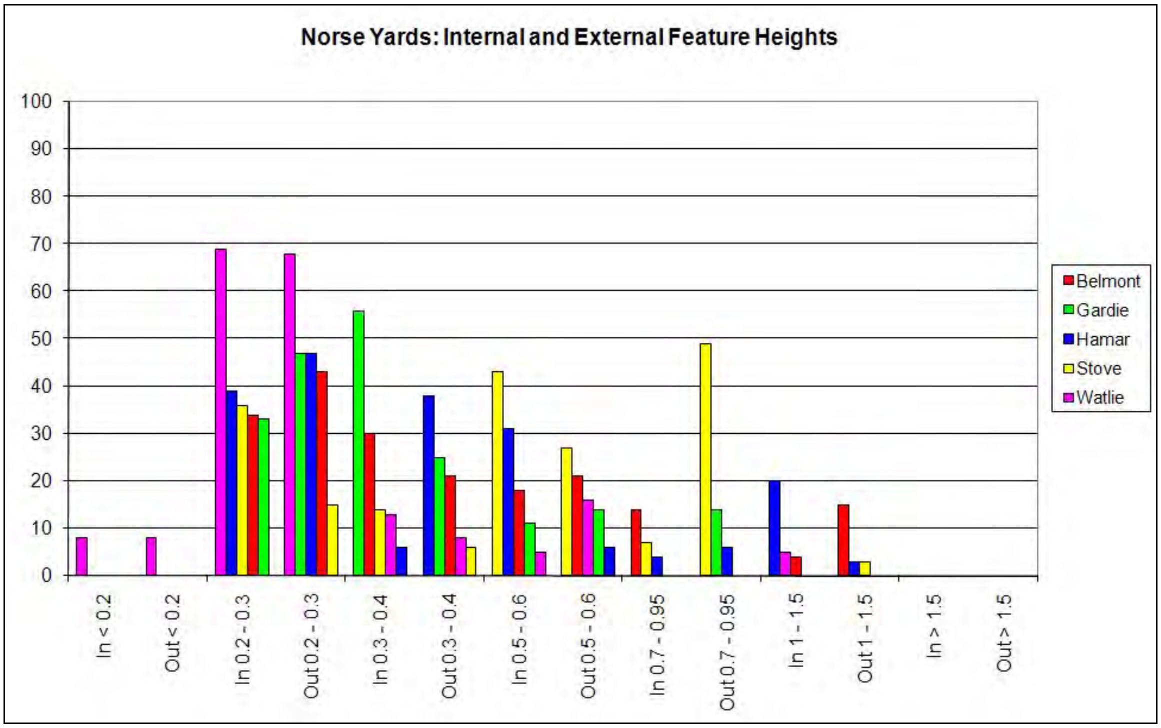


Fig 6.10d Graph showing percentage of points of Internal and External Feature Height recorded per Norse Yard

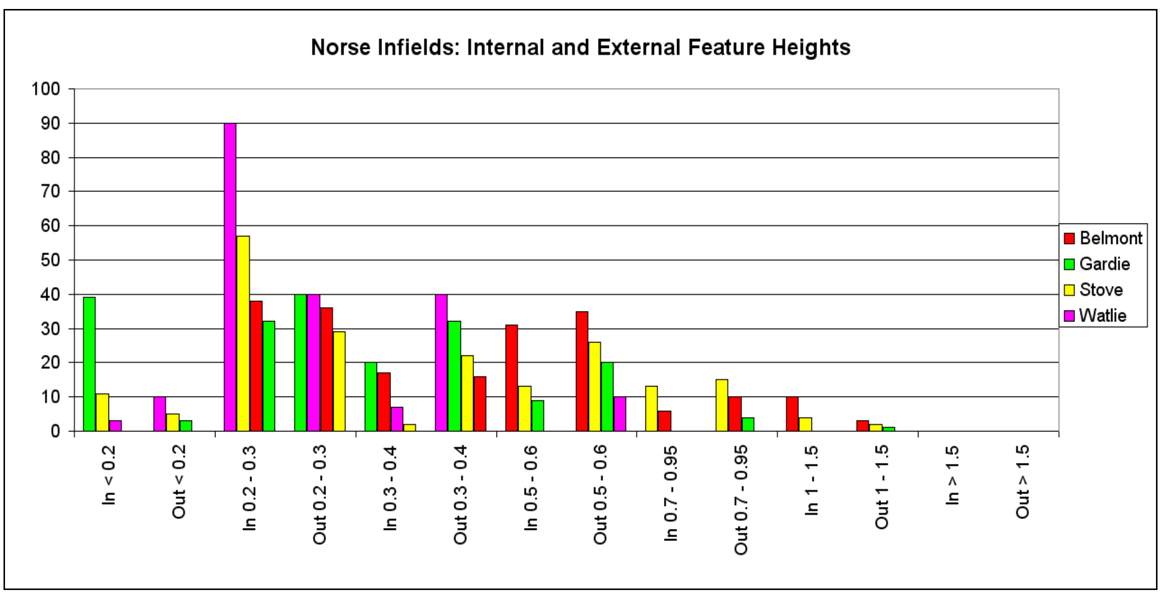


Fig 6.10e Graph showing percentage of points of Internal and External Feature Height recorded per Norse Infield Boundary

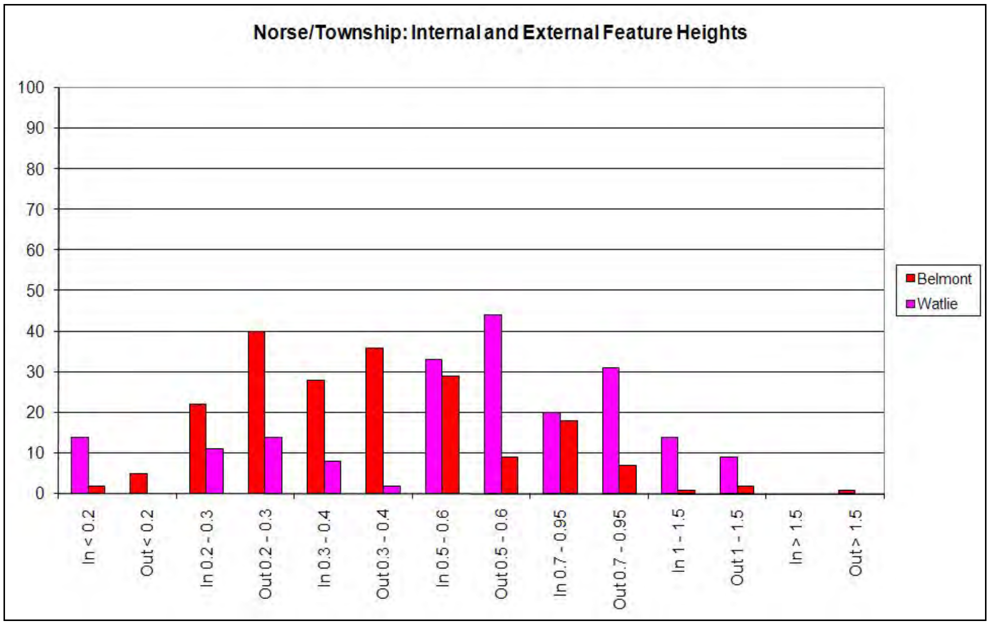


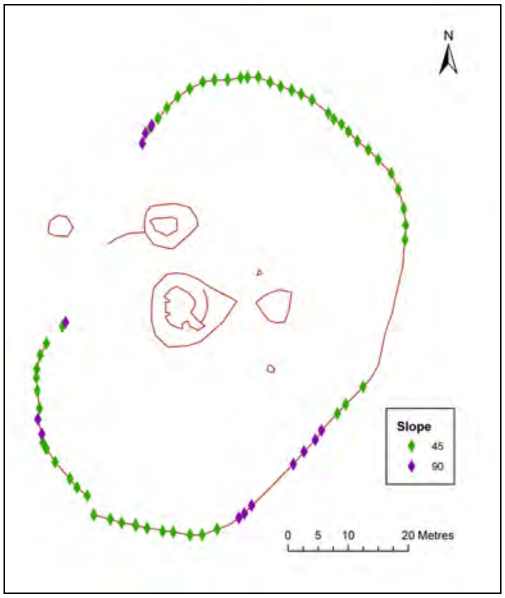
Fig 6.10f Graph showing percentage of points of Internal and External Feature Height recorded per Norse Infield/Township Boundary

Angle of Slope

The angle of slope was defined as the angle of the dominant, or higher, face of an earthwork (dykes were largely excluded). The angle was recorded as either 33, 45 or 90 degrees, whichever most closely corresponded. It was expected that the angle of slope would produce an objective method of determining how well-defined a feature was, providing a measure of its survival. However, survival and definition corresponded less than anticipated: a slope of 33º could be either clearly- or ill-defined, depending on the nature of the surrounding ground, although ill-defined features almost always had a 33º slope. In some cases it was difficult to determine the edge of a shallow slope. Angles were, however, found to be a useful shorthand for describing slope type (table 6.2).

	Definition applied
90º	Usually stone revetted, occasionally a stone or outcrop protruding from the face.
45º	Slope which is fairly steep, closer to 45 º than 33º or 90º.
33º	Diffuse or shallow slope, closest to 33º and also including slopes of a very small angle.

Table 6.2 Definitions of Angle of Slope used in recording Boundary Form.



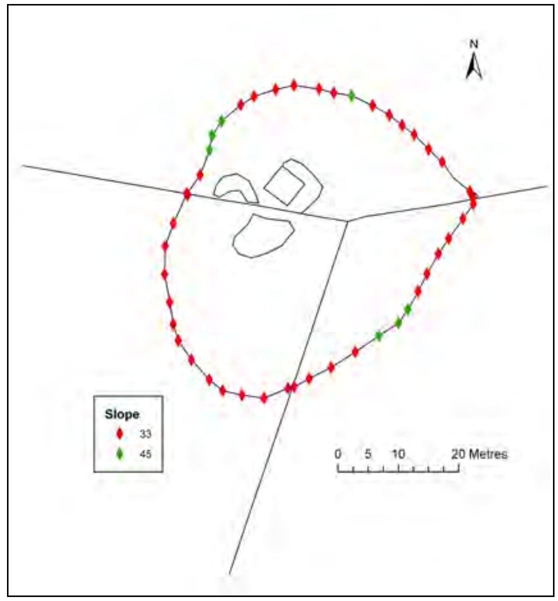
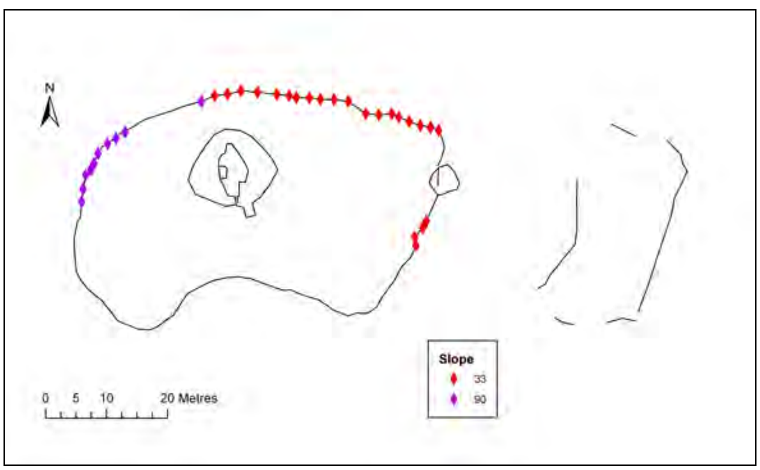
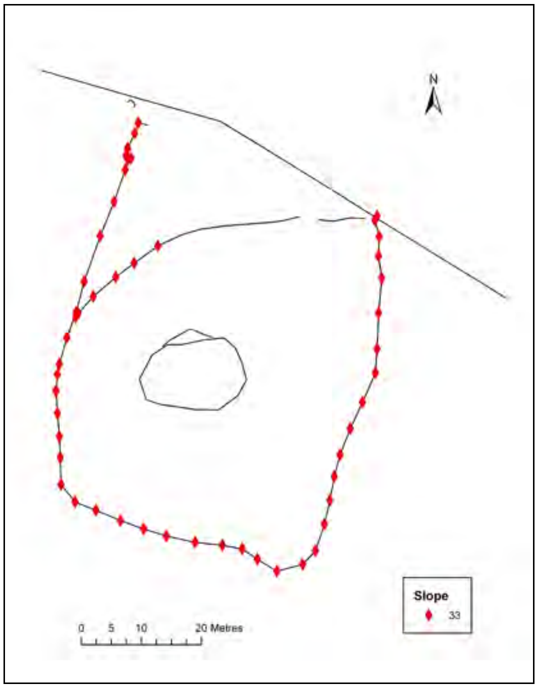


Fig 6.11a (Left) Angle of Slope: Croag Lea Homestead Enclosure
Fig 6.11b (Right) Angle of Slope: Exnaboe Homestead Enclosure

Fig 6.11c Angle of Slope: Hill of the Taing Homestead Enclosure





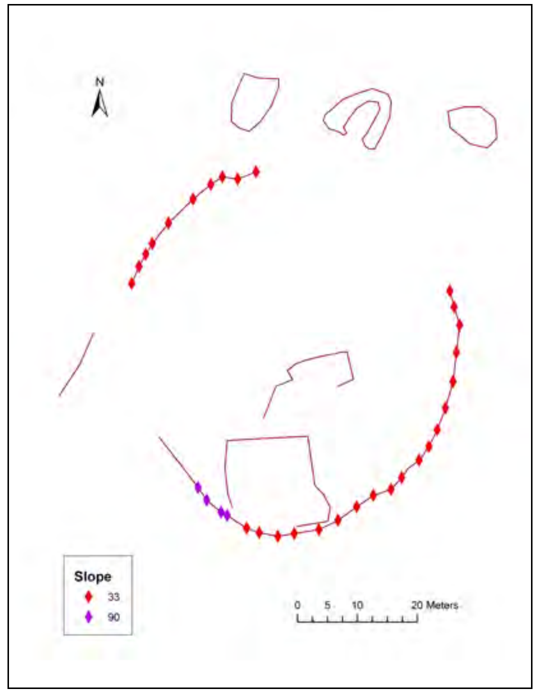
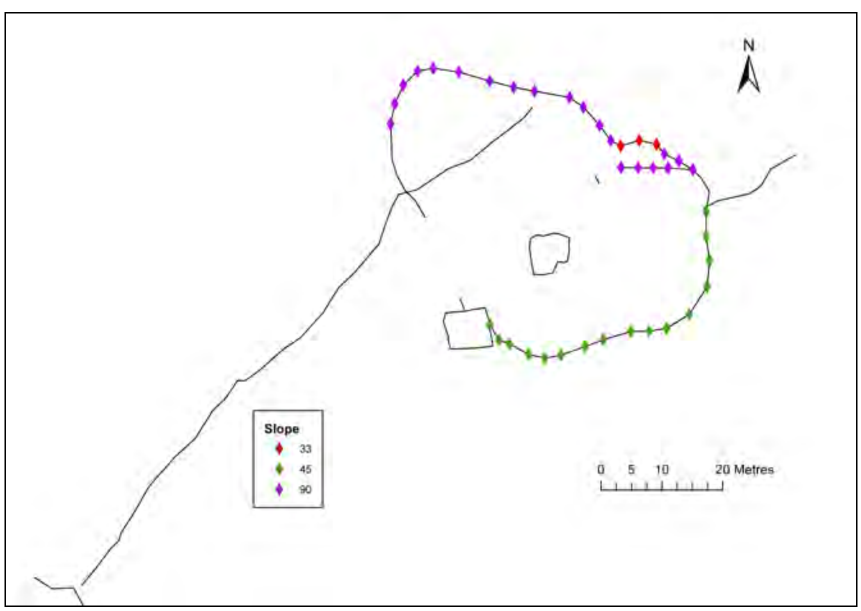
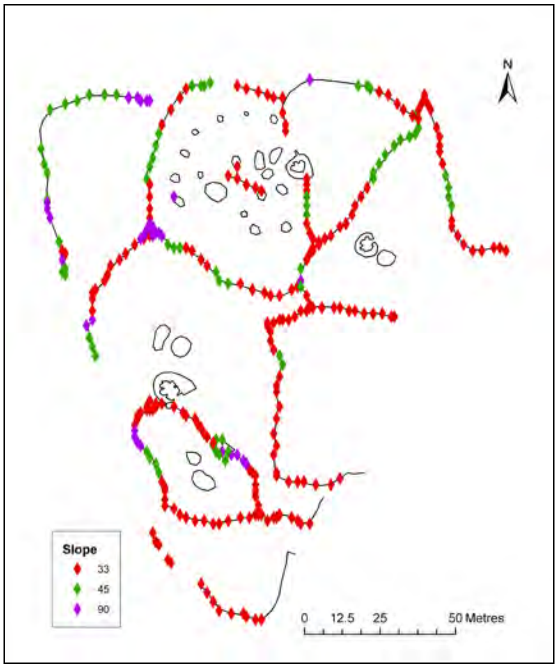
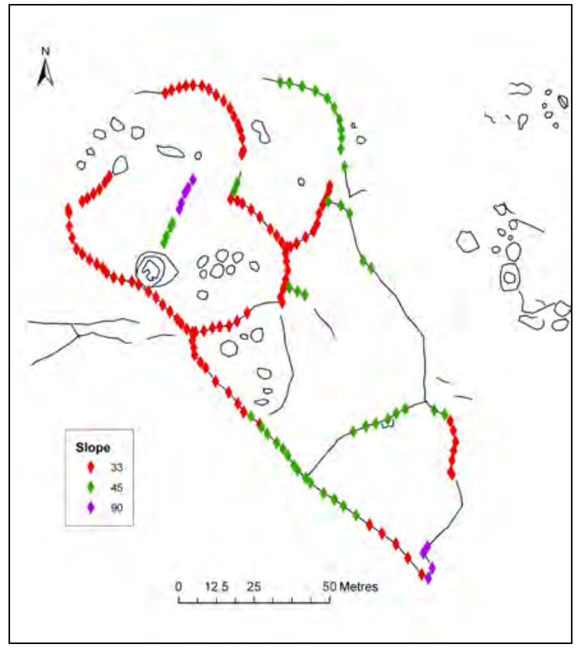


Fig 6.11d (Left) Angle of Slope: Houlland Homestead Enclosure
Fig 6.11e (Right) Angle of Slope: Vassa Homestead Enclosure

Fig 6.11f Angle of Slope: South Newing Homestead Enclosure







(Left) Fig 6.12a Angle of Slope: Scord of Brouster Multiple Field System
(Right) Fig 6.12b Angle of Slope: Gallow Hill Multiple Field System

Fig 6.12c Angle of Slope: Clevigarth Multiple Field System

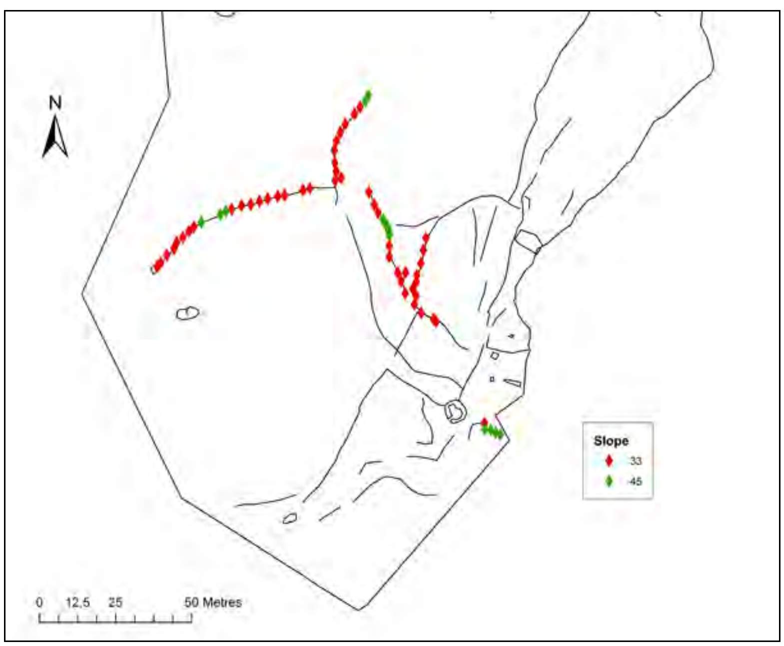


Fig 6.12d Angle of Slope: Ness of Gruting Multiple Field System

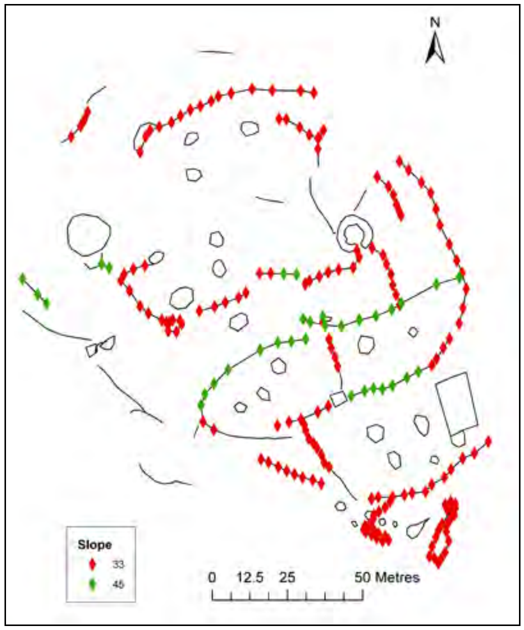


Fig 6.12e Angle of Slope: Pinhoulland Multiple Field System

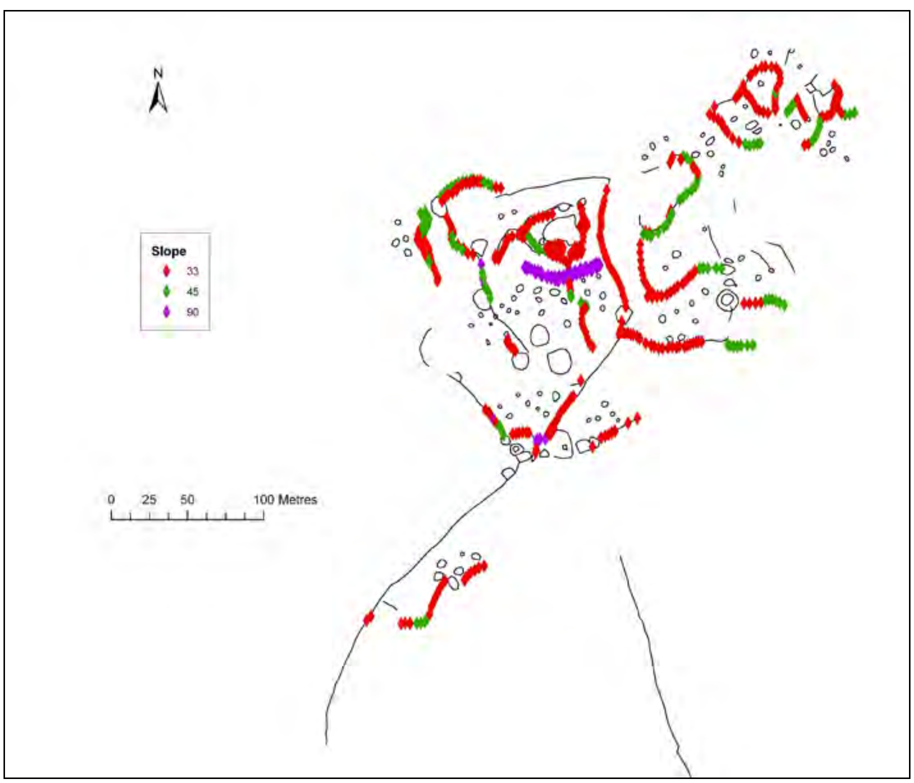


Fig 6.12f Angle of Slope: Sumburgh Head Multiple Field System

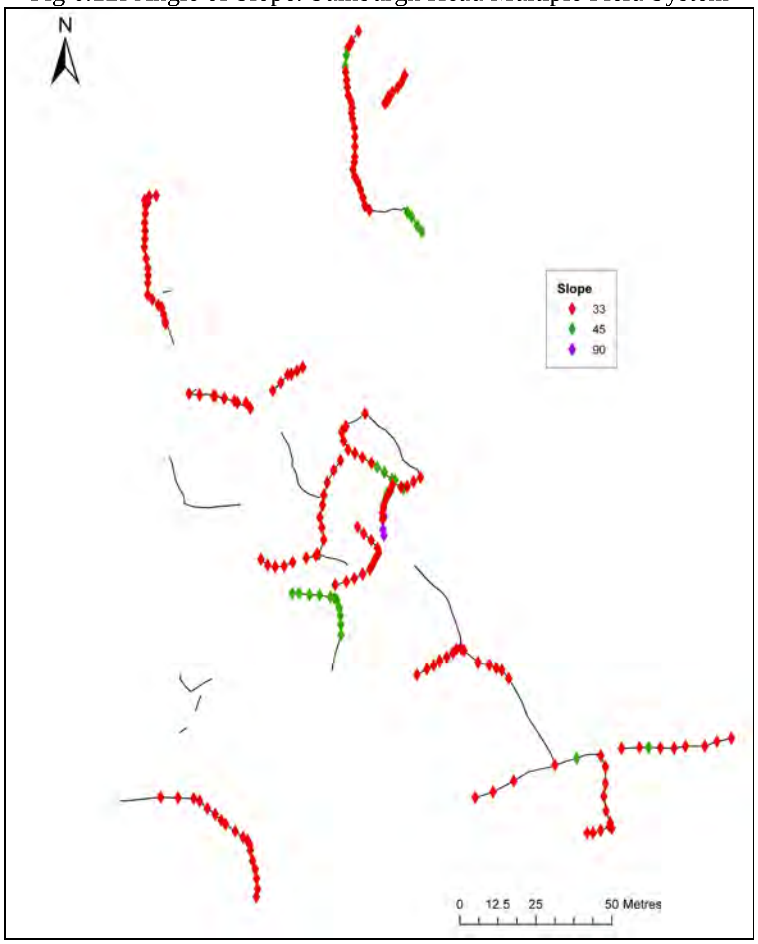
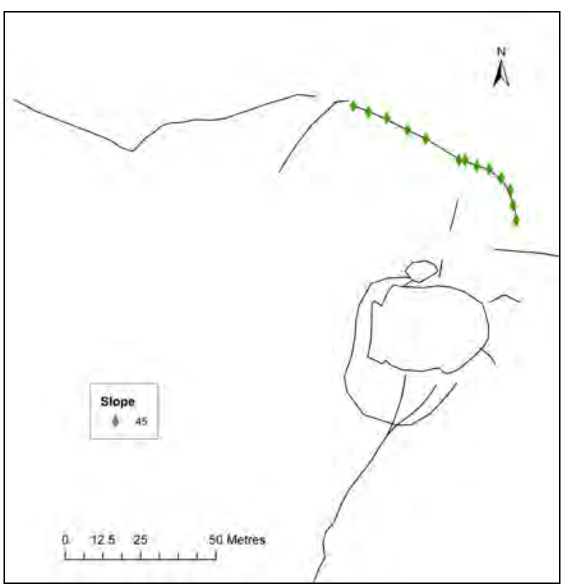


Fig 6.13a Angle of Slope: Clevigarth Broch Boundary; Fig 6.13b Tumblin Broch Boundaries



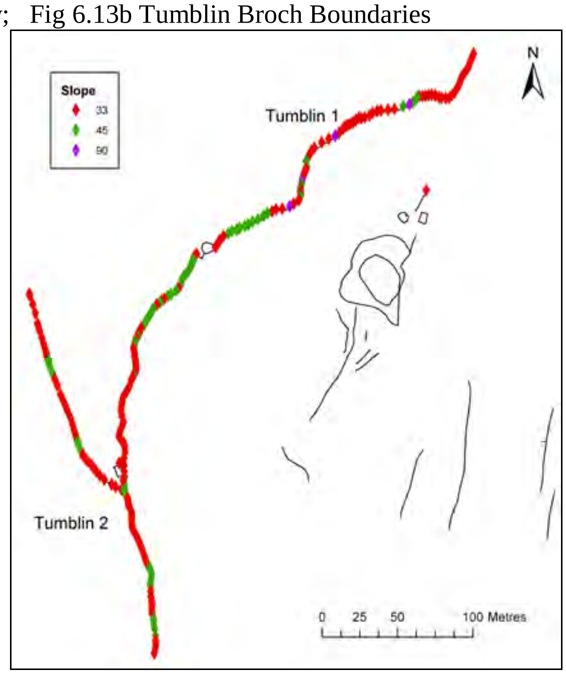


Fig 6.13c Angle of Slope: Sae Breck Broch Boundaries

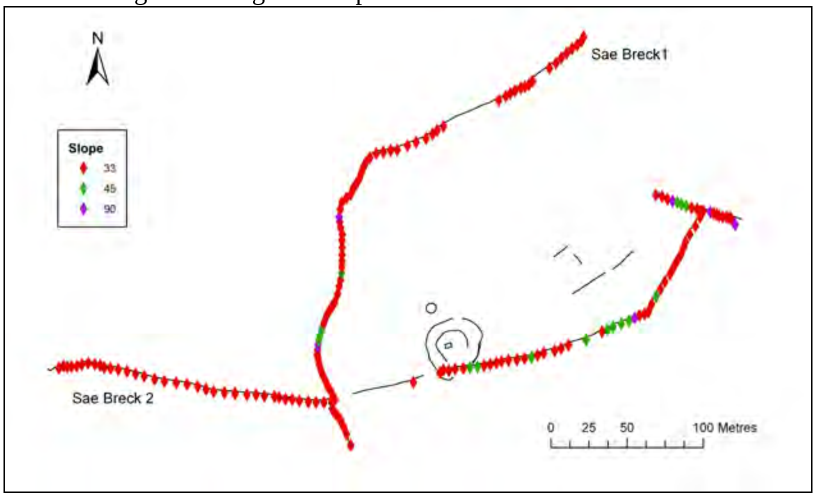


Fig 6.14a Angle of Slope: Belmont Norse Boundaries

Fig 6.14b Angle of Slope: Gardie Norse Boundaries

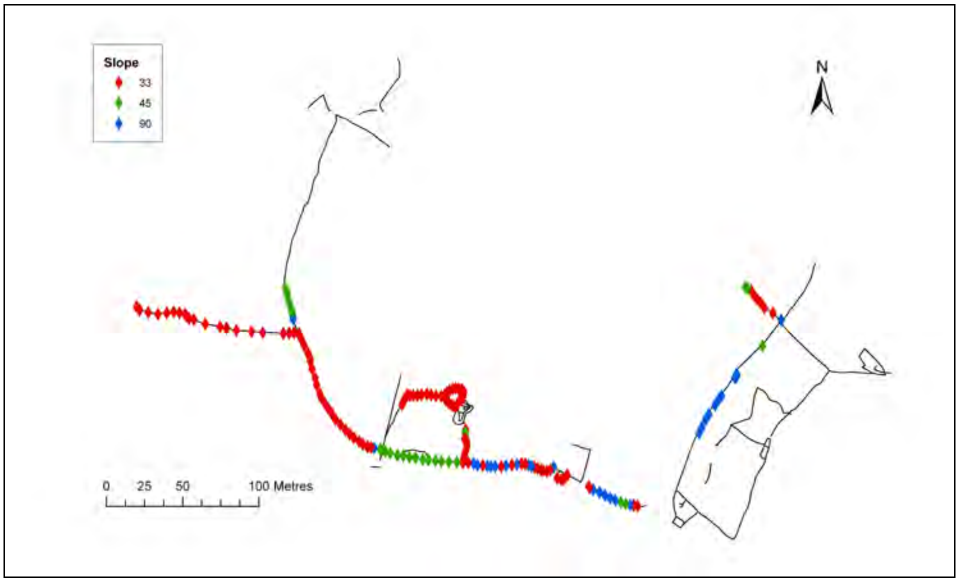


Fig 6.14c Angle of Slope: Watlie Norse Boundaries

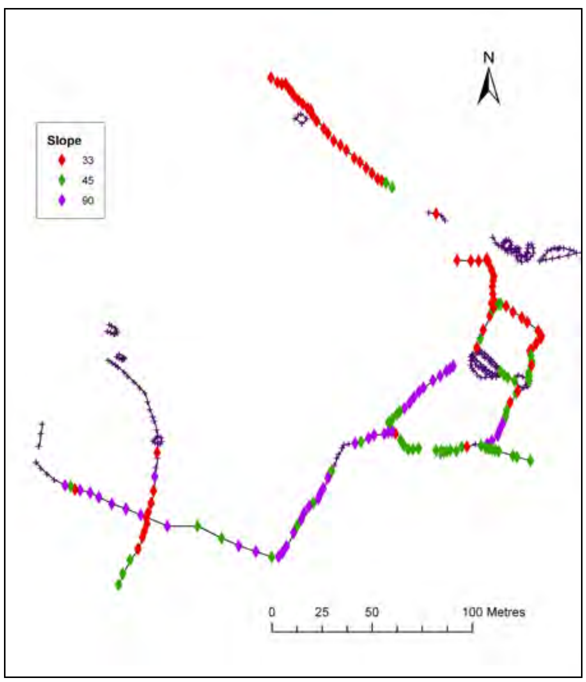
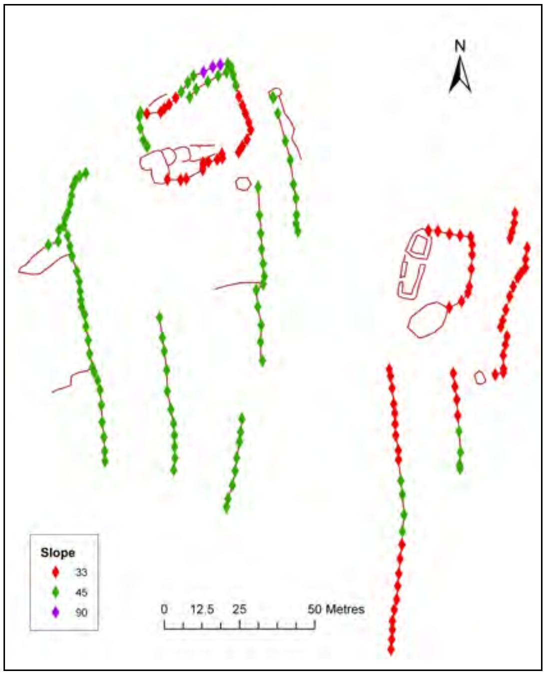
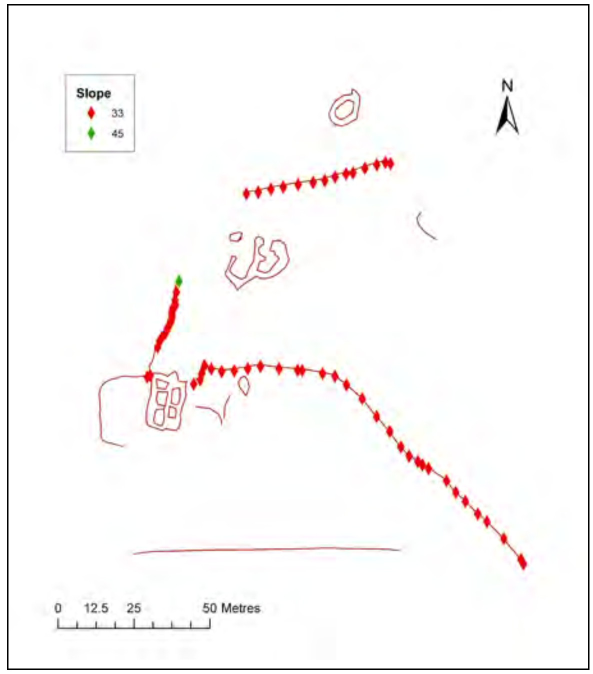


Fig 6.14d Angle of Slope: Hamar Norse Boundaries; Fig 6.14e Angle of Slope: Stove Norse Boundaries





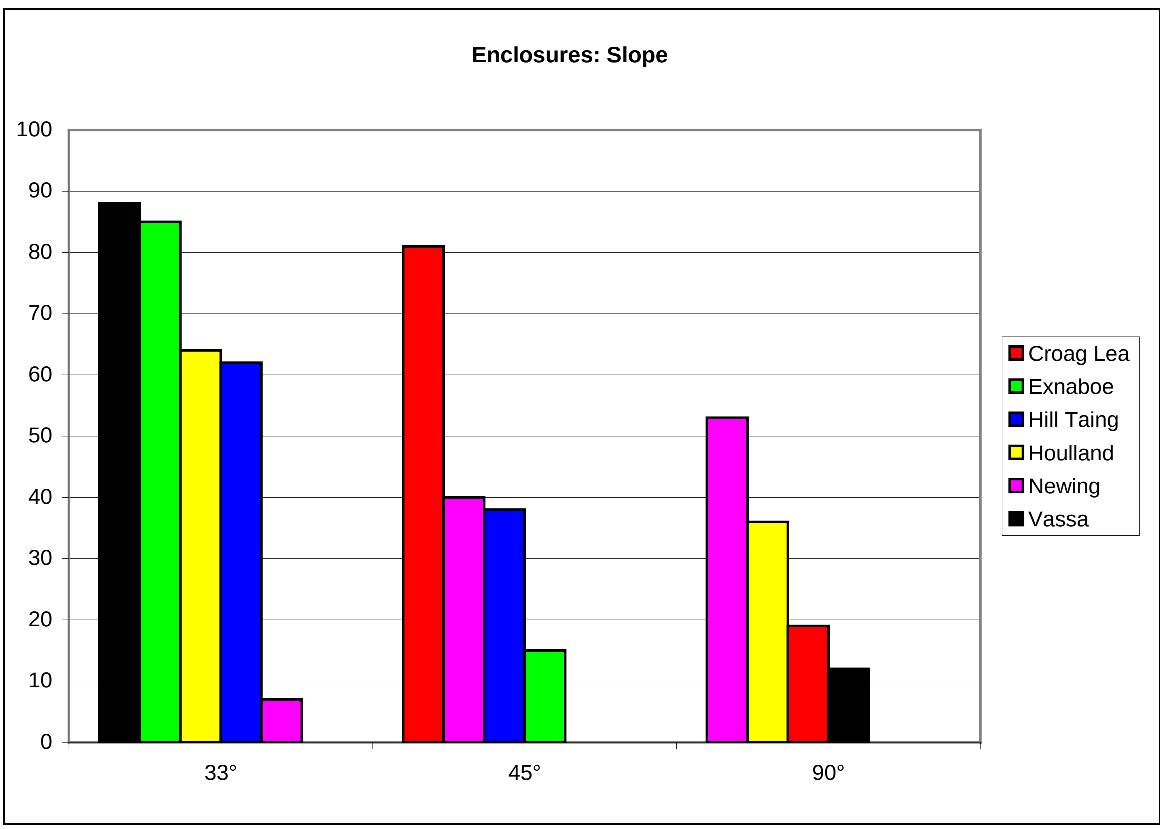


Fig 6.15a Graph showing percentage of points of Angle of Slope recorded per Homestead Enclosure

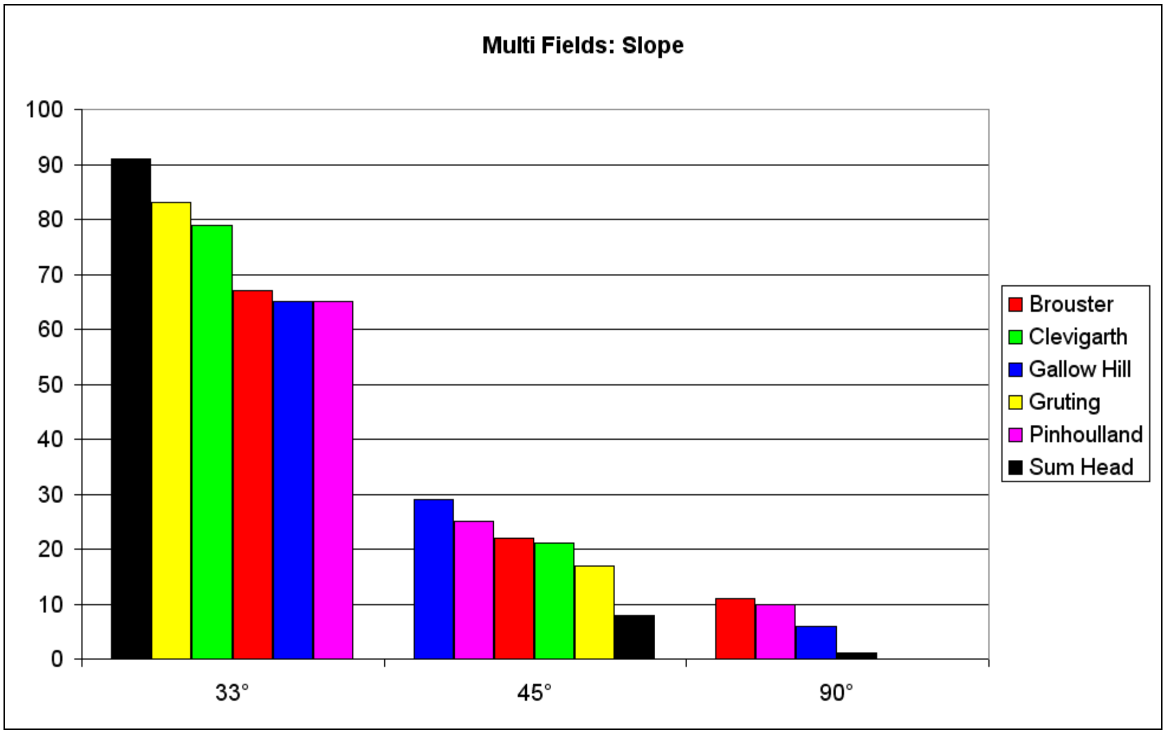


Fig 6.15b Graph showing percentage of points of Angle of Slope recorded per Multiple Field System

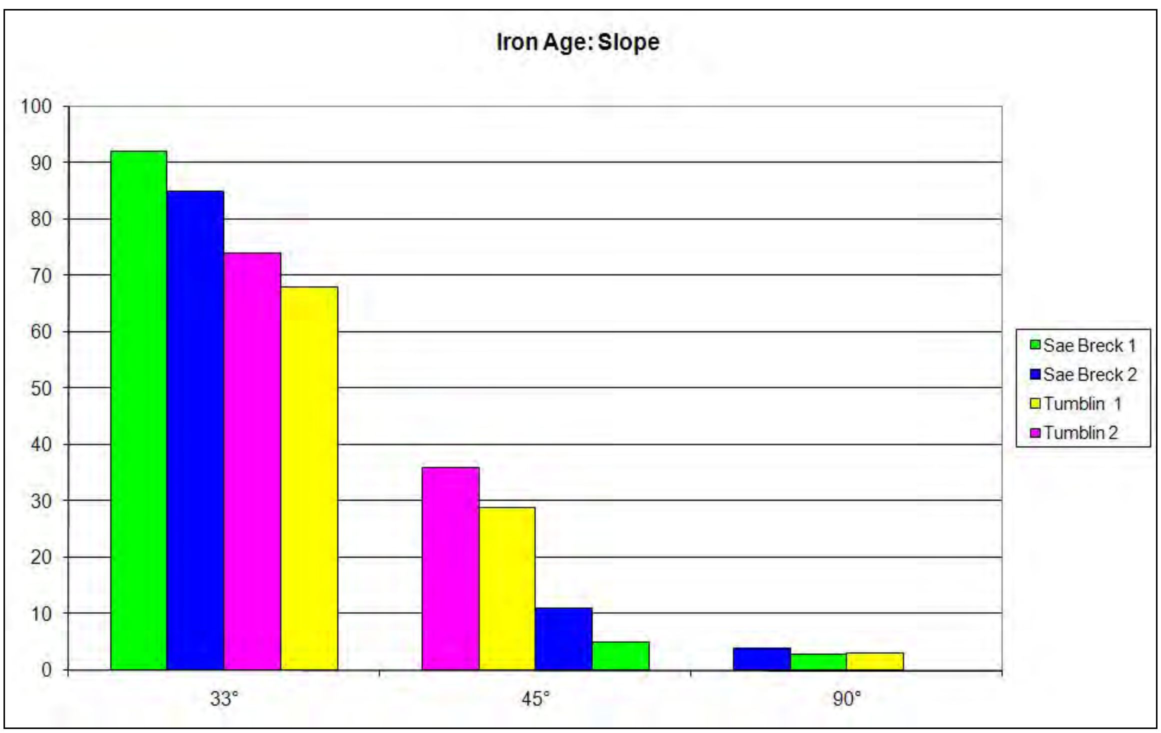


Fig 6.15c Graph showing percentage of points of Angle of Slope recorded per Iron Age boundary

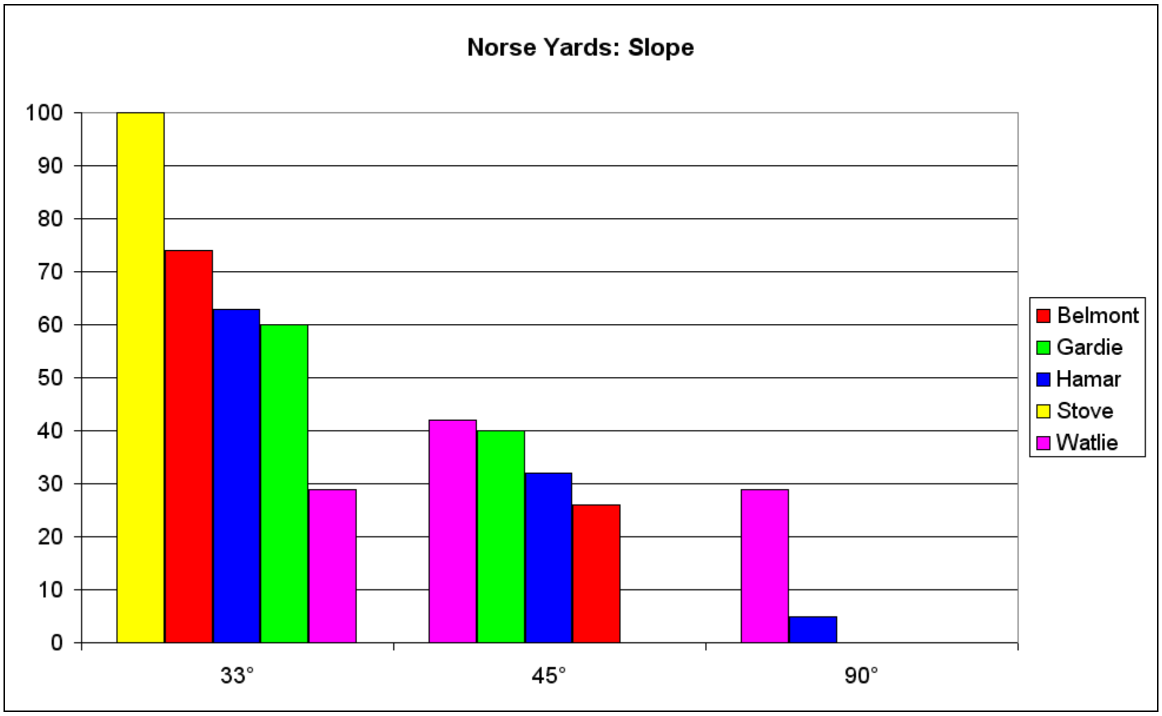


Fig 6.15d Graph showing percentage of points of Angle of Slope recorded per Norse Yard.

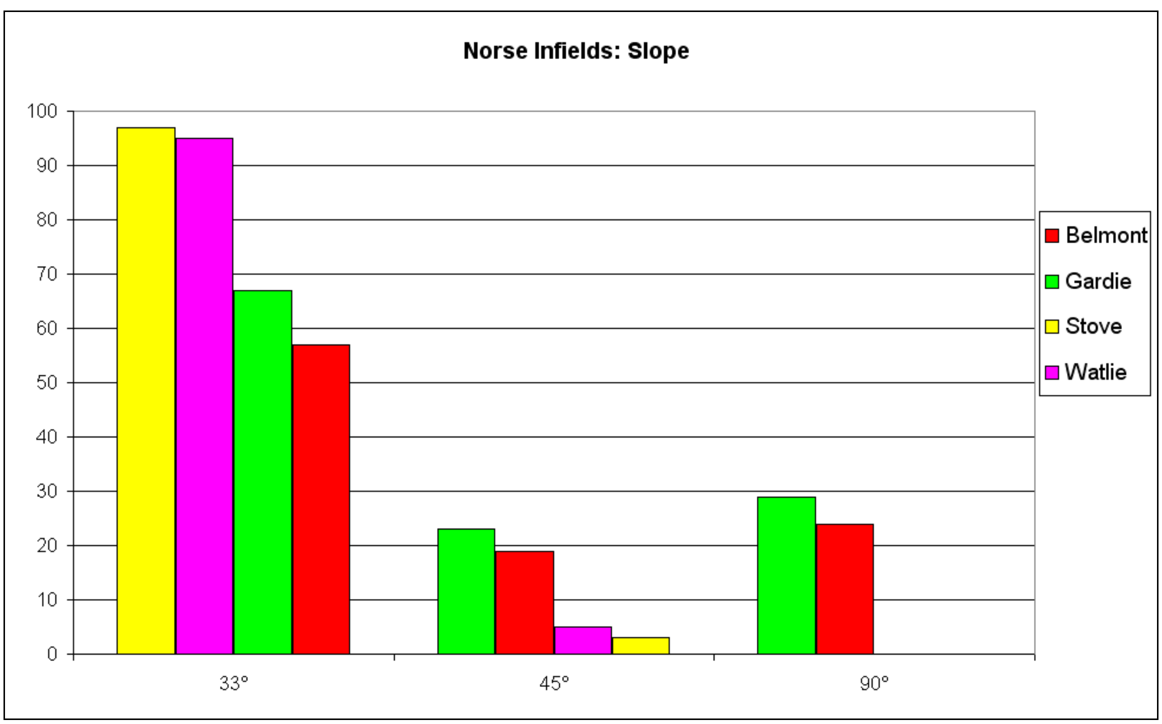


Fig 6.15e Graph showing percentage of points of Angle of Slope recorded per Norse Infield

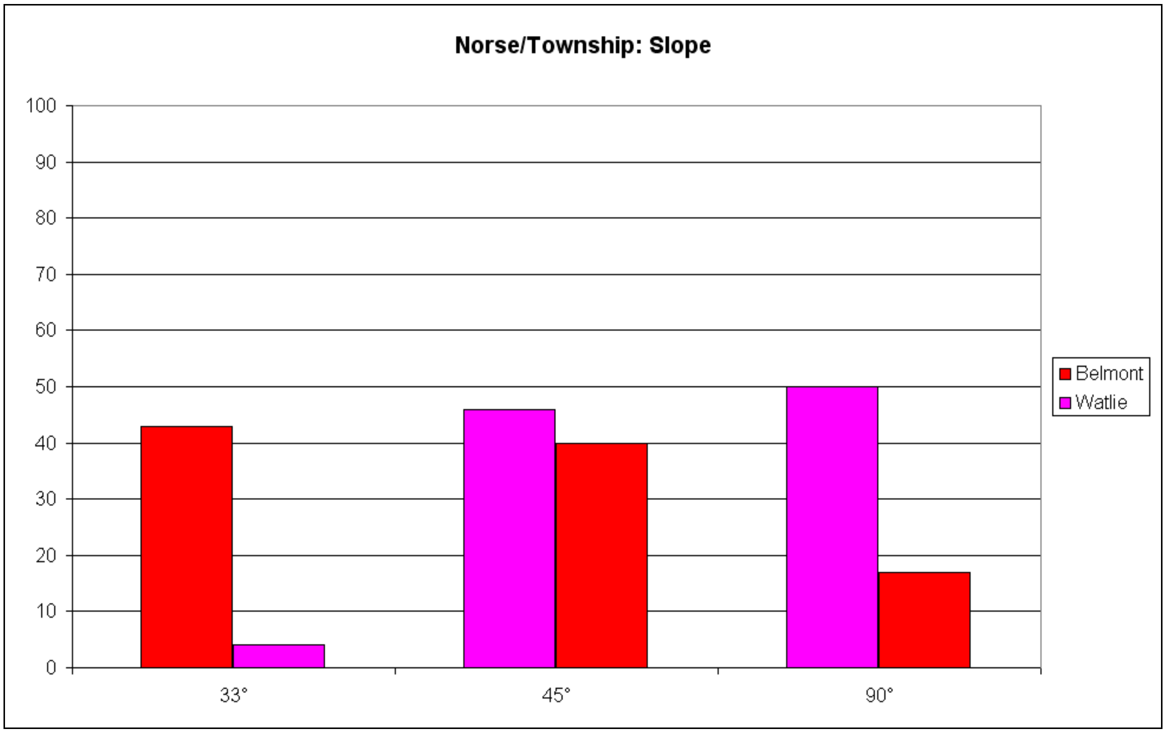
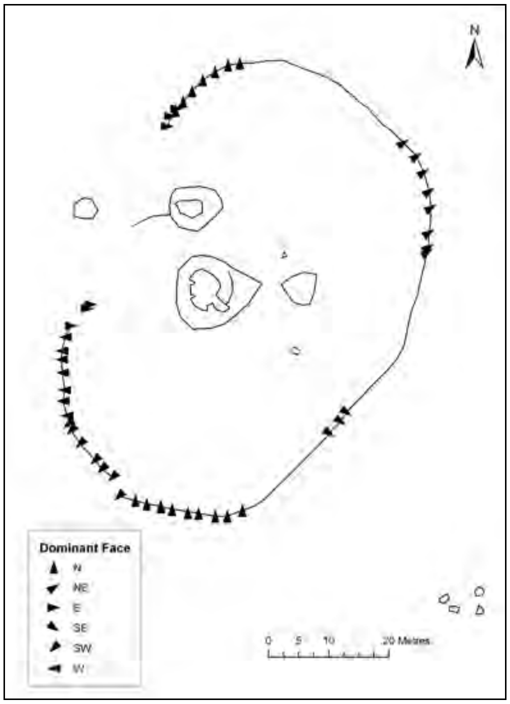


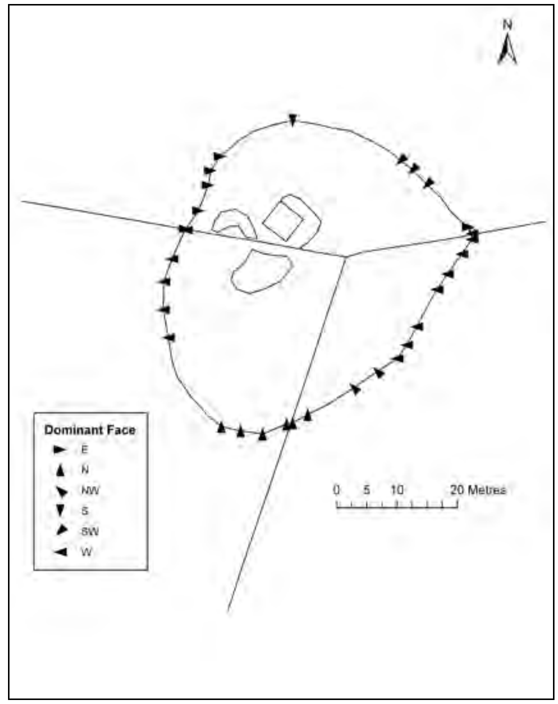
Fig 6.15f Graph showing percentage of points of Angle of Slope recorded per Norse Infield/Township Boundary

Direction of Dominant Face

The direction of dominant face was closely allied to feature height, although not exclusively. The direction of face was recorded both in terms of eight principle compass points and also with respect to its relationship with site itself. This was complex within the Multiple Field Systems as many boundaries were shared between fields and therefore were both internal and external. In some cases, direction of slope appeared to be the dominant factor, therefore the terms "downslope", "upslope" and "across" the hill slope were employed. The term "equal" was applied when a bank was of equal height on both sides.

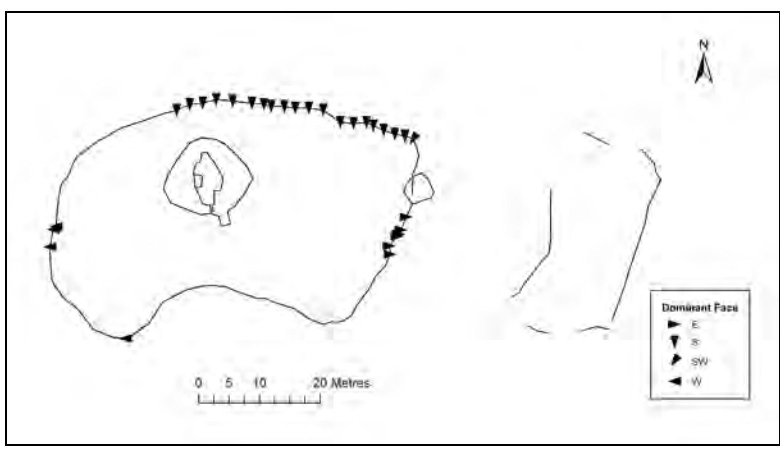
There were also occasions when the relationship between boundaries and field systems was clearer in the mapping than it was in the field due to the localised topography.

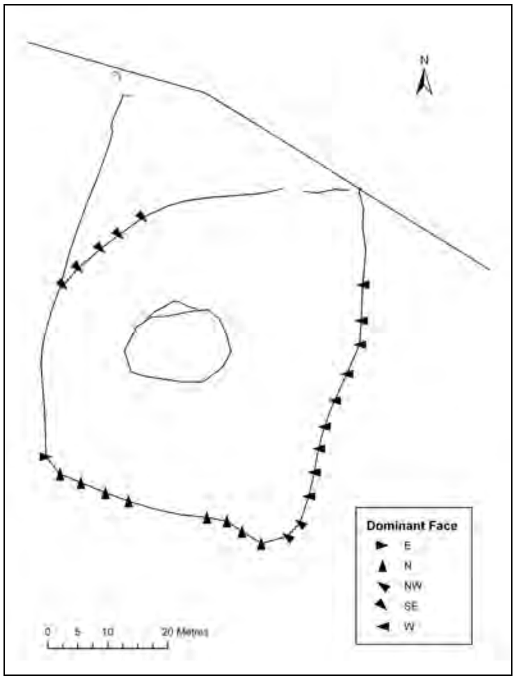


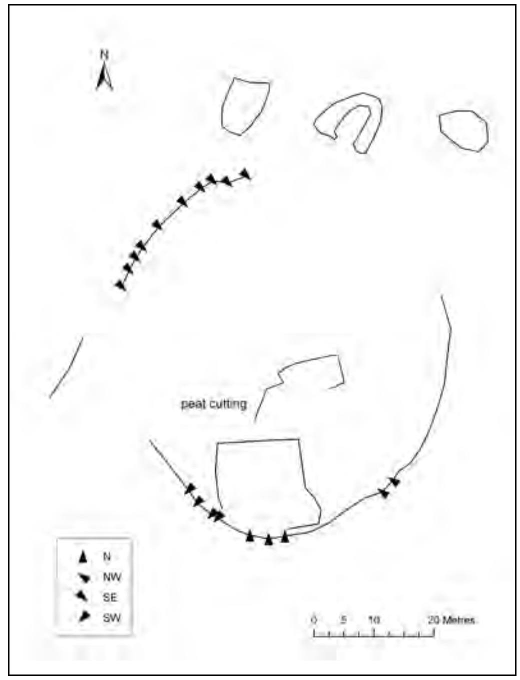


(Left) Fig 6.16a Dominant Face: Croag Lea Homestead Enclosure
(Right) Fig 6.16b Dominant Face: Exnaboe Homestead Enclosure

Fig 6.16c Dominant Face: Hill of the Taing Homestead Enclosure







(Left) Fig 6.16d Dominant Face: Houlland Homestead Enclosure
(Right) Fig 6.16e Dominant Face: Vassa Homestead Enclosure Houlland

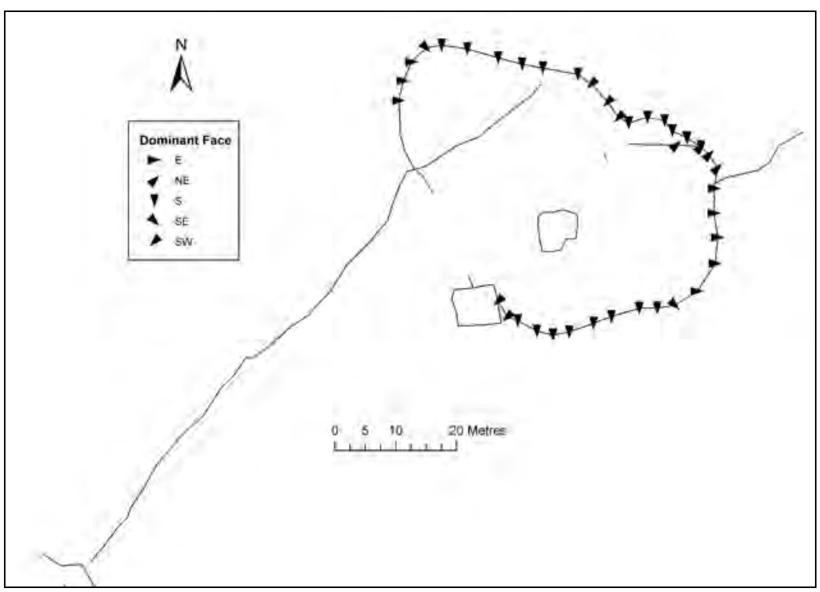
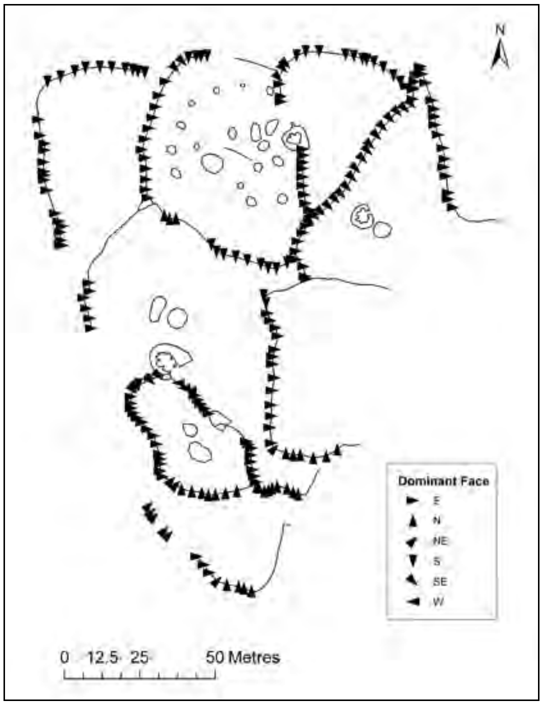


Fig 6.16f Dominant Face: South Nesting Homestead Enclosure



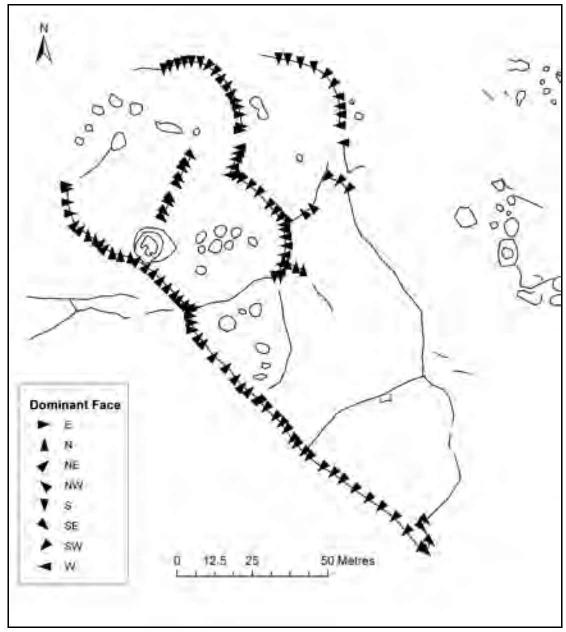


Fig 6.17a (Left) Dominant Face: Scord of Brouster Multiple Field System
Fig 6.17b (Right) Dominant Face: Gallow Hill Multiple Field System

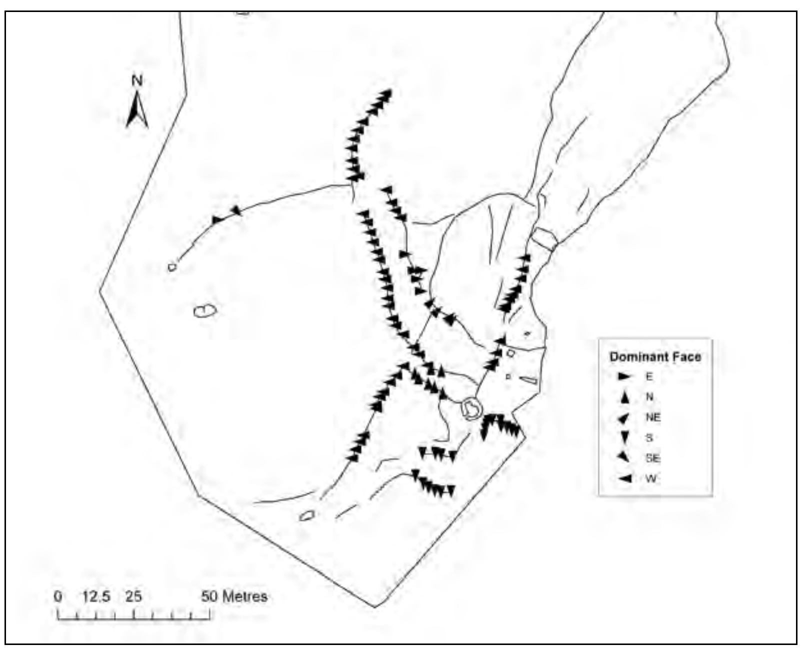


Fig 6.17c Dominant Face: Clevigarth Multiple Field System

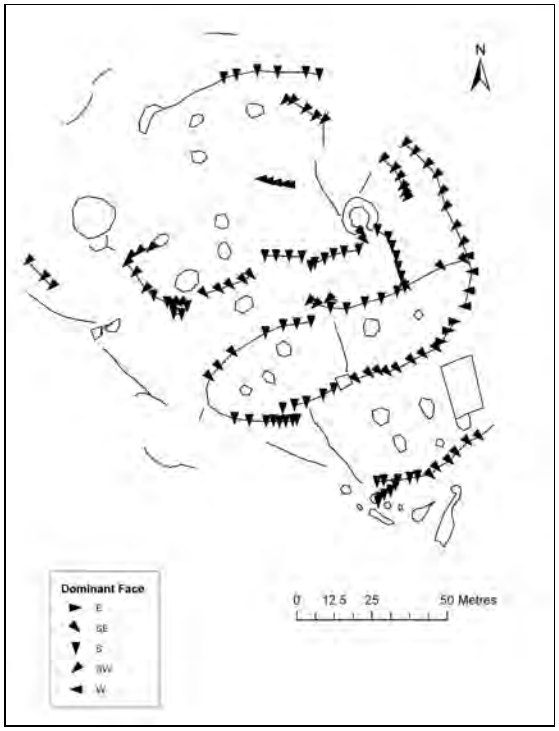
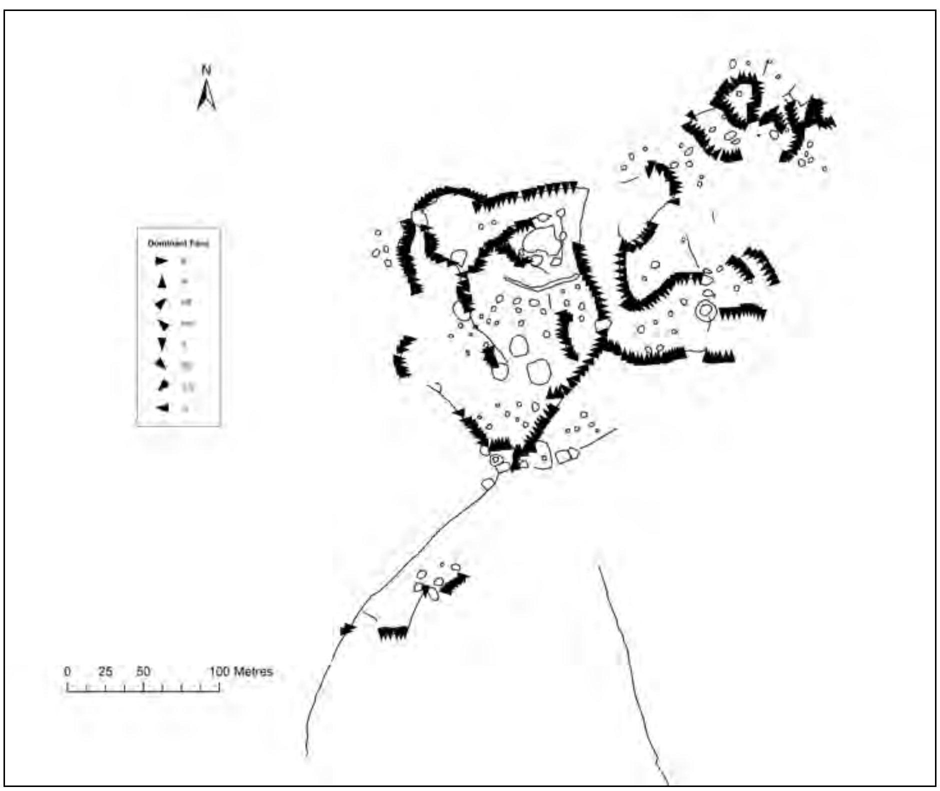


Fig 6.17d Dominant Face: Ness of Gruting Multiple Field System

Fig 6.17e Dominant Face: Pinhoulland Multiple Field System



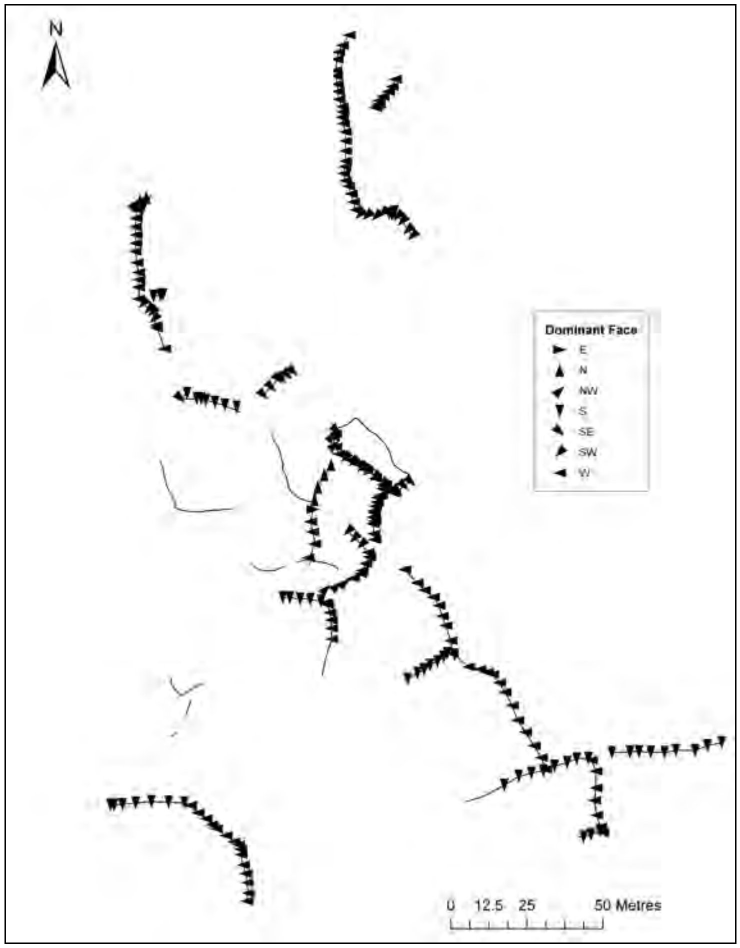
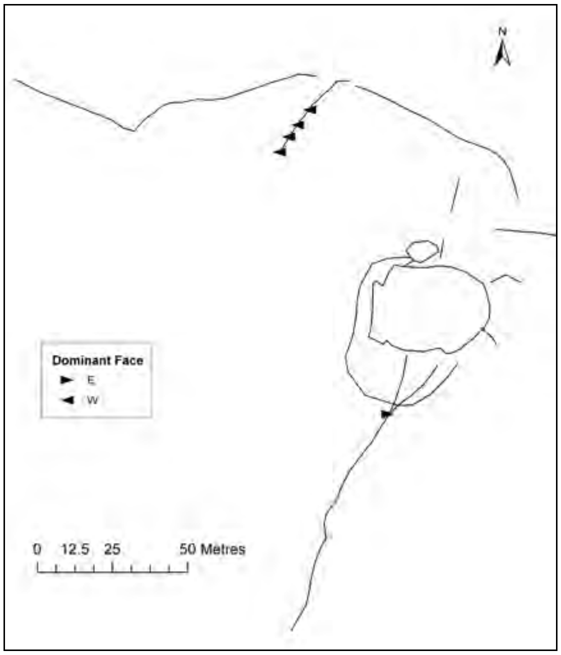


Fig 6.17f Dominant Face: Sumburgh Head Multiple Field System



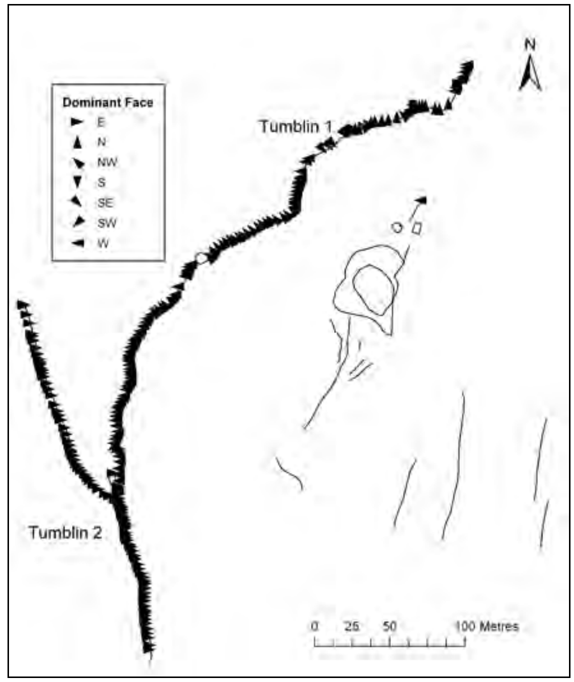


Fig 6.18a (Left) Dominant Face: Clevigarth Broch Boundary
Fig 6.18b (Right) Dominant Face: Tumblin Broch Boundaries

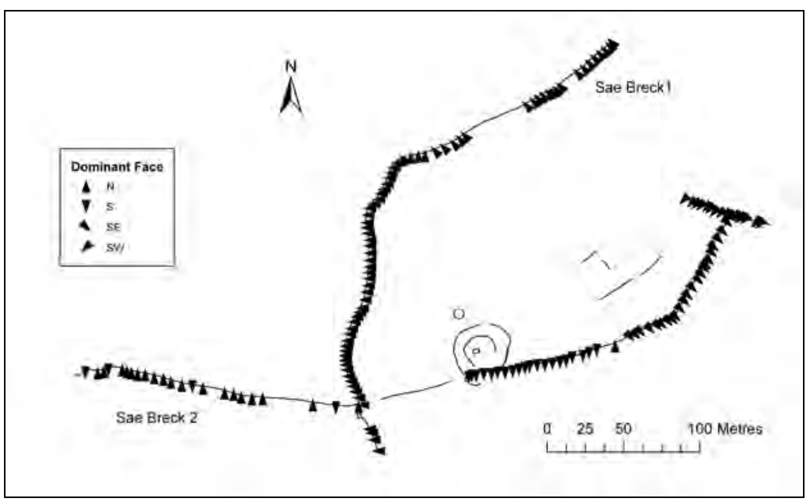


Fig 6.18c Dominant Face: Sae Breck Broch Boundaries

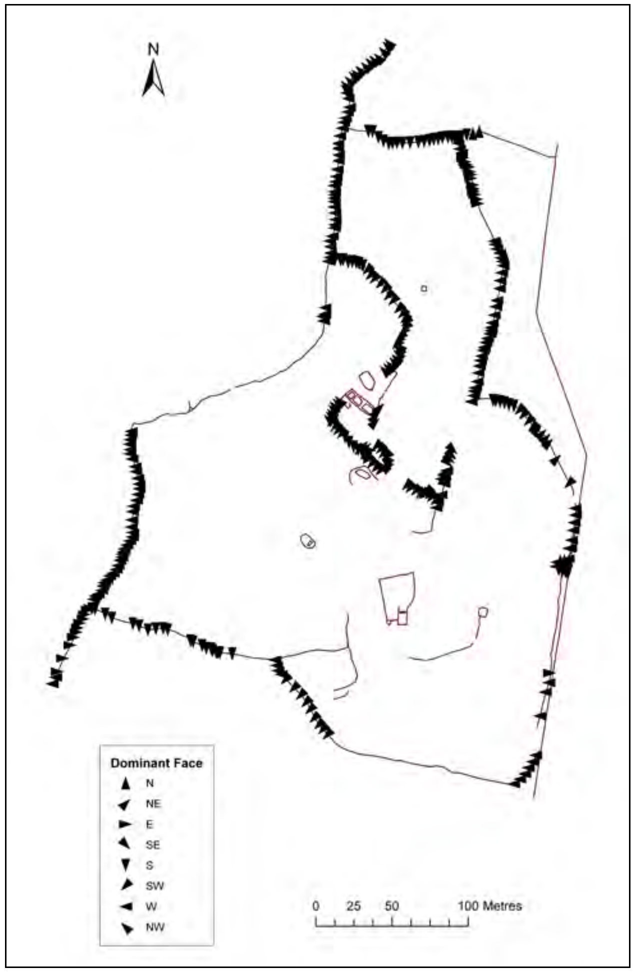


Fig 6.19a Dominant Face: Belmont Norse Boundaries

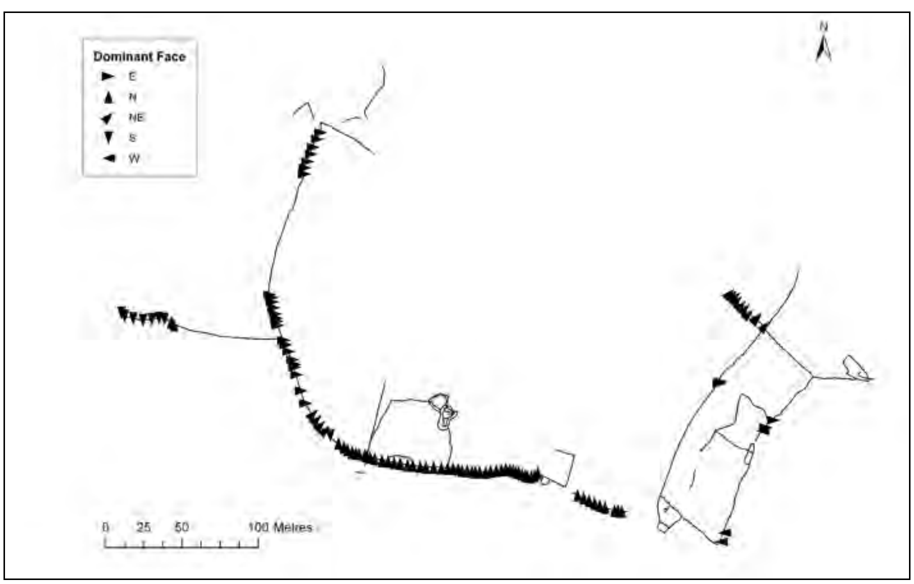


Fig 6.19b Dominant Face: Gardie Norse Boundaries

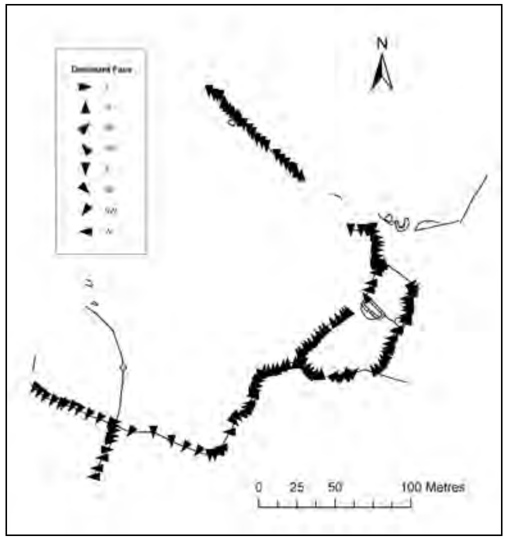
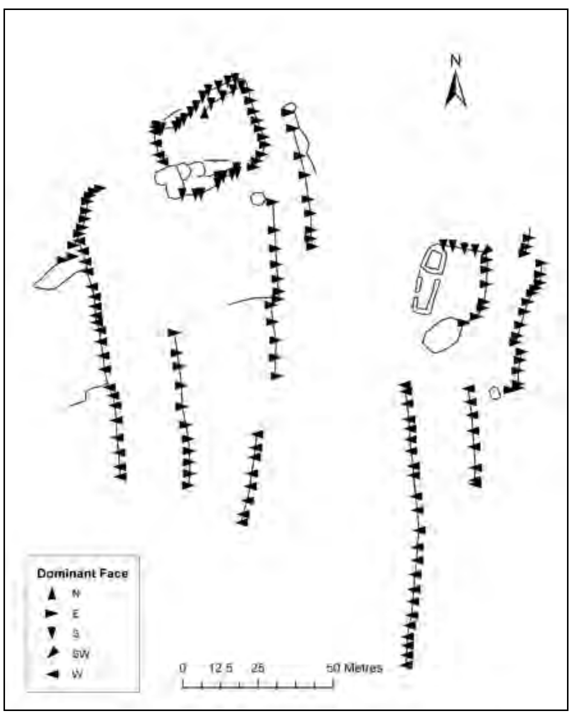


Fig 6.19c Dominant Face: Watlie Norse Boundaries



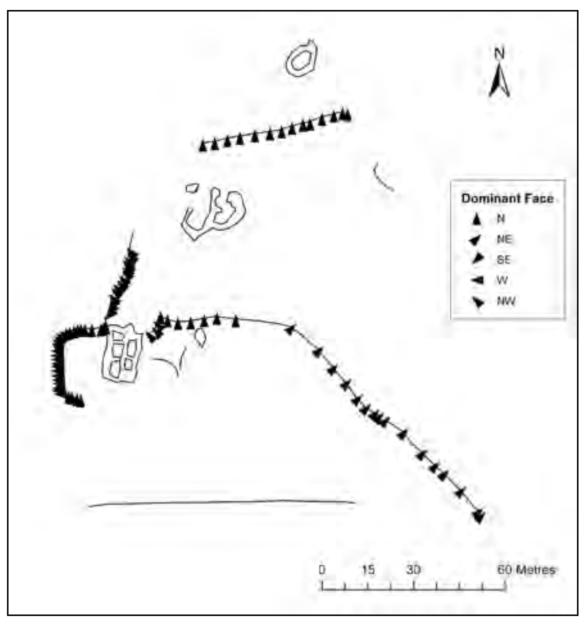


Fig 6.19d Dominant Face: Hamar Norse Boundaries; Fig 6.19e   Dominant Face: Stove Norse Boundaries

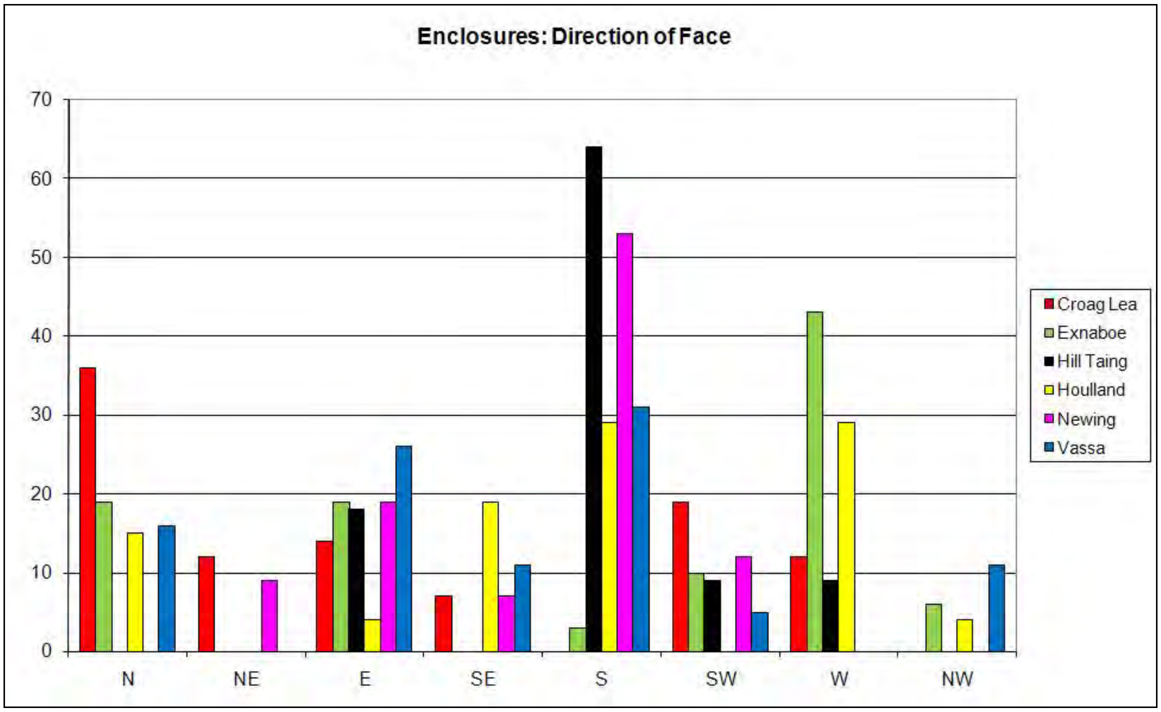


Fig 6.20a Graph showing percentage of points for Direction of Face by Cardinal Point per Homestead Enclosure

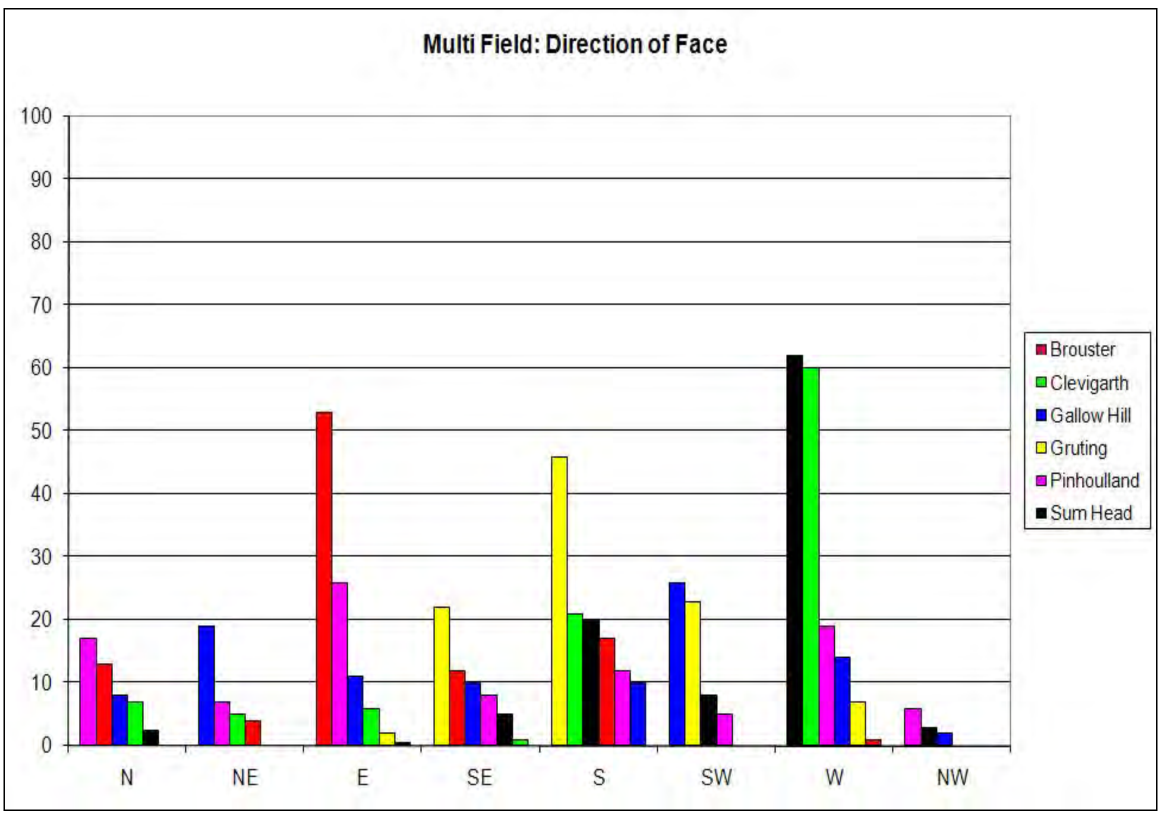


Fig 6.20b Graph showing percentage of points for Direction of Face by Cardinal Point recorded per Multiple Field System

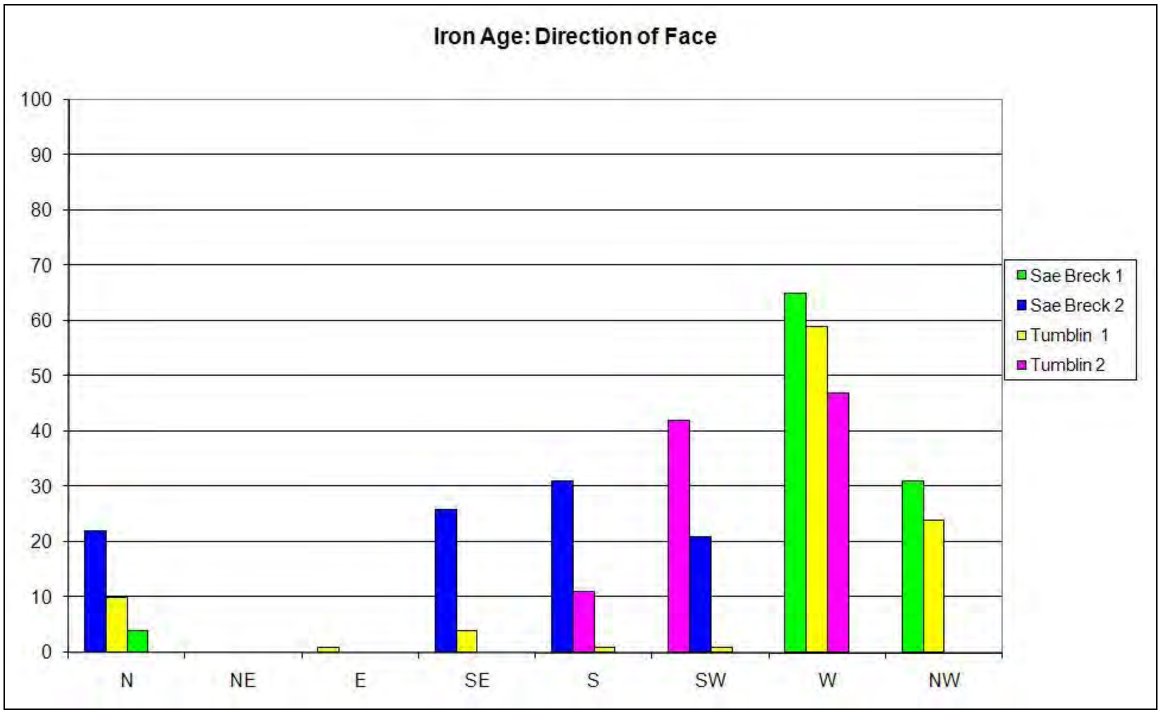


Fig 6.20c Graph showing percentage of points for Direction of Face by Cardinal Point recorded per Iron Age Boundary

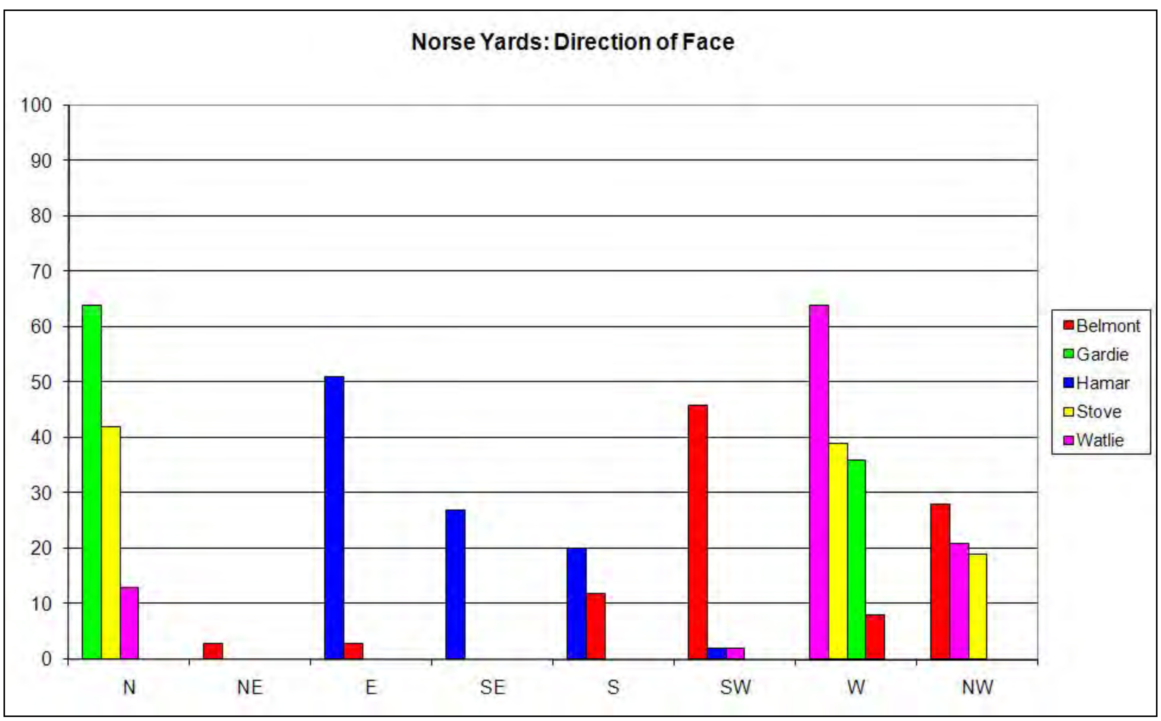


Fig 6.20d Graph showing percentage of points for Direction of Face by Cardinal Point recorded per Norse Yard

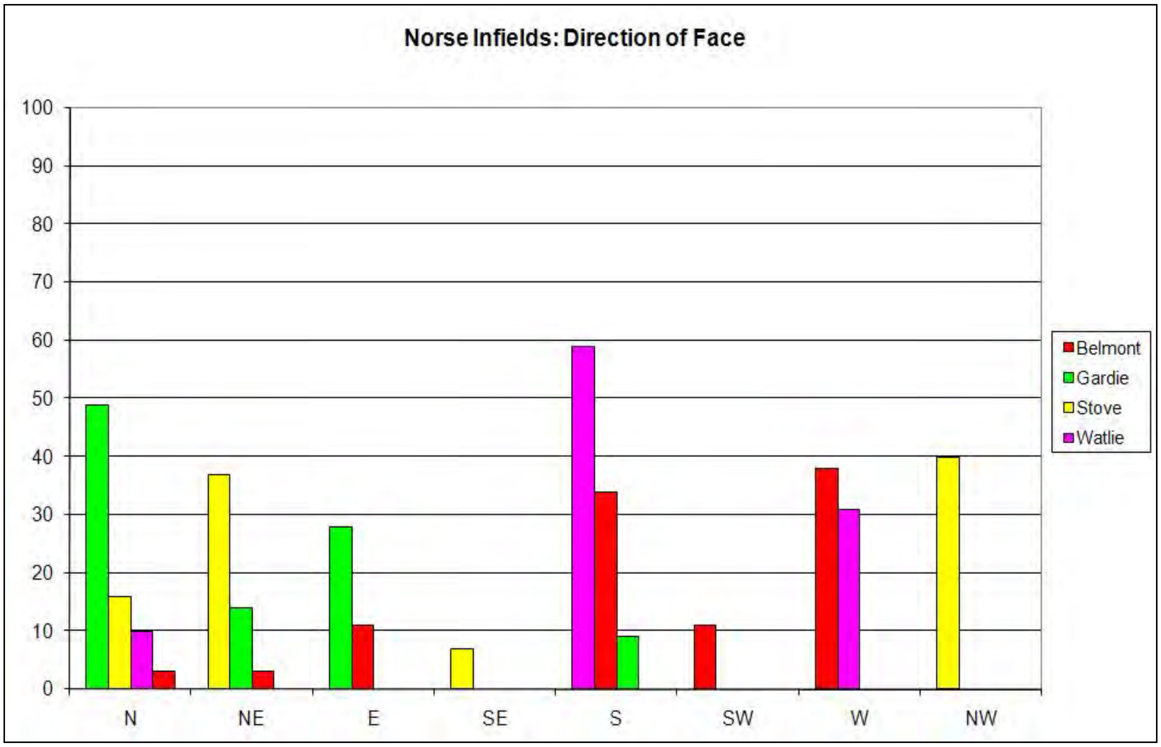


Fig 6.20e Graph showing percentage of points for Direction of Face by Cardinal Point recorded per Norse Infield Boundary

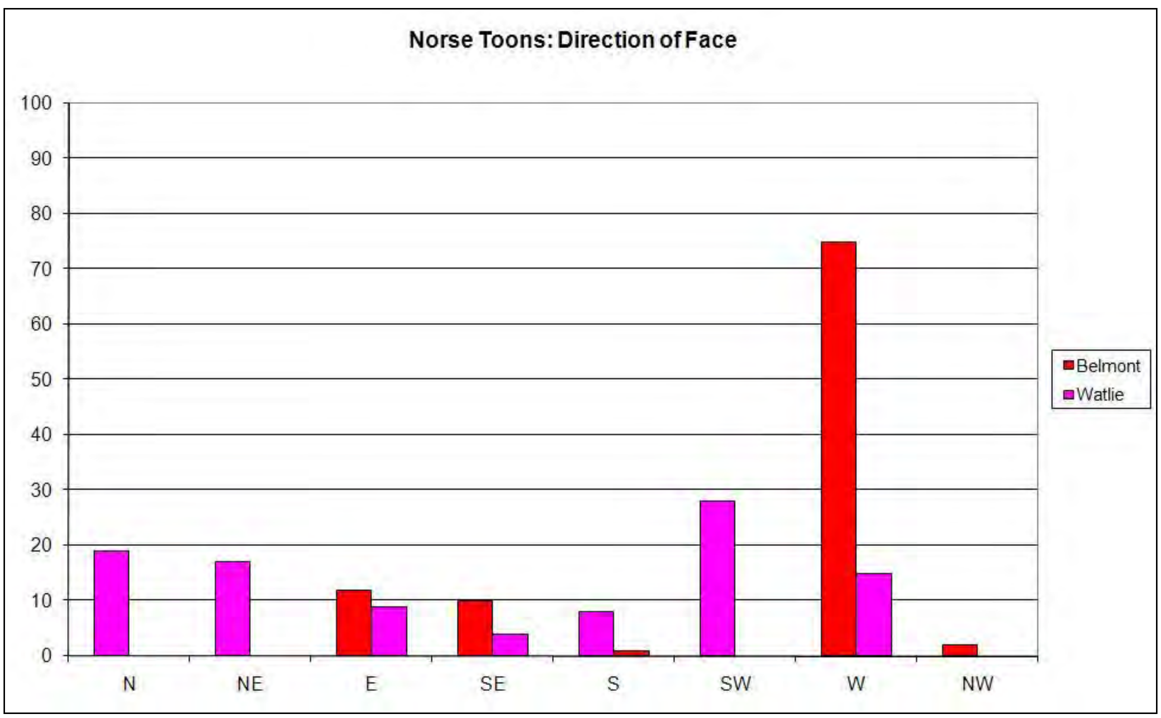


Fig 6.20f Graph showing percentage of points for Direction of Face recorded by Cardinal Point per Norse Infield/Township Boundary

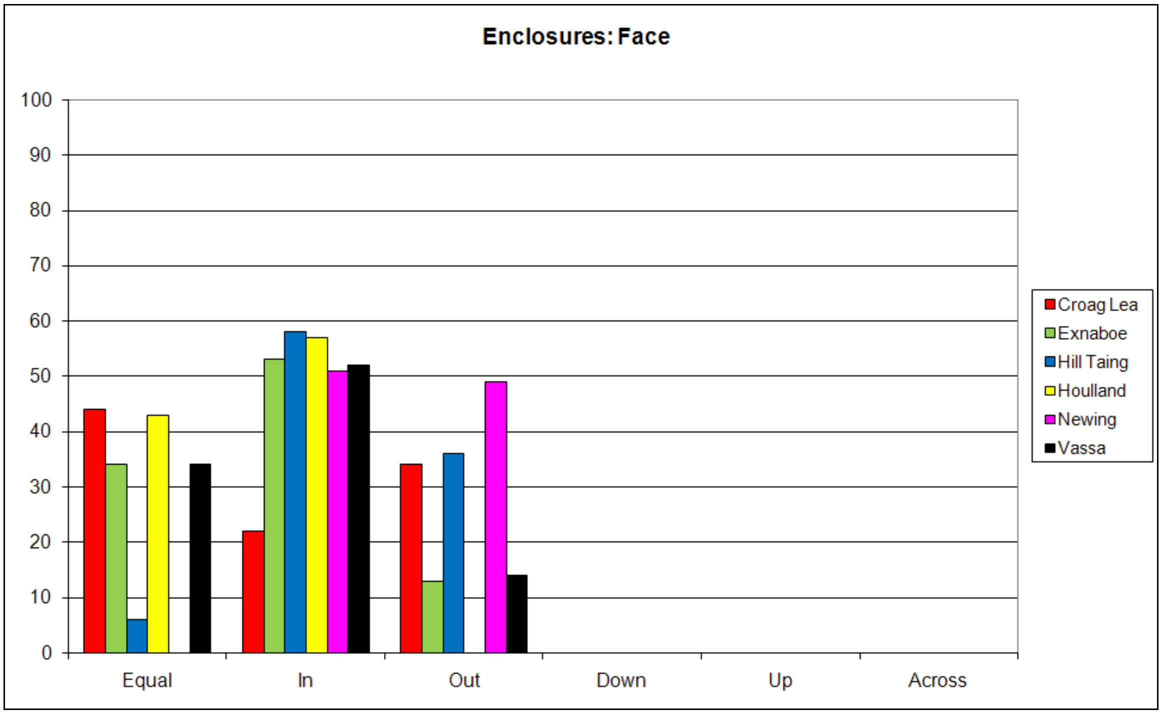


Fig 6.21a Graph showing percentage of points for Face recorded per Homestead Enclosure

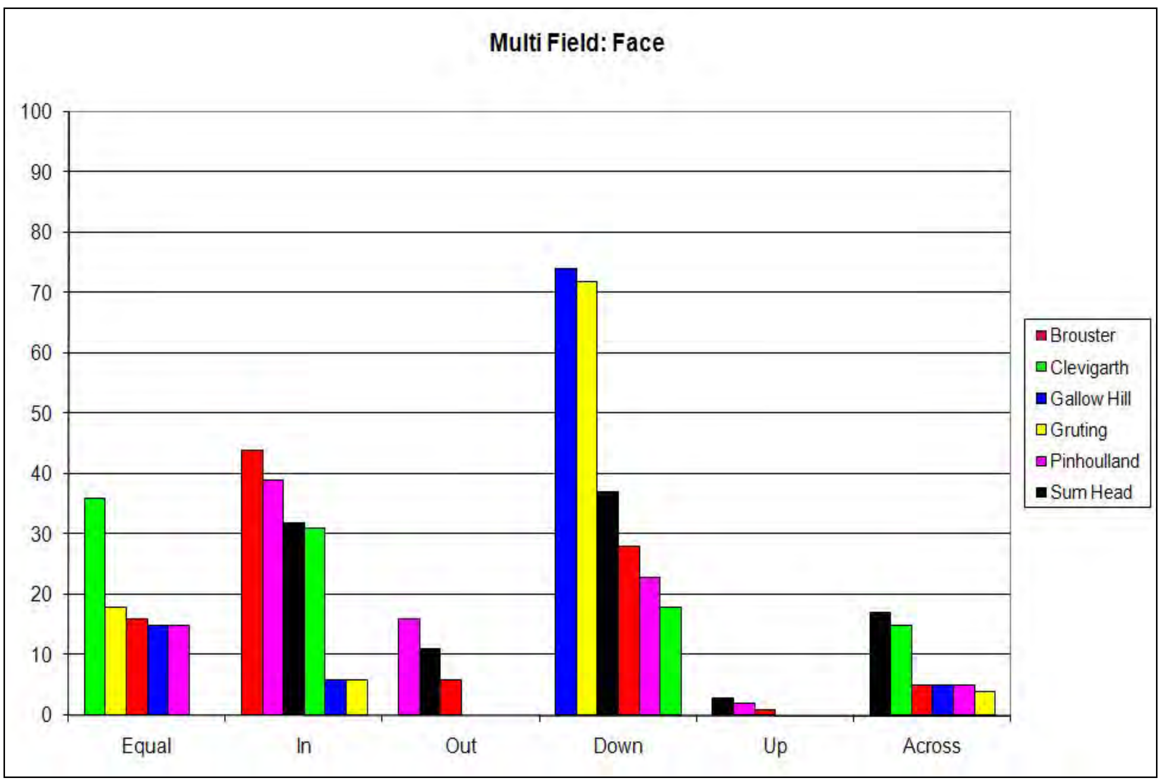


Fig 6.21b Graph showing percentage of points for Face recorded per Multiple Field System

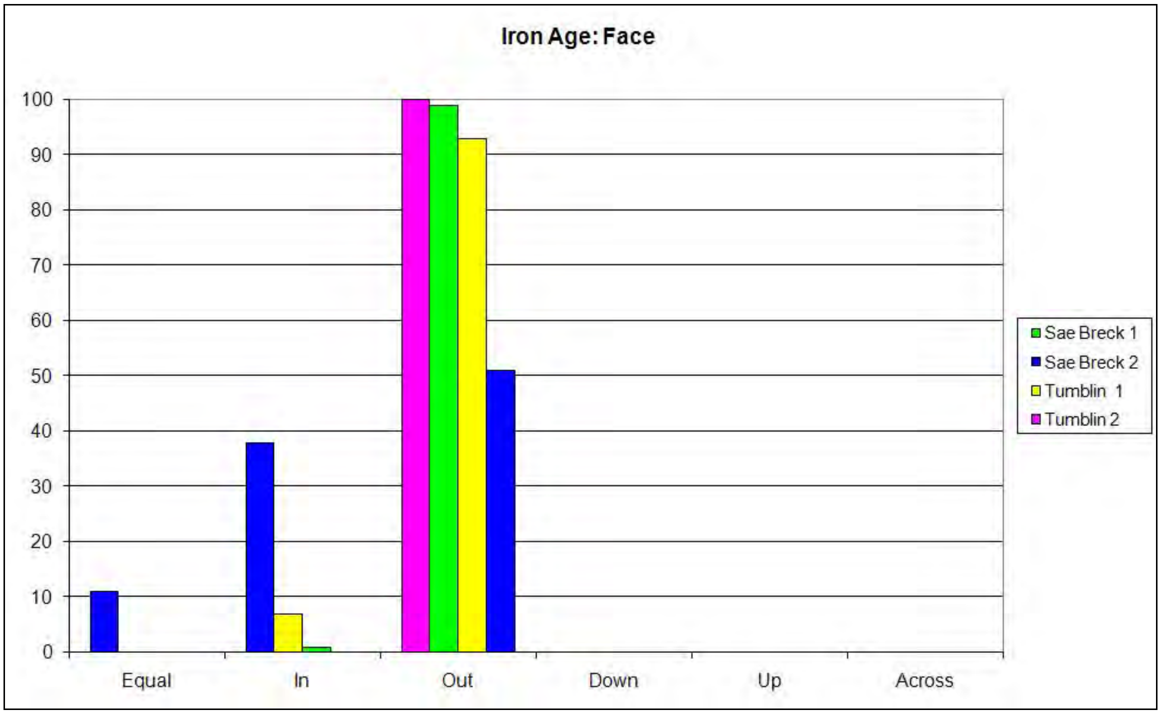


Fig 6.21c Graph showing percentage of points for Face recorded for Iron Age related boundaries.

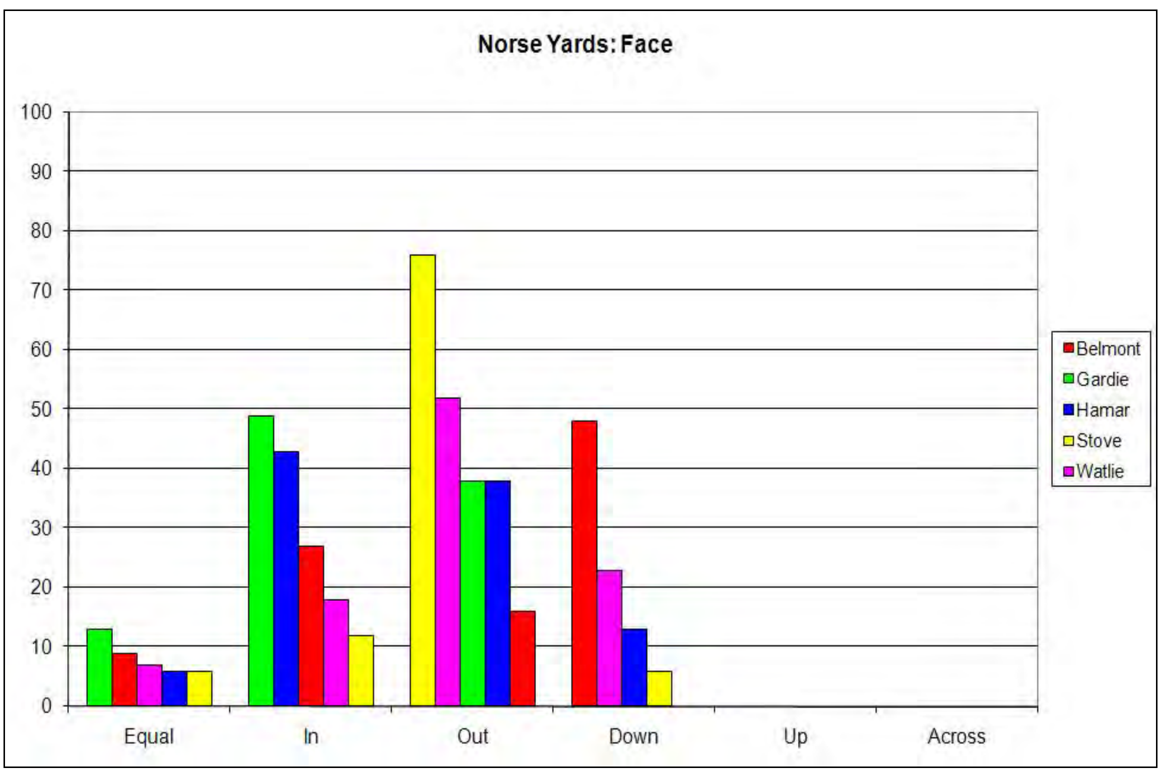


Fig 6.21d Graph showing percentage of points for Face recorded per site containing Norse yards

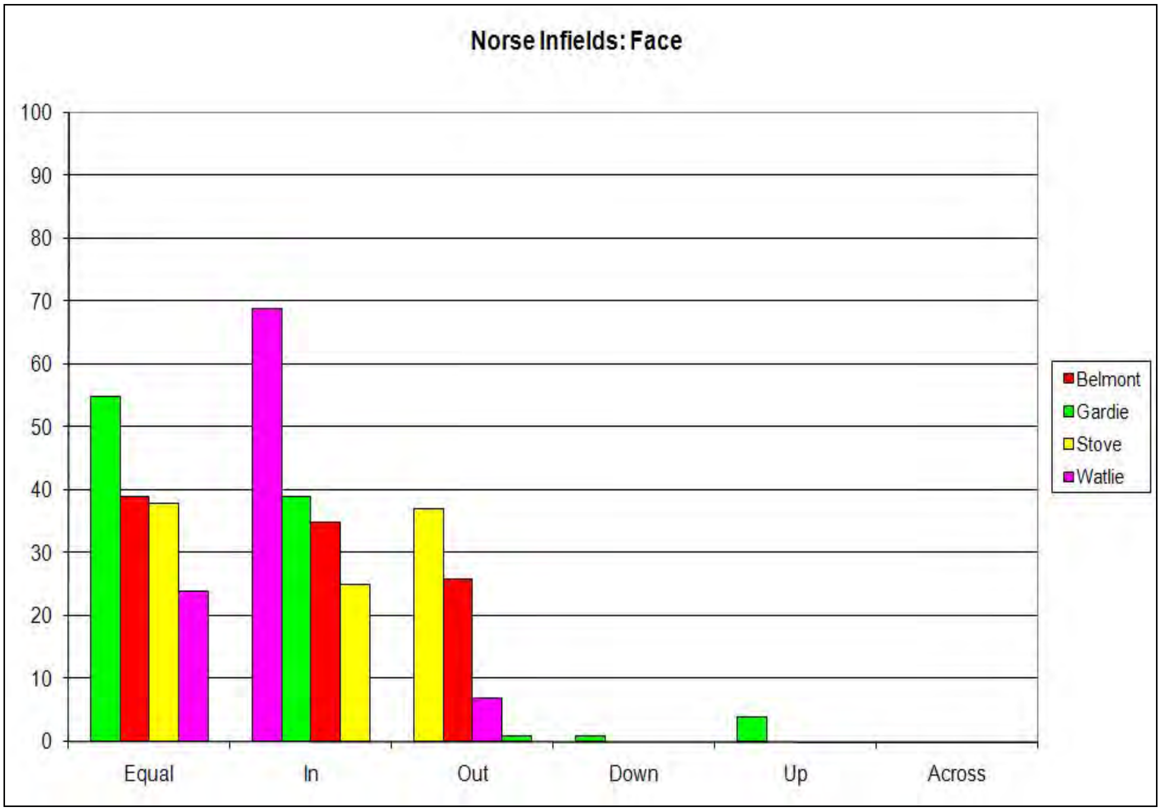


Fig 6.21e Graph showing percentage of points for Face recorded per Norse Infield Boundary.

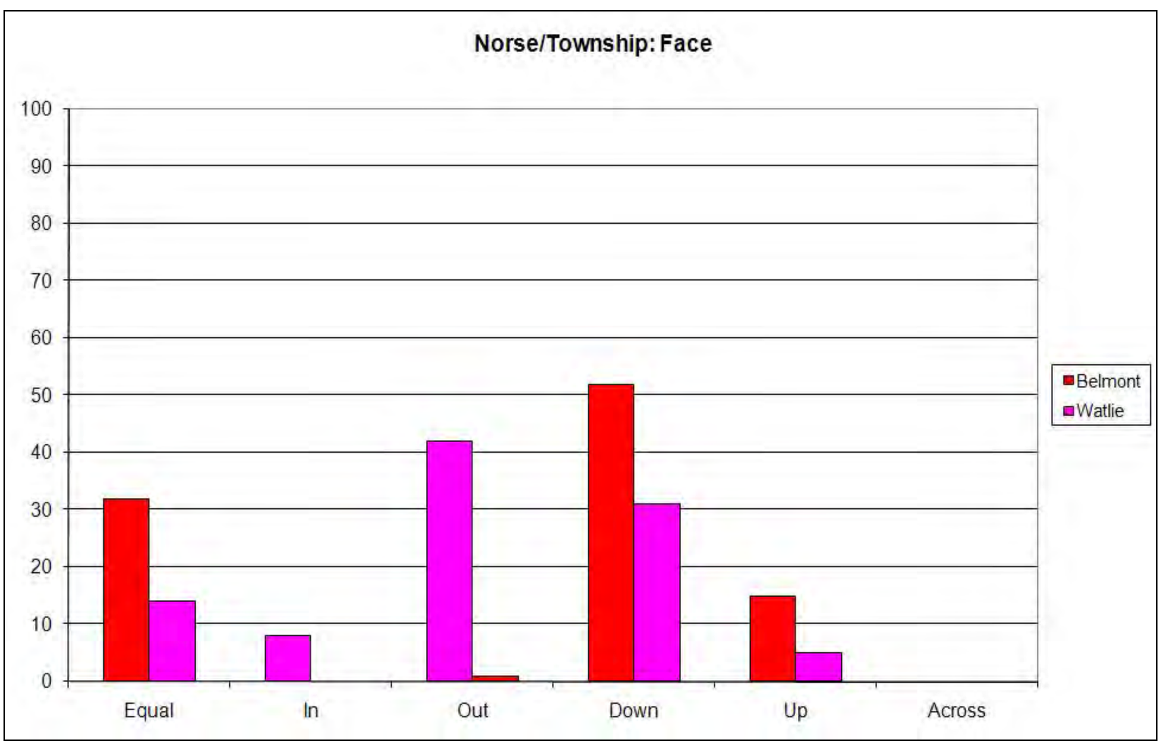
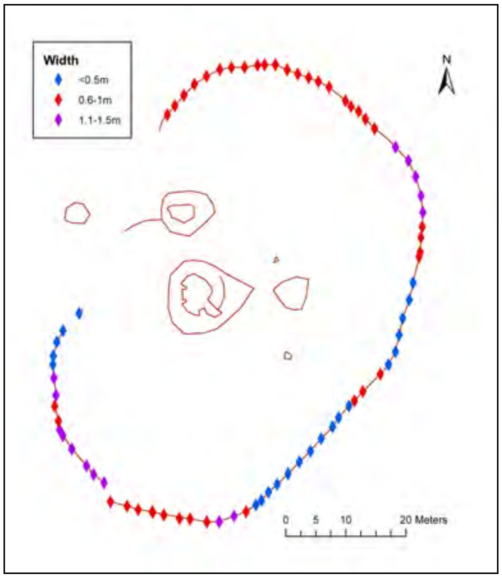


Fig 6.21f Graph showing percentage of points for Face recorded per Norse Infield/Township Boundary

Width of Feature

This was a measurement the width of earthwork features. As dyke width related closely to stone size, this was only recorded where the stone was set into a broader earthwork.



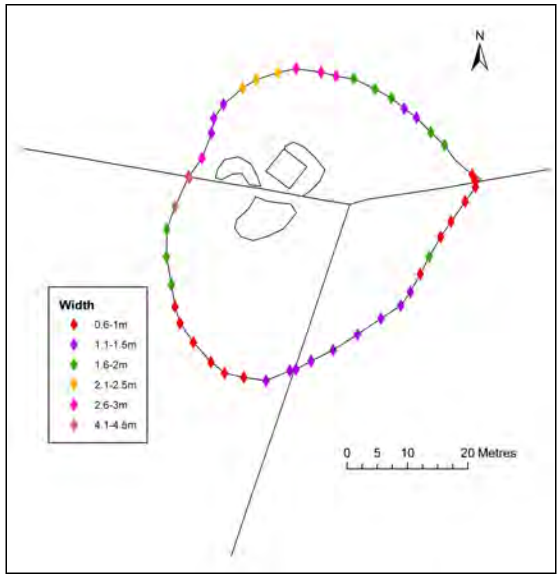


Fig. 6.22a Feature Width: Croag Lea Homestead Enclosure; Fig 6.22b Feature Width: Exnaboe Homestead Enclosure

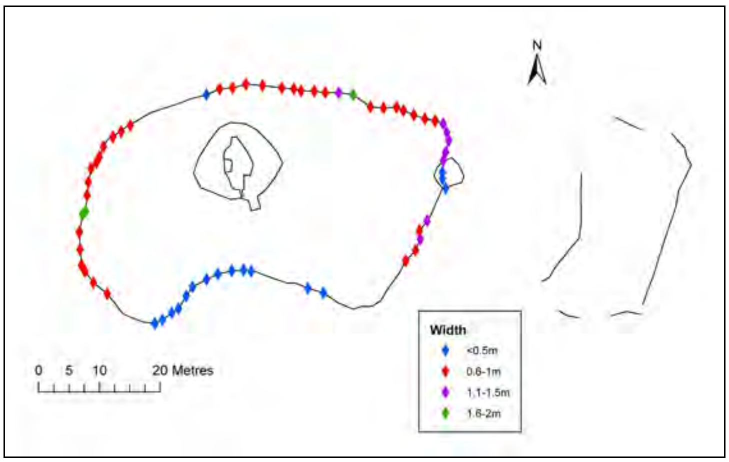


Fig. 6.22c Feature Width: Hill of the Taing Homestead Enclosure

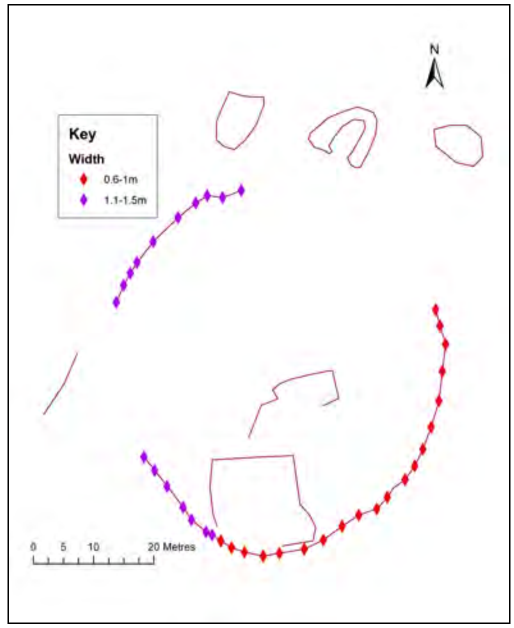


Fig. 6.22d Feature Width: Houlland Homestead Enclosure; Fig 6.22e Feature Type: Vassa Homestead Enclosure

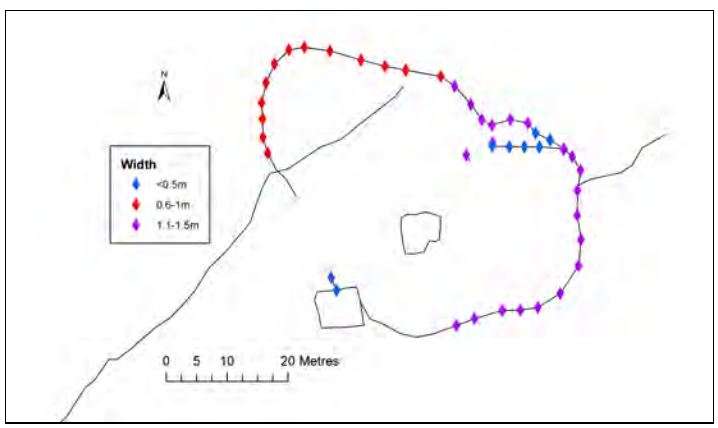
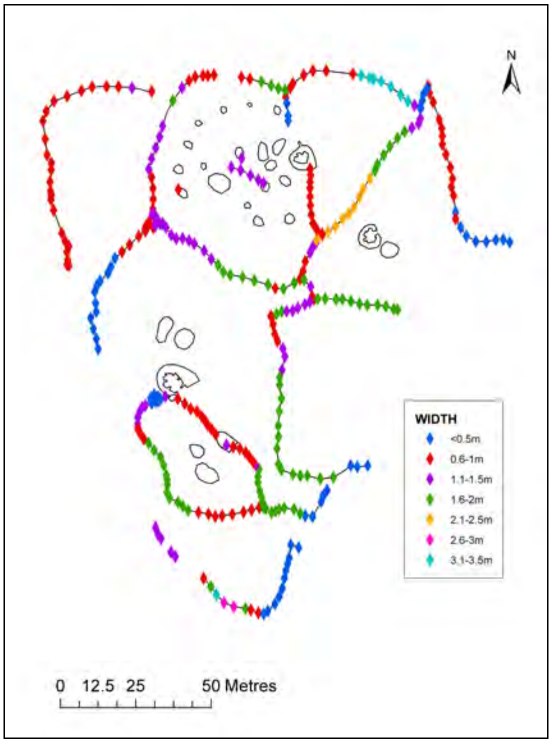


Fig. 6.22f Feature Width: South Newing Homestead Enclosure



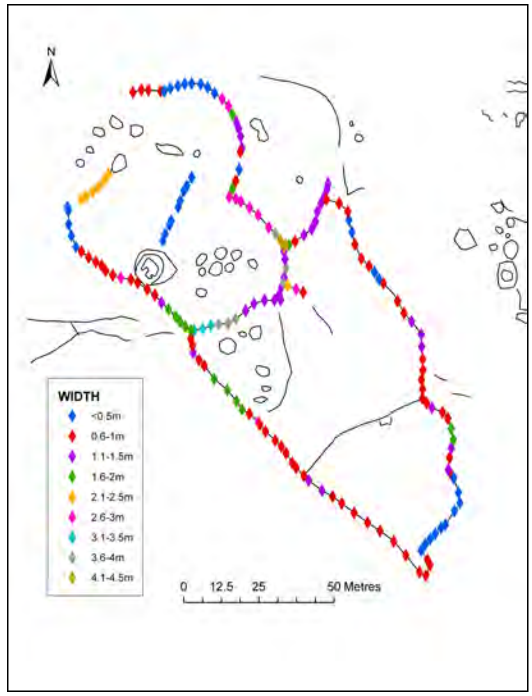


Fig. 6.23a Feature Width: Scord of Brouster Multiple Field System; Fig 6.23b Feature Width: Gallow Hill Multiple Field System.

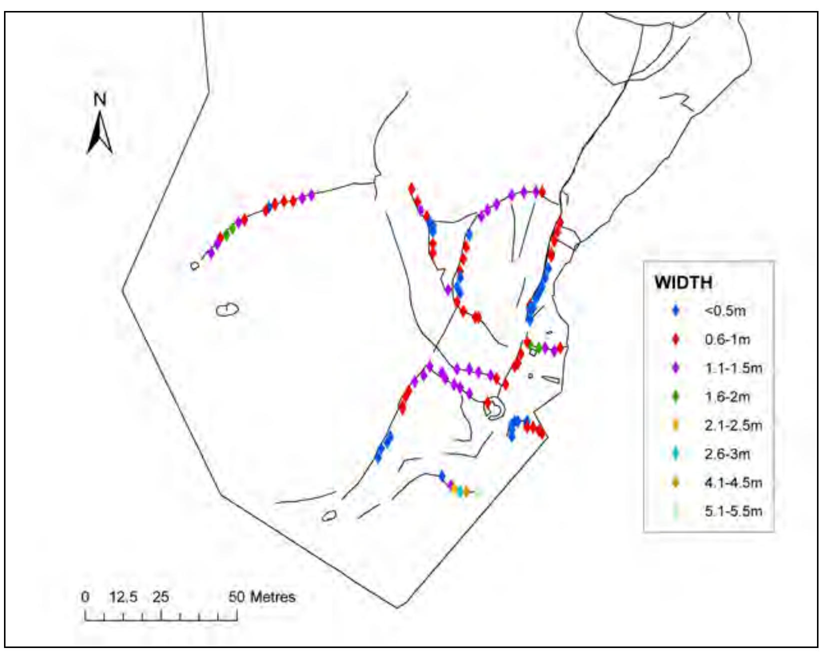


Fig. 6.23c Feature Width: Clevigarth Multiple Field System.

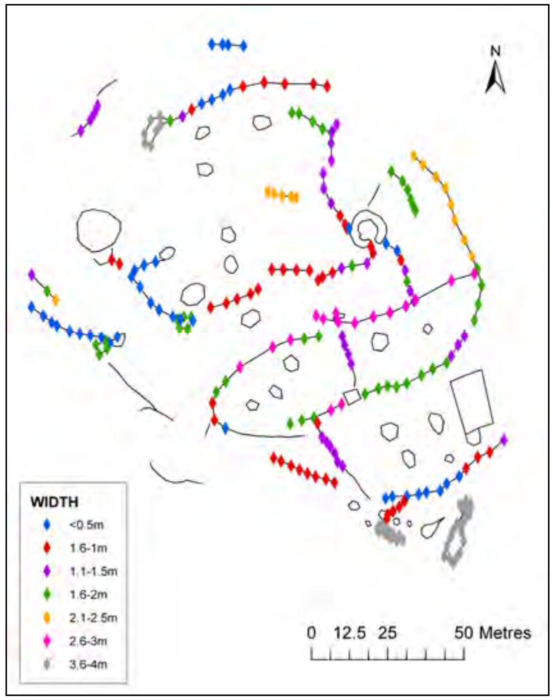


Fig. 6.23d Feature Width: Ness of Gruting Multiple Field System.

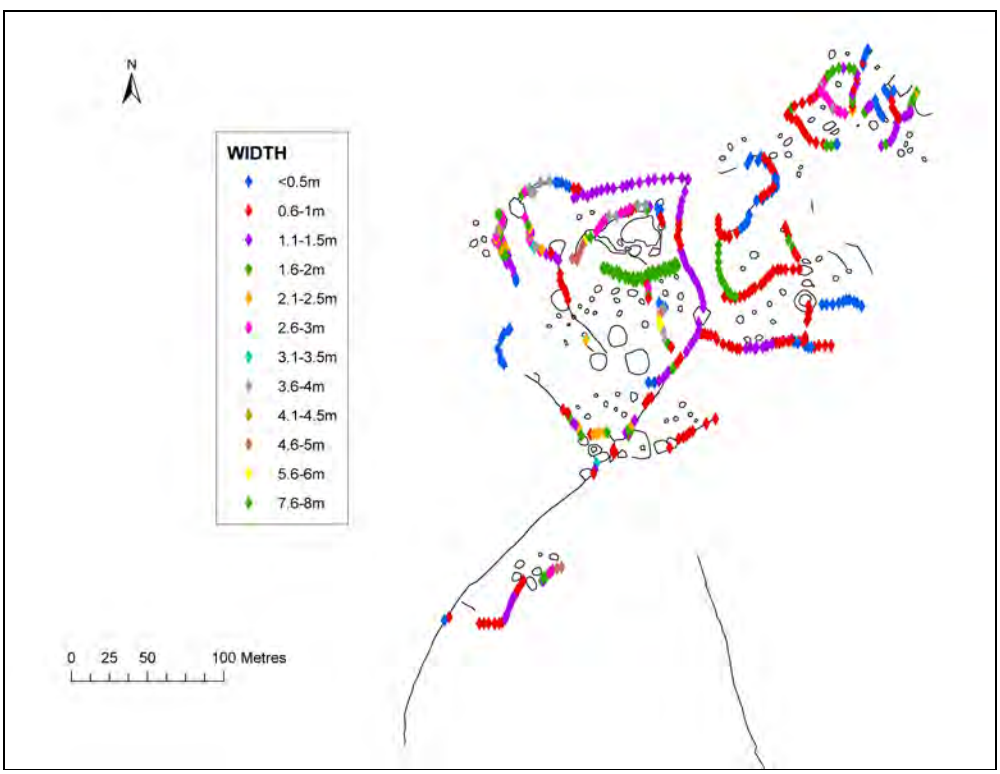


Fig. 6.23e Feature Width: Pinhoulland Multiple Field System.

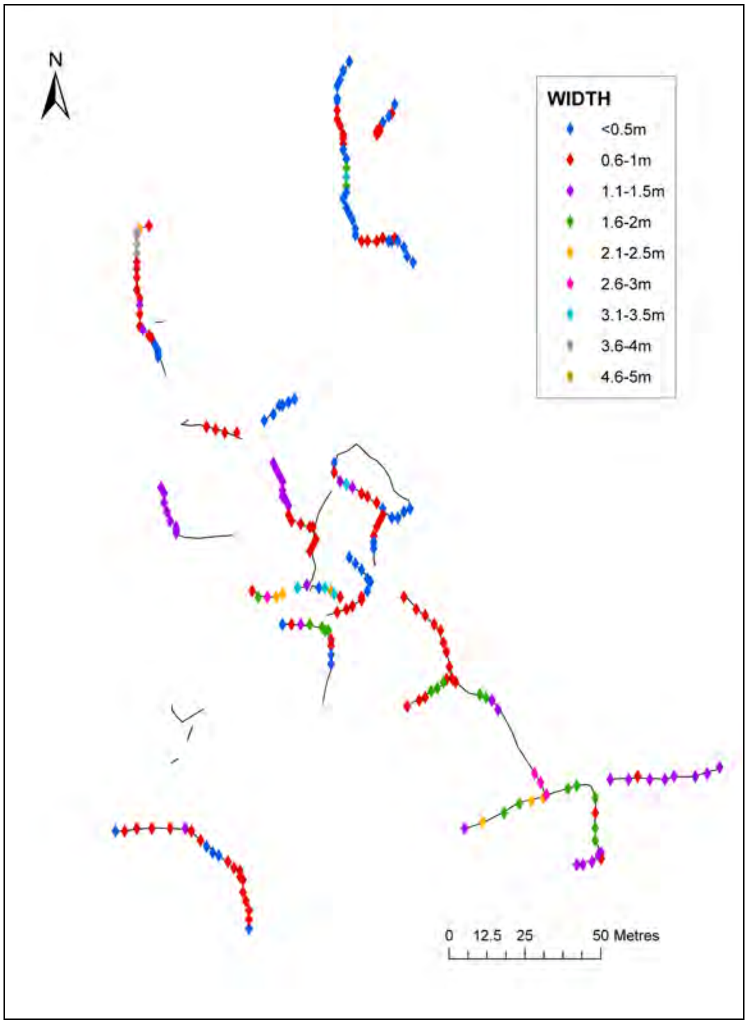
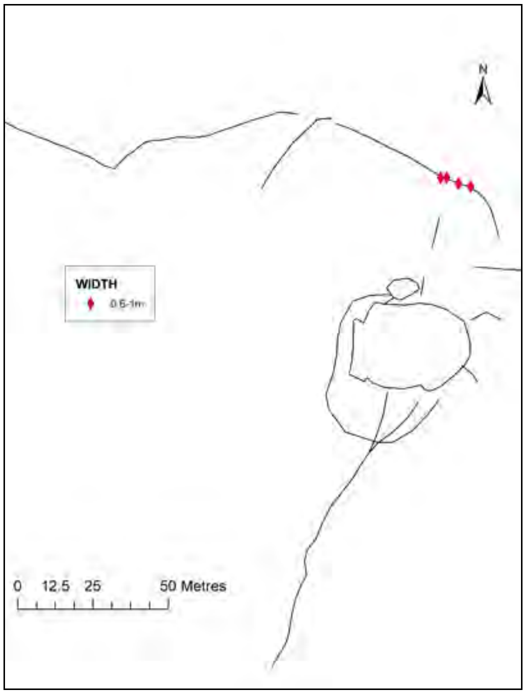


Fig. 6.23f Feature Width: Sumburgh Head Multiple Field System.



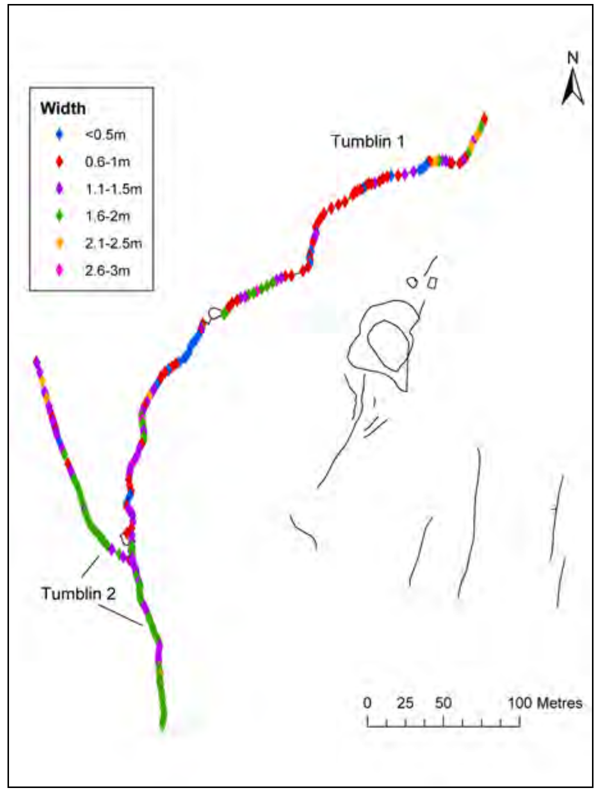


Fig. 6.24a Feature Width: Clevigarth Broch Field System; Fig 6.24b Feature Width: Tumblin Broch Field System.

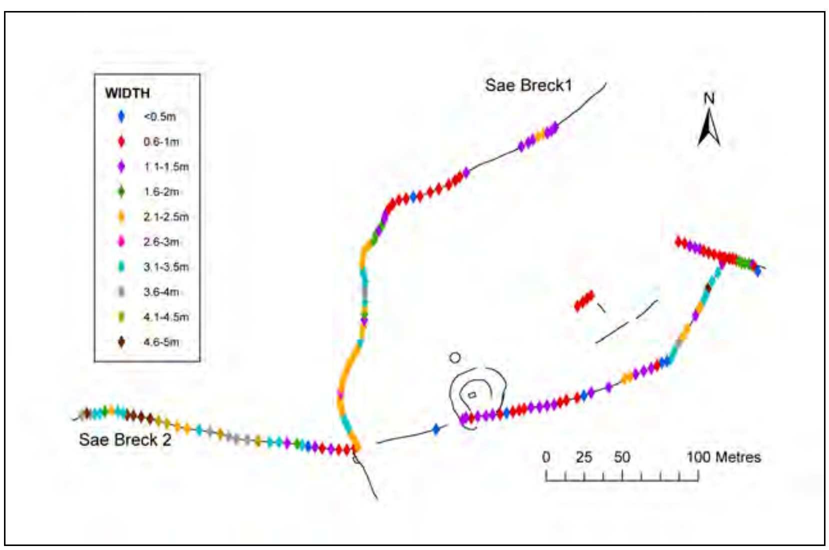


Fig. 6.24c Feature Width: Sae Breck Broch Field System.

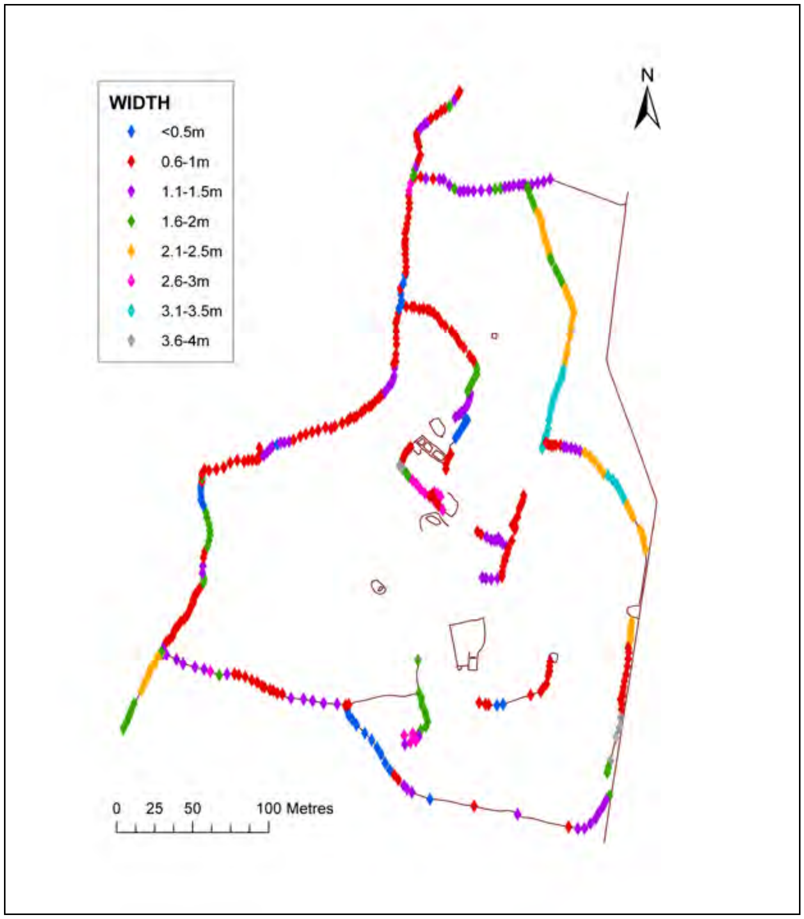


Fig. 6.25a Feature Width: Belmont Norse Field System.

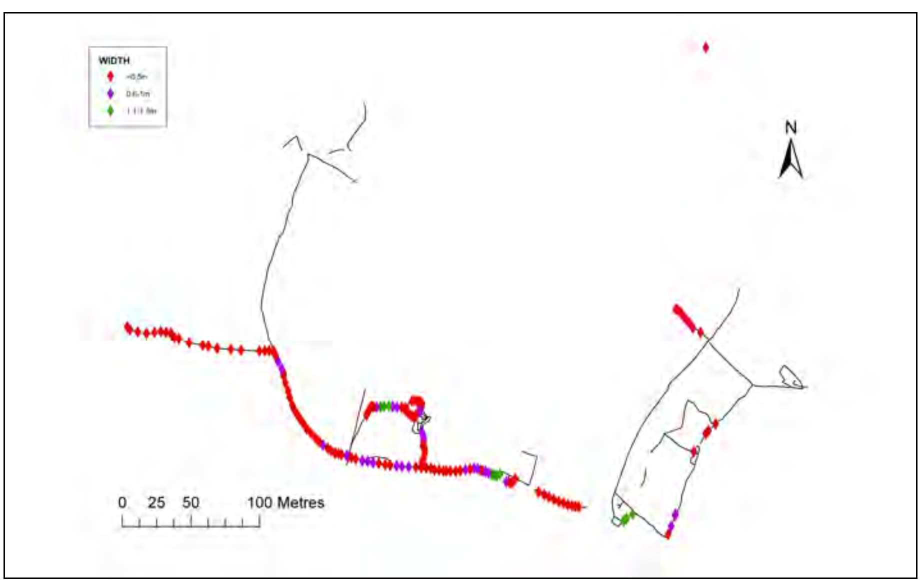


Fig. 6.25b Feature Width: Gardie Norse Field System.

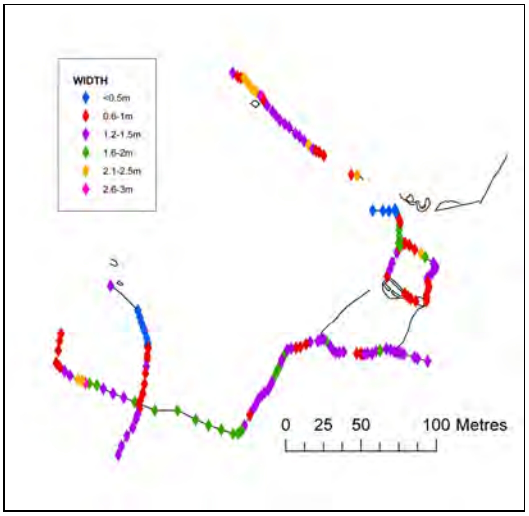
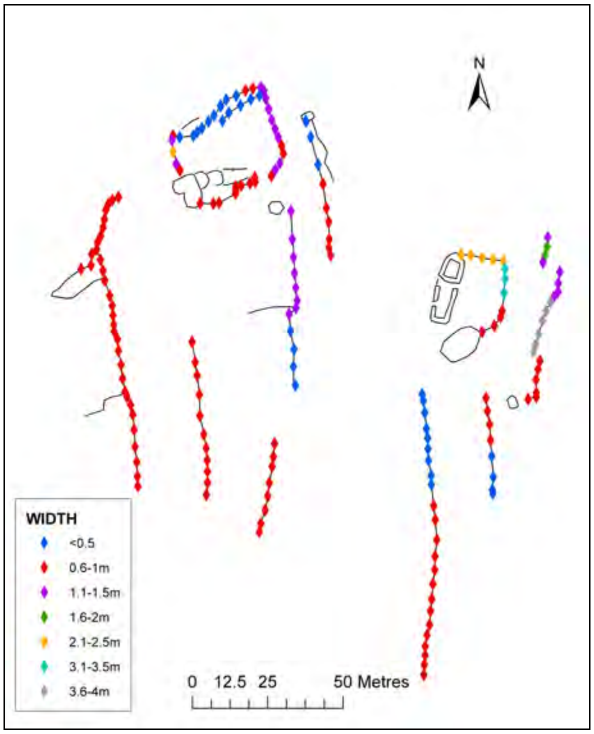


Fig. 6.25c Feature Width: Watlie Norse Field System.



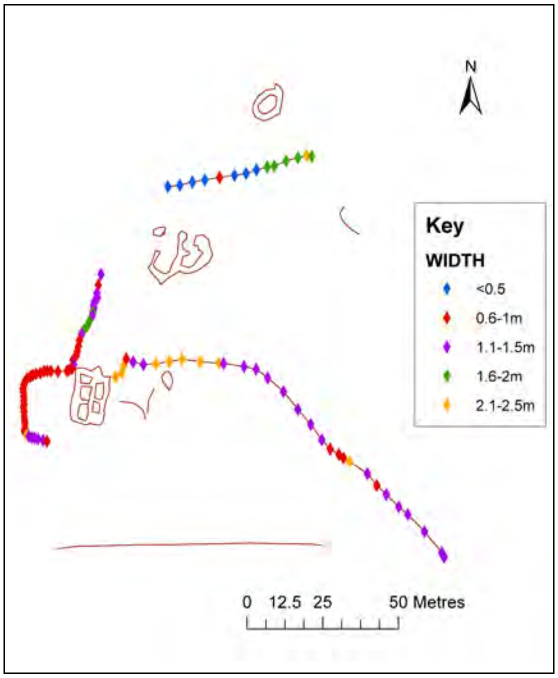


Fig. 6.25d Feature Width: Hamar Norse Field System. Fig. 6.25e Feature Width: Stove Norse Field System.

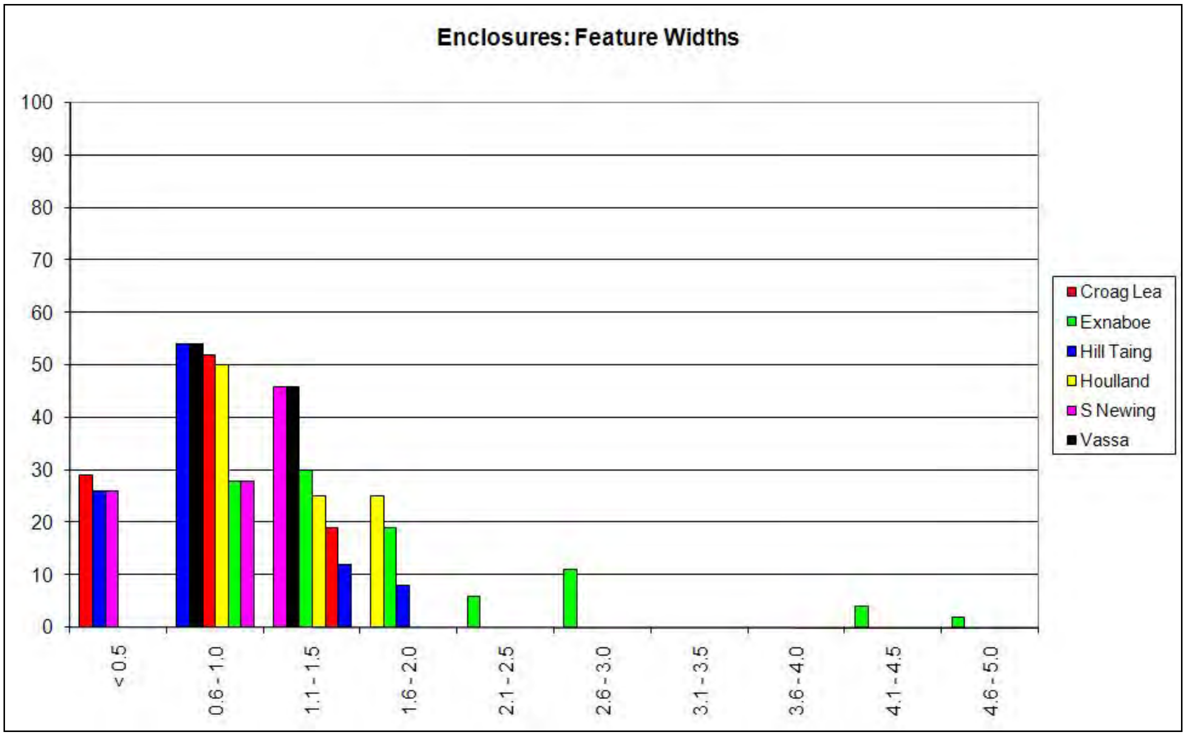


Fig 6.26a Graph showing percentage of points of Feature Width, per Homestead Enclosure site

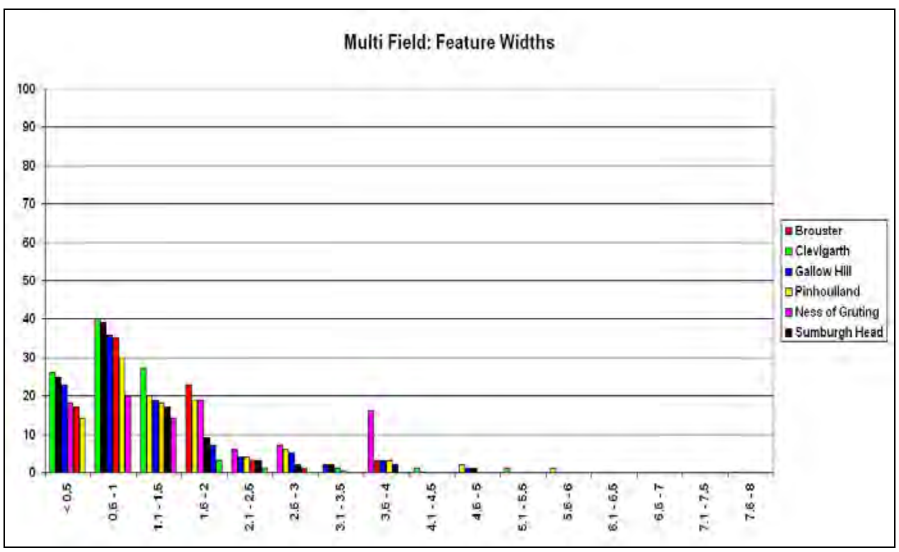


Fig 6.26b Graph showing percentage of points of each Feature Width, per Multiple Field site

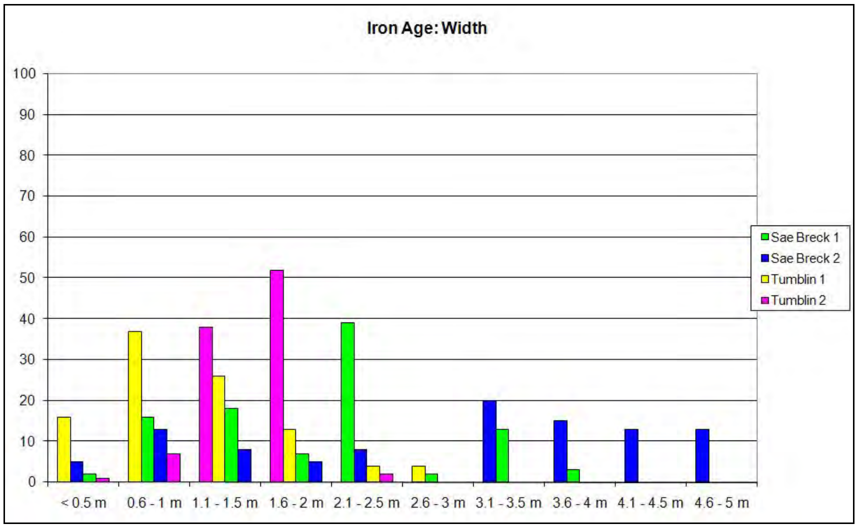


Fig 6.26c Graph showing percentage of points of each Feature Width, per Iron Age site

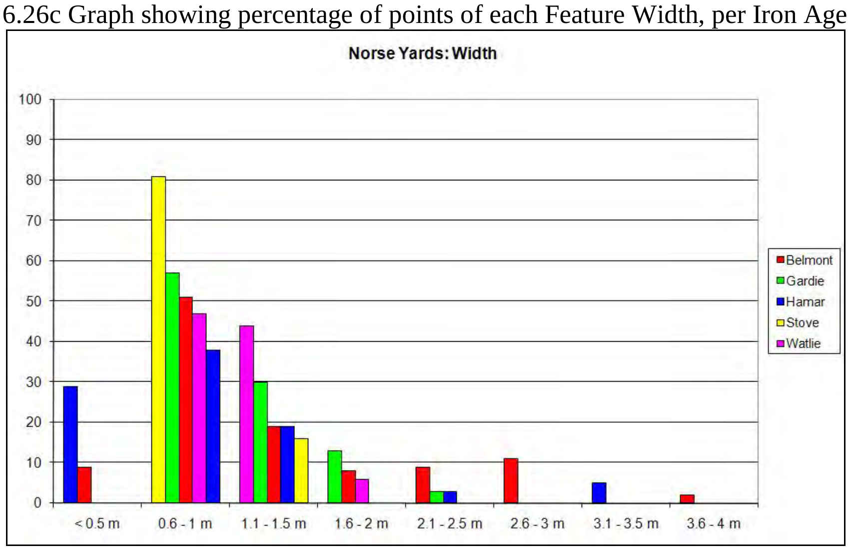


Fig 6.26d Graph showing percentage of points of each Feature Width, per Norse Yard site

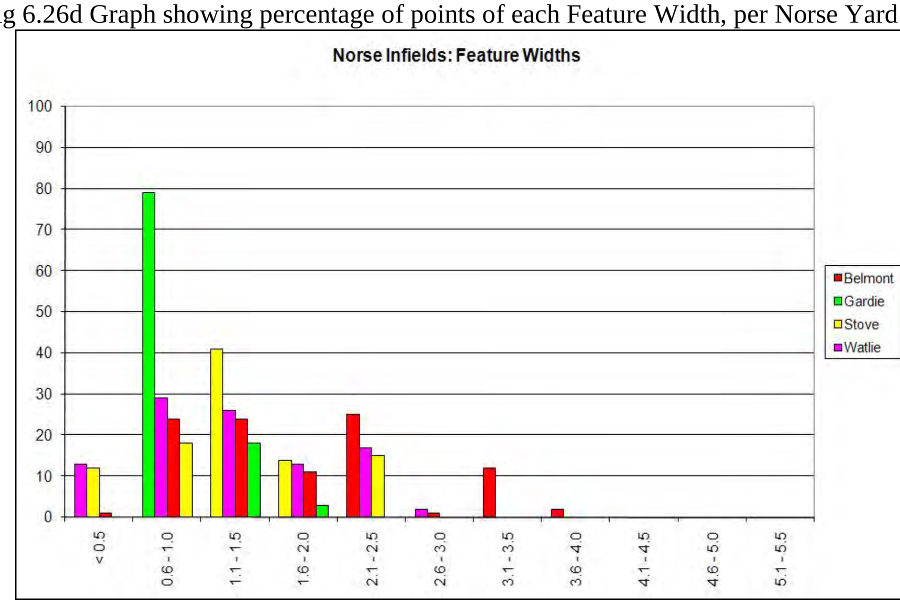


Fig 6.26e Graph showing percentage of points of each Feature Width, per Norse Infield site

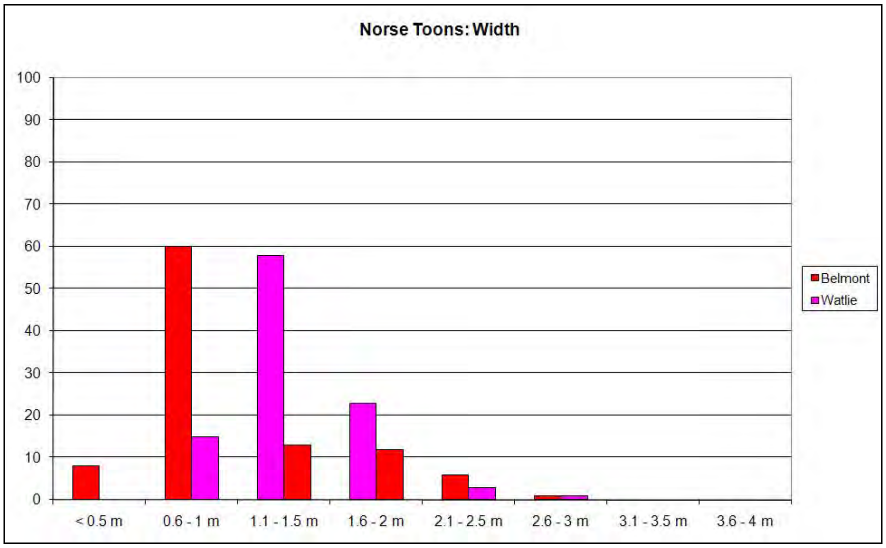


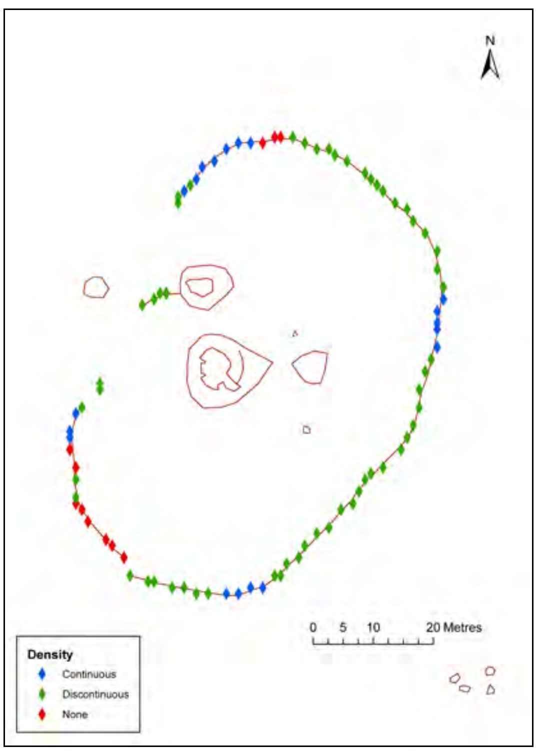
Fig 6.26f Graph showing percentage of points of each Feature Width, per Infield/Township boundary

Density of Visible Stone.

This recorded the amount of stone visible. Where stones were obscured by vegetation these were recorded as "no stone visible", even if the outlines of stones could be discerned under a mound of vegetation.

	Definition applied
Built	Constructed, more than one course of stone visible (although not necessarily placed in regular fashion).
Continuous	Stones which were either touching the next or had very small spaces between them.
Fairly Continuous	Stones which had intervals of no more than 0.5m between them.
Discontinuous	Stones occurring at intervals, which might be a few metres, but clearly belonging to the same feature, either because they comprised a line of othostats or because there were signs of a bank or vegetation covered stone linking them.
Very Few	One or two individual stones within a length of metre or more within a feature. Can be applied to small stones or single orthostats.

Table 6.3 Definitions of Density of Visible Stone used in recording Boundary Form.



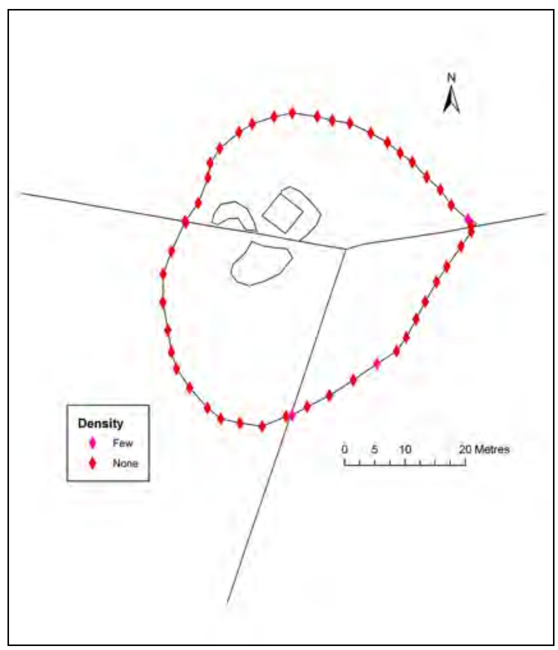


Fig. 6.27a Visible Stone Density: Croag Lea Homestead Enclosure; Fig. 6.27b Visible Stone Density: Exnaboe Homestead Enclosure.

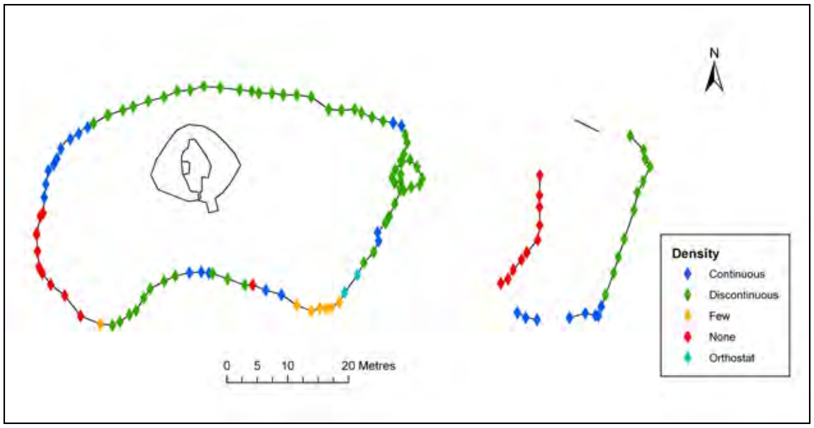
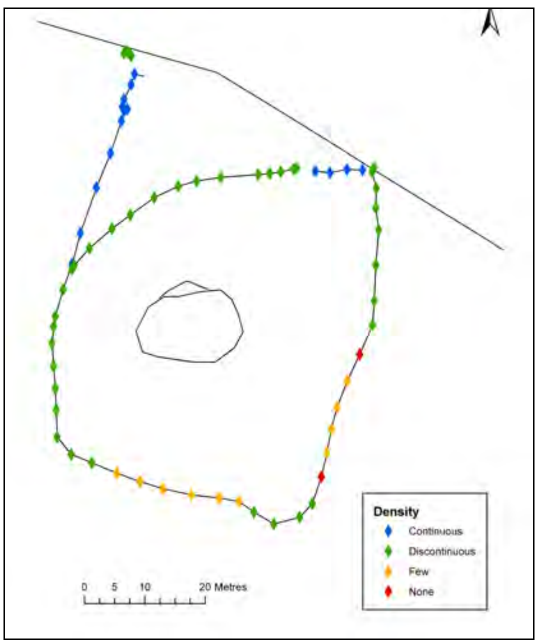


Fig. 6.27c Visible Stone Density: Hill of the Taing Homestead Enclosure



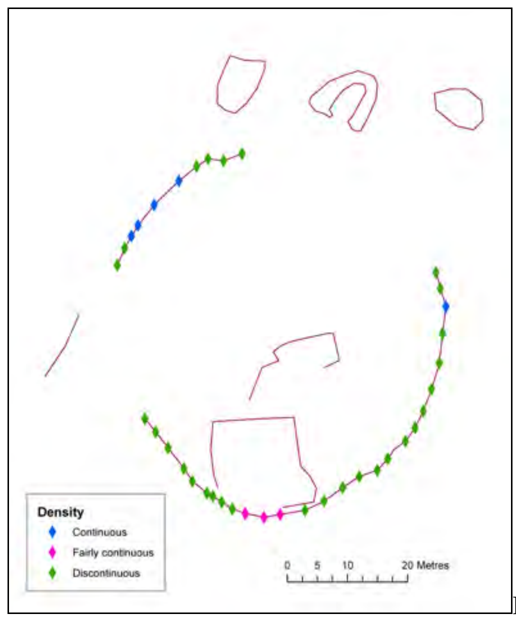


Fig. 6.27d Visible Stone Density: Houlland Homestead Enclosure Fig. 6.27e Visible Stone Density: Vassa Homestead Enclosure

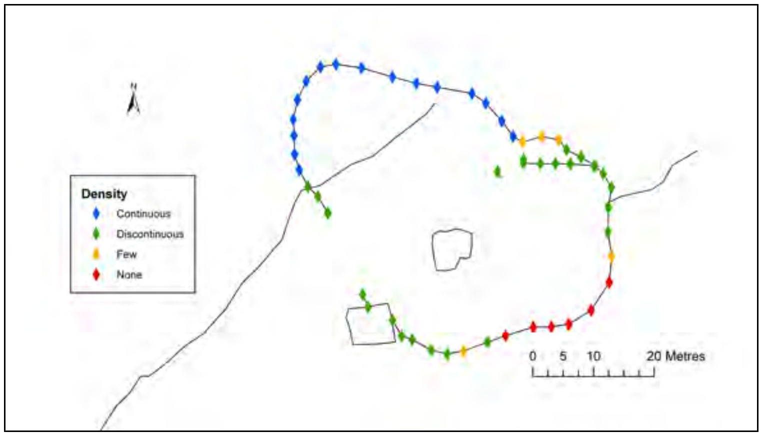
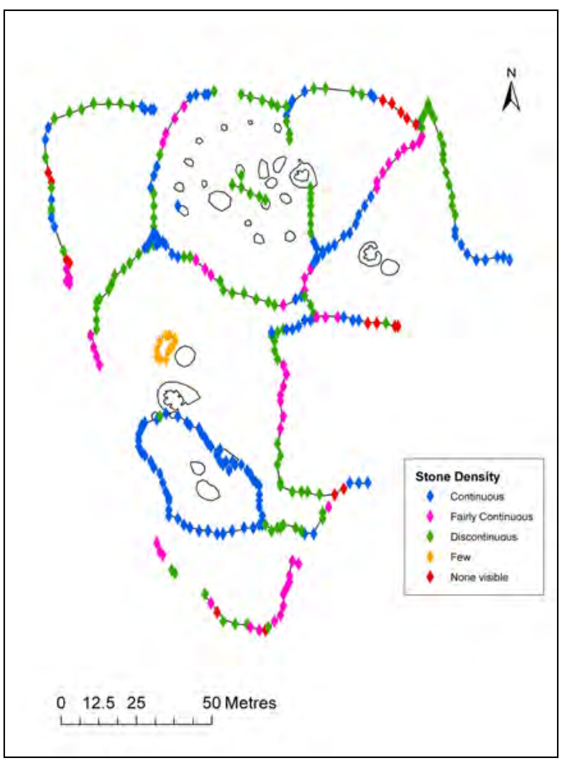


Fig. 6.27f Visible Stone Density: South Newing Homestead Enclosure



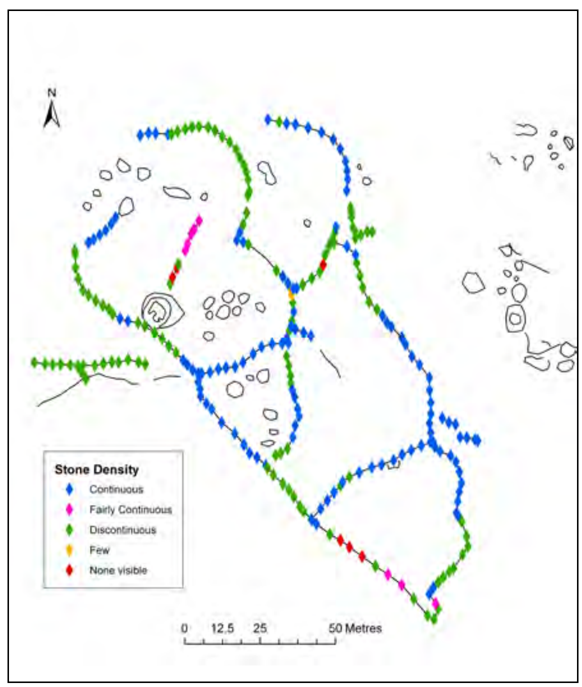


Fig. 6.28a Visible Stone Density: Scord of Brouster Multiple Field System; Fig. 6.28b Visible Stone Density: Gallow Hill

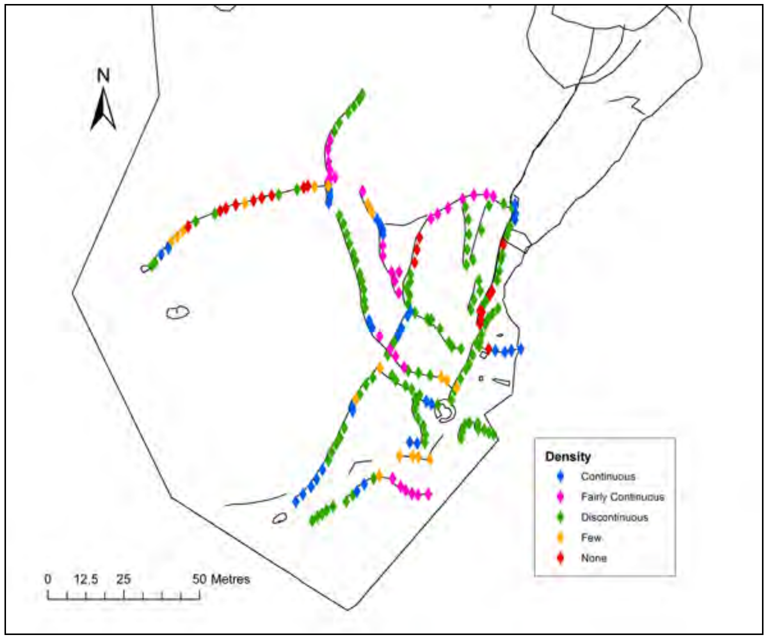


Fig. 6.28c Visible Stone Density: Clevigarth Multiple Field System.

Fig. 6.28d Visible Stone Density: Ness of Gruting Multiple Field System.

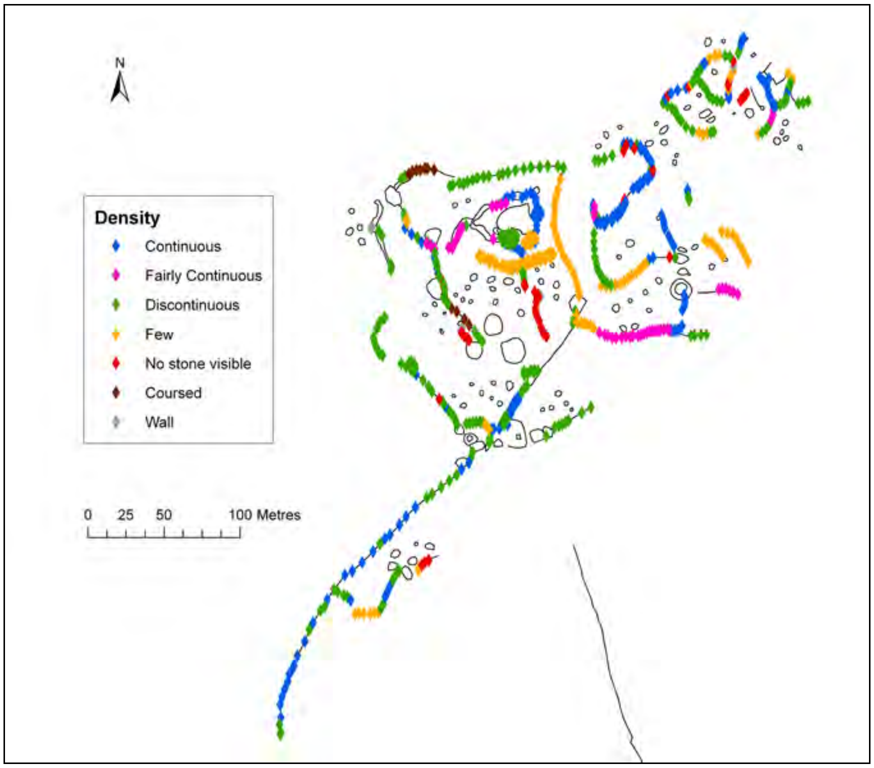


Fig. 6.28e Visible Stone Density: Pinhoulland Multiple Field System.

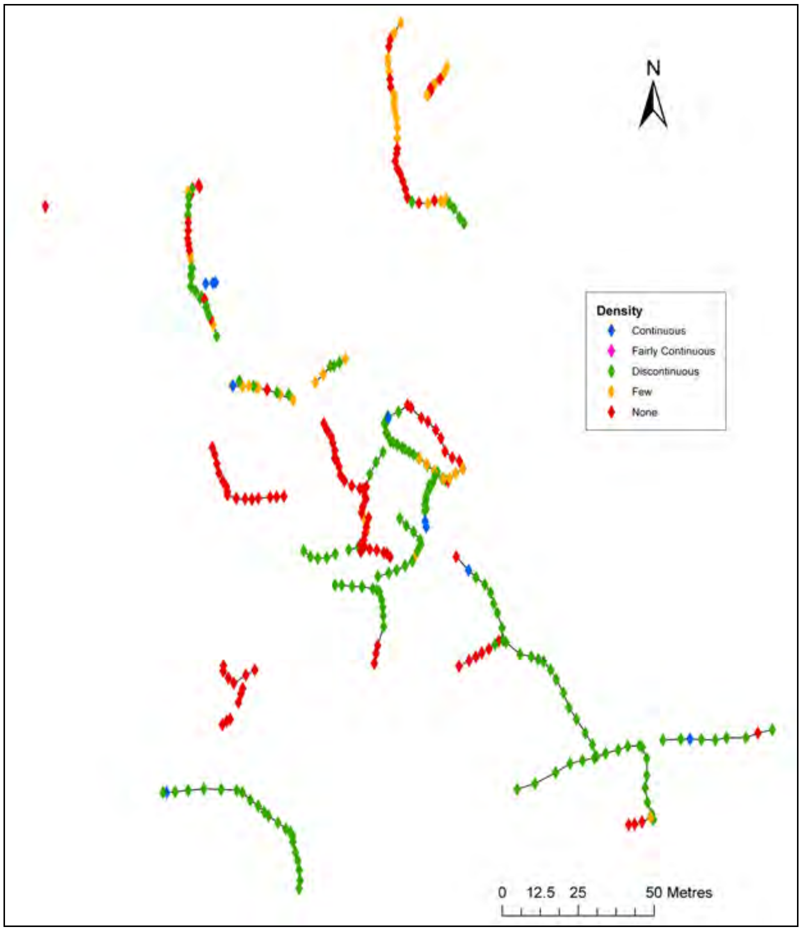
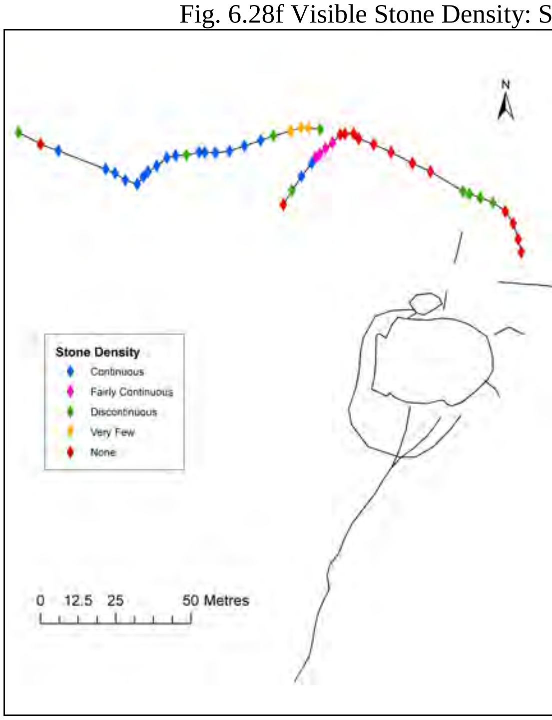


Fig. 6.28f Visible Stone Density: Sumburgh Head Multiple Field System.



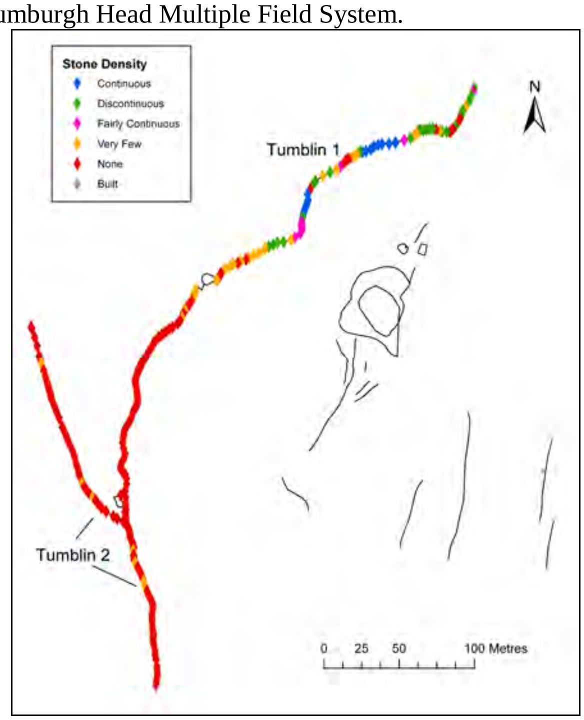


Fig. 6.29a Visible Stone Density: Clevigarth Broch Field System; Fig. 6.29b Visible Stone Density: Tumblin Broch Field System

Fig. 6.29c Visible Stone Density: Sae Breck Broch Field System.

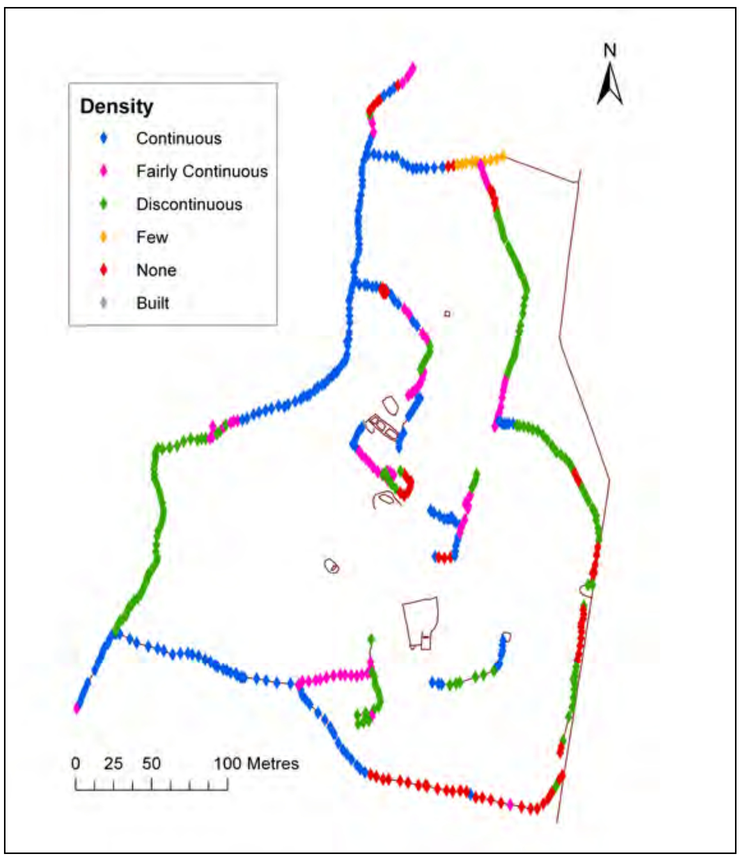


Fig. 6.30a Visible Stone Density: Belmont Norse Field System.

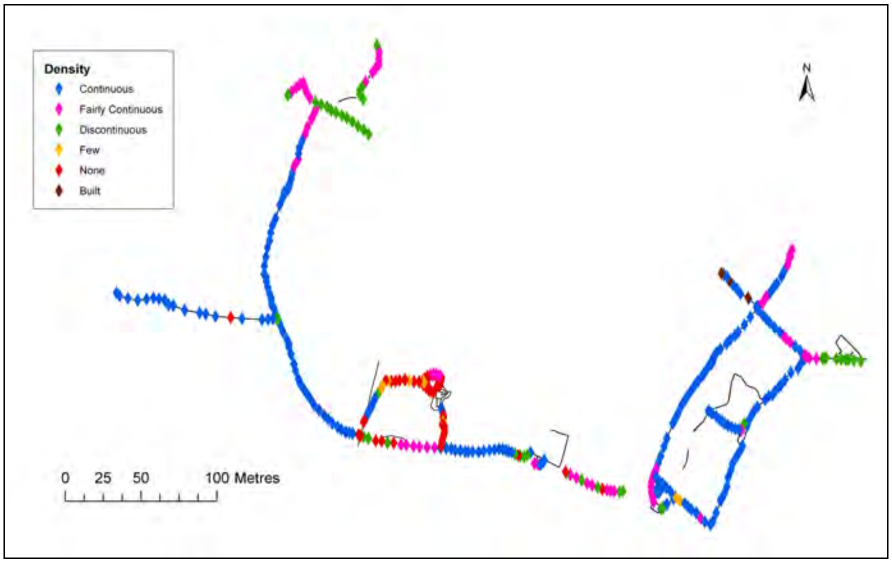


Fig. 6.30b Visible Stone Density: Gardie Norse Field System.

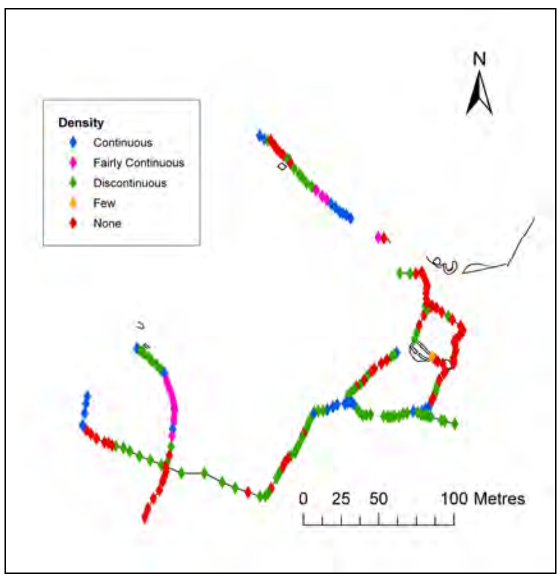
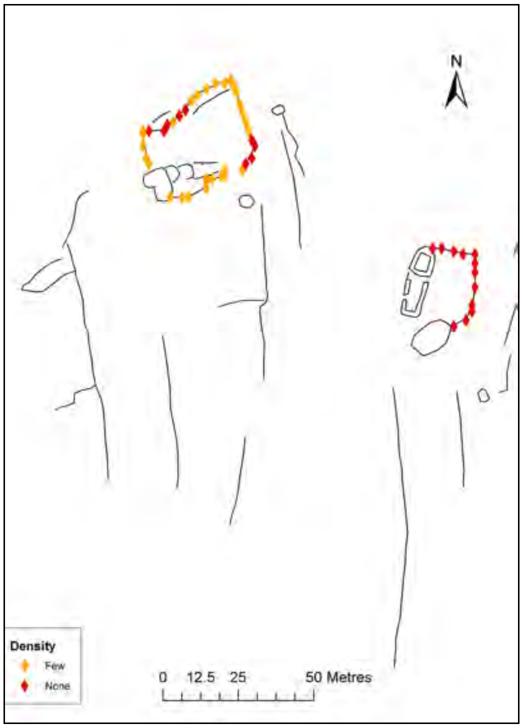


Fig. 6.30c Visible Stone Density: Watlie Norse Field System.



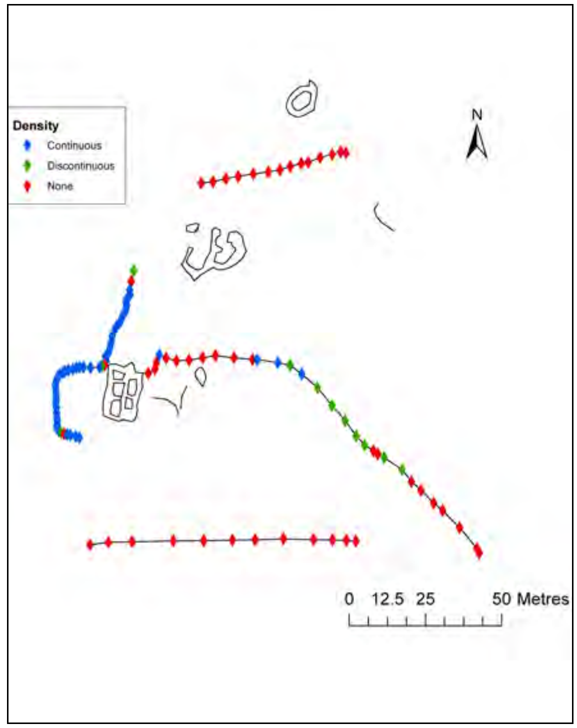


Fig. 6.30d Visible Stone Density: Hamar Norse Field System. Fig. 6.30e Visible Stone Density: Stove Norse Field System.

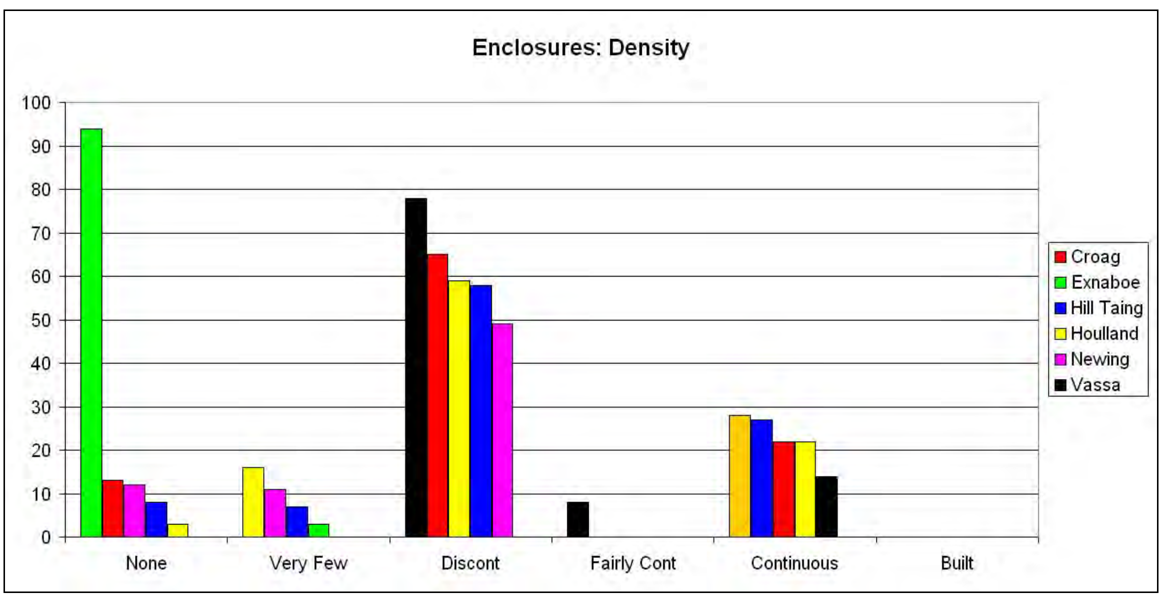


Fig 6.31a Graph showing percentage of points of Visible Stone Density, per Homestead Enclosure site

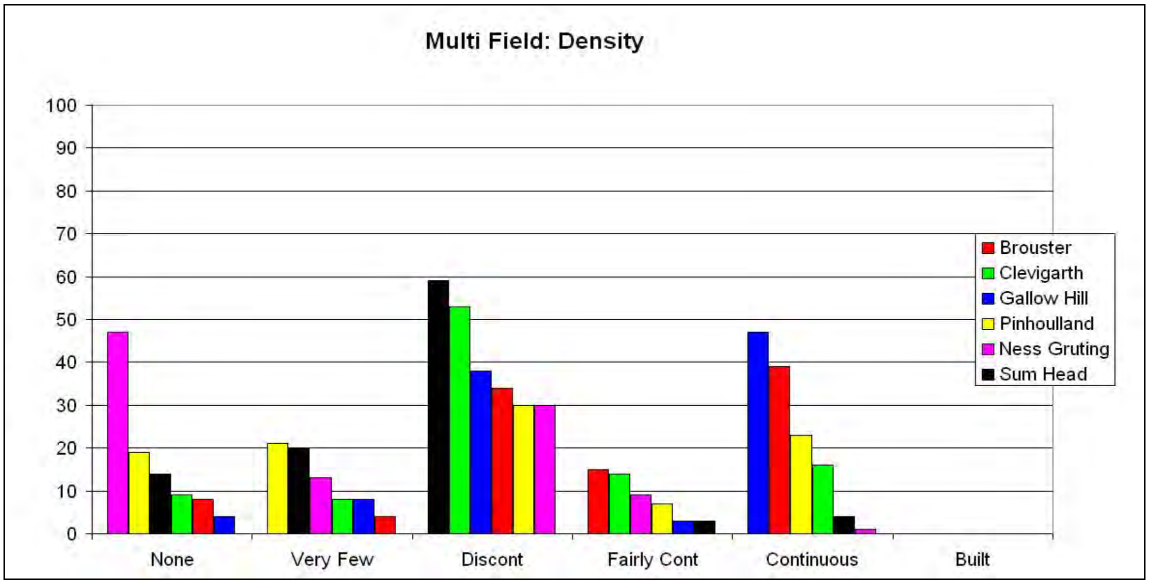


Fig 6.31b Graph showing percentage of points of Visible Stone Density, per Multiple Field System

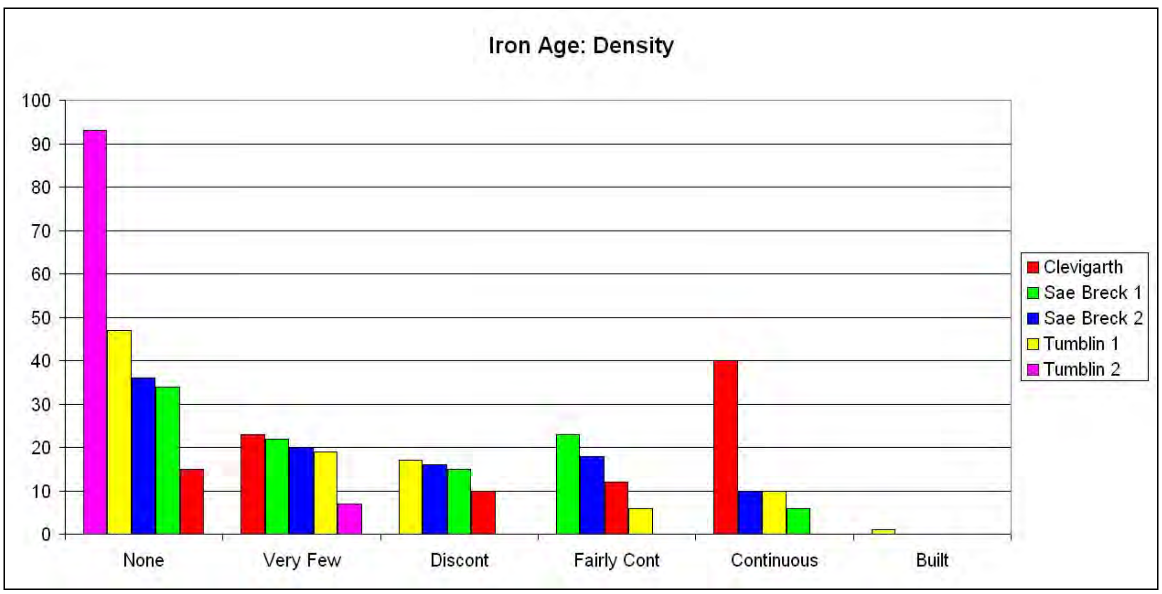


Fig 6.31c Graph showing percentage of points of Visible Stone Density, per Iron Age site

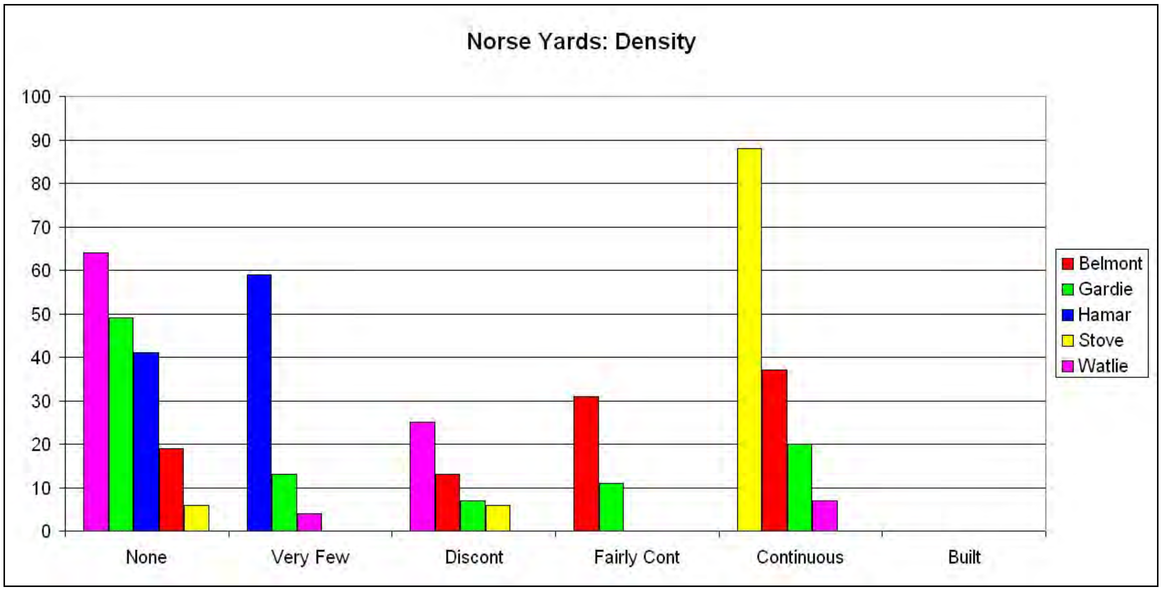


Fig 6.31d Graph showing percentage of points of Visible Stone Density, per Norse Yard

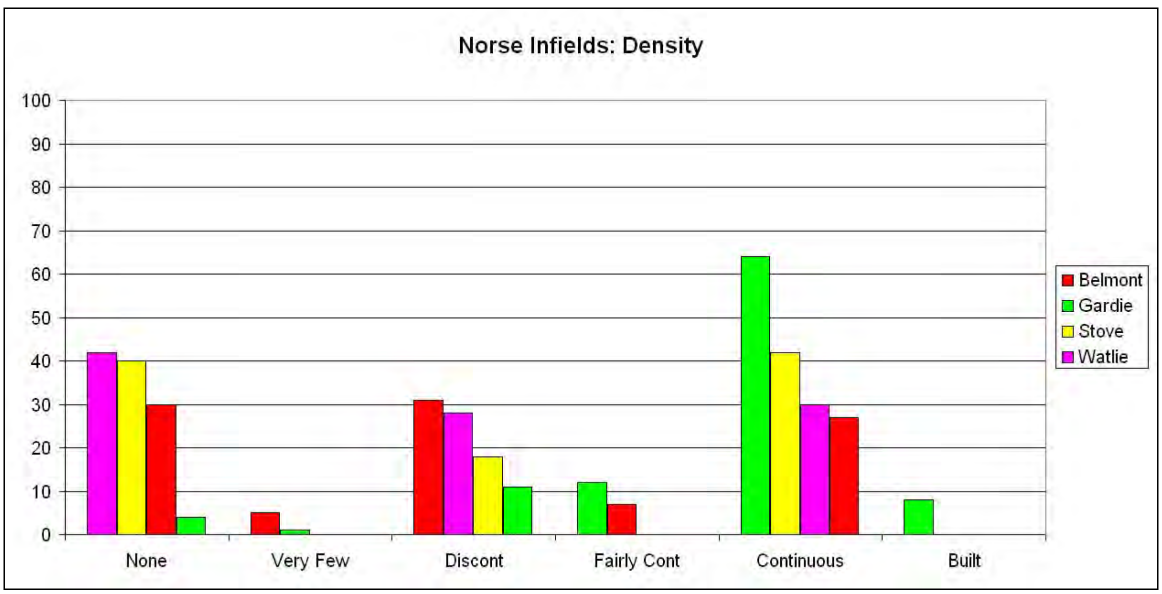


Fig 6.31e Graph showing percentage of points of Visible Stone Density, per Norse Infield

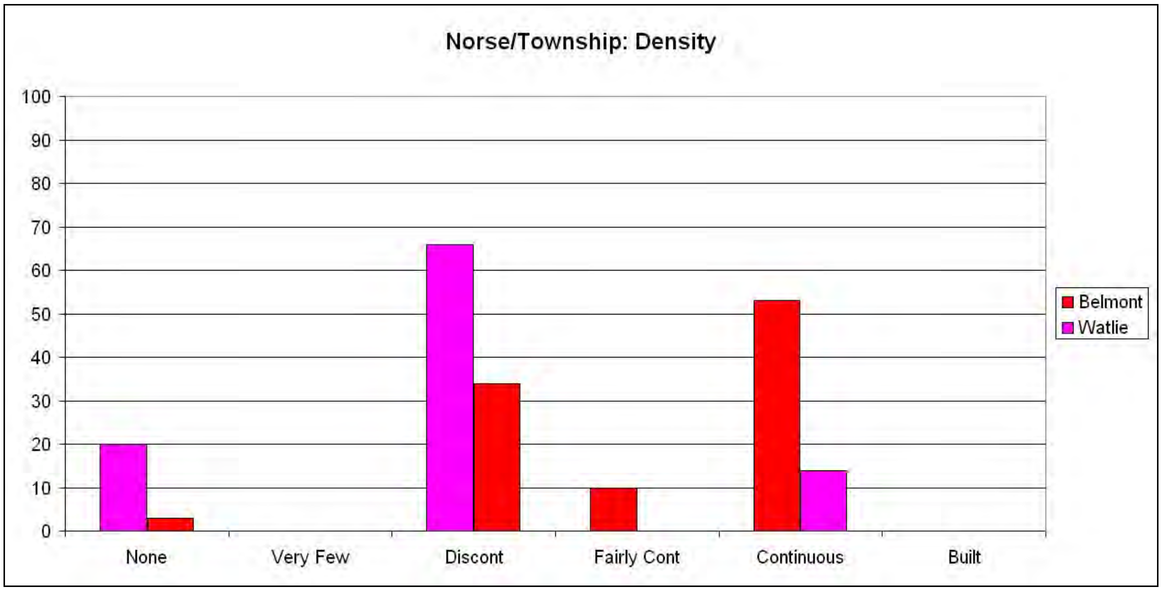
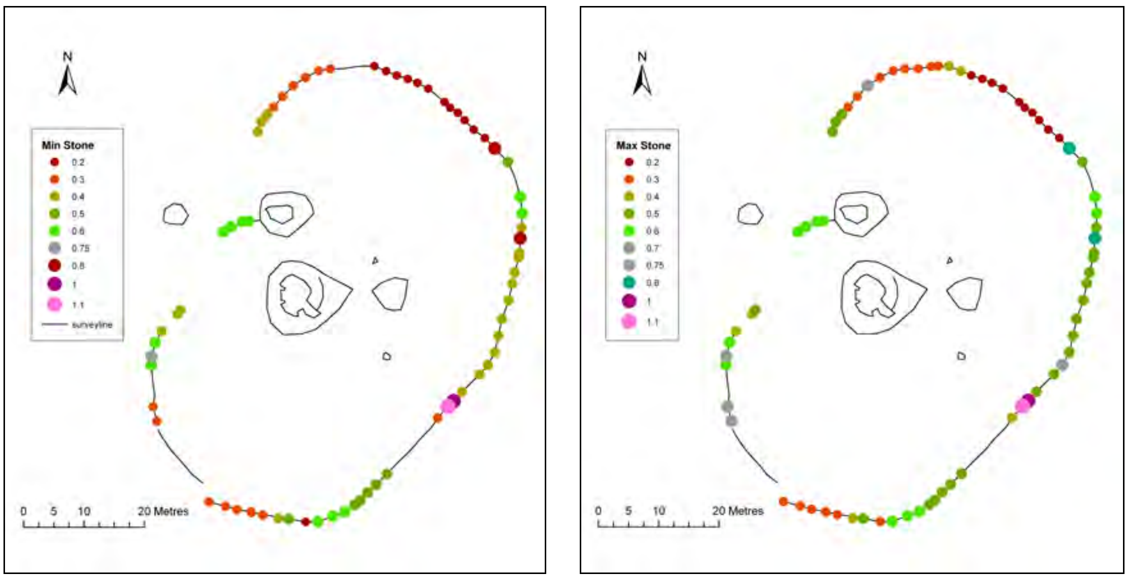


Fig 6.31f Graph showing percentage of points of Visible Stone Density, per Infield/Township boundary.

Minimum and Maximum Stone Size

This measurement included stone both at the point surveyed and also within a metre either side of the recorded point (in the feature). This mitigated for the tendency to record survey points taken at large stones; including a greater length represented the feature more accurately. Where stones were partially obscured, stone size was applied strictly to what was visible.



Figs 6.32a & Fig 6.32b Minimum and Maximum Stone Sizes: Croag Lea Homestead Enclosure.

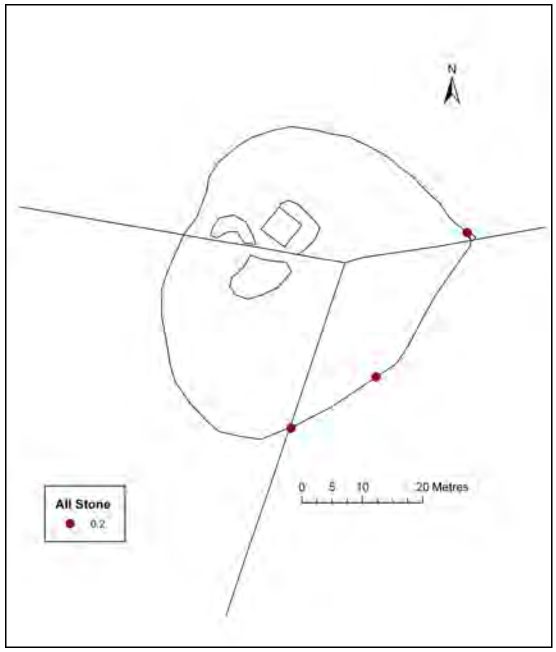


Fig. 6.32c All Stone: Exnaboe Homestead Enclosure

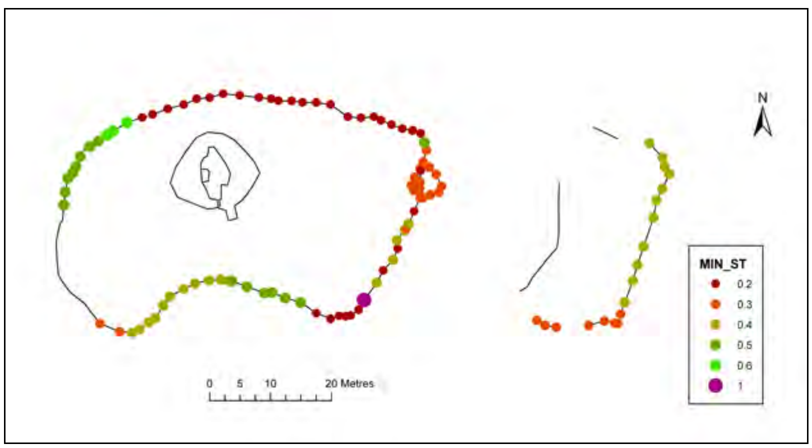


Fig. 6.32d Minimum Stone Sizes: Hill of the Taing Homestead Enclosure

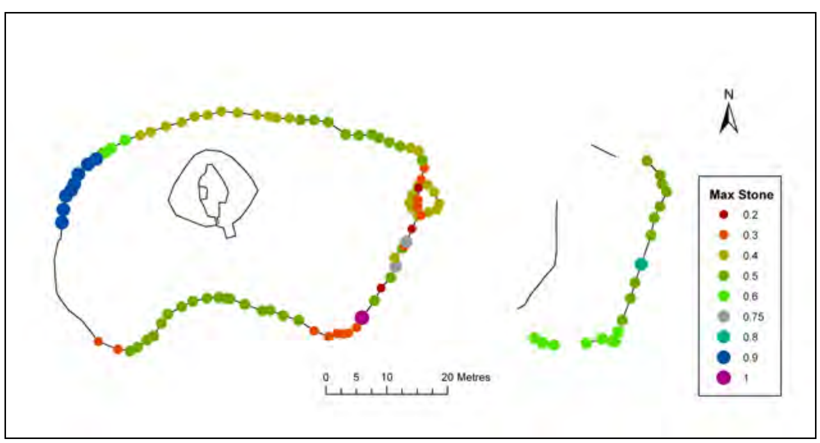


Fig. 6.32e Maximum Stone Sizes: Hill of the Taing Homestead Enclosure

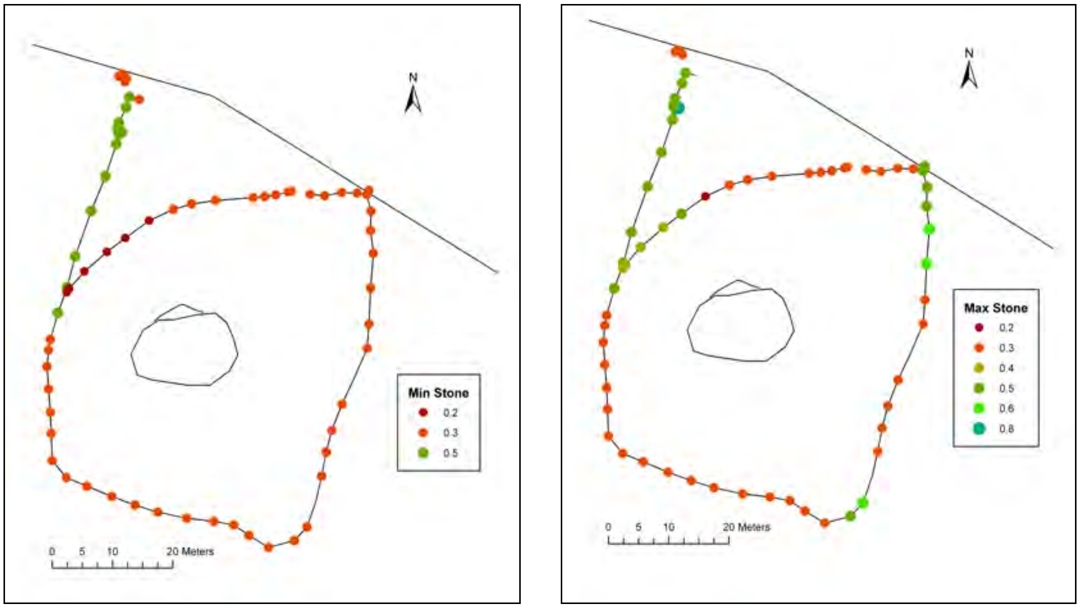


Fig. 6.32f & Fig 6.32g Minimum and Maximum Stone Sizes: Houlland Homestead Enclosure

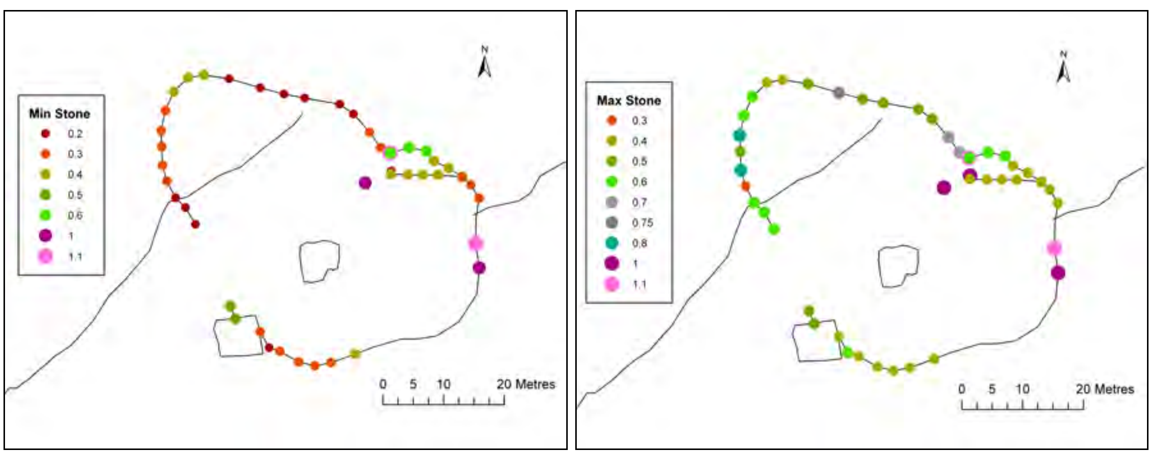


Fig. 6.32h and Fig 6.32i Minimum and Maximum Stone Sizes: South Newing Homestead Enclosure

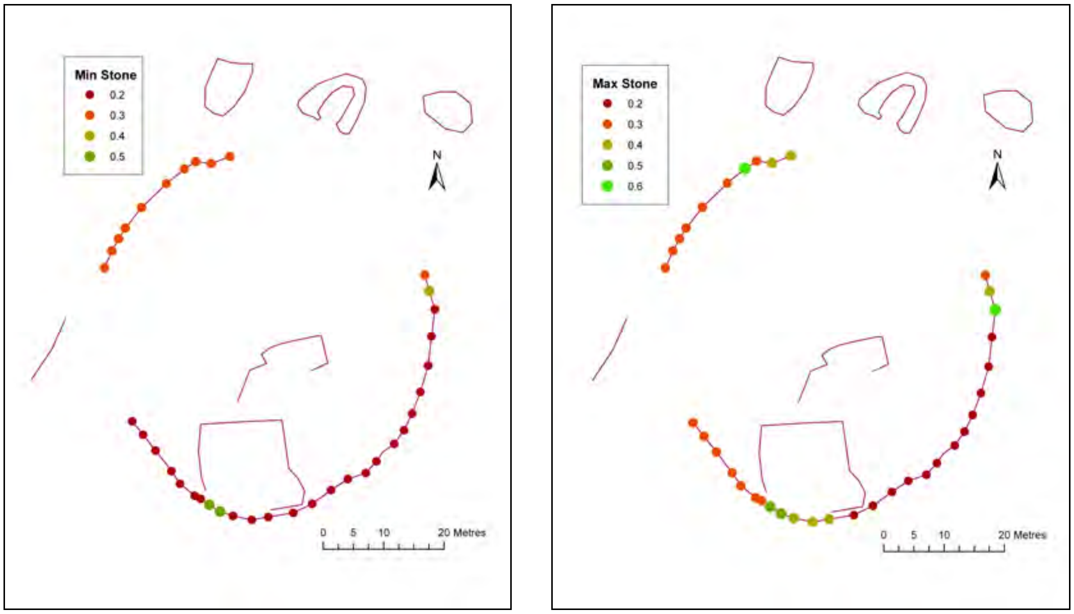


Fig. 6.32j and Fig 6.32k Minimum and Maximum Stone Sizes: Vassa Homestead Enclosure

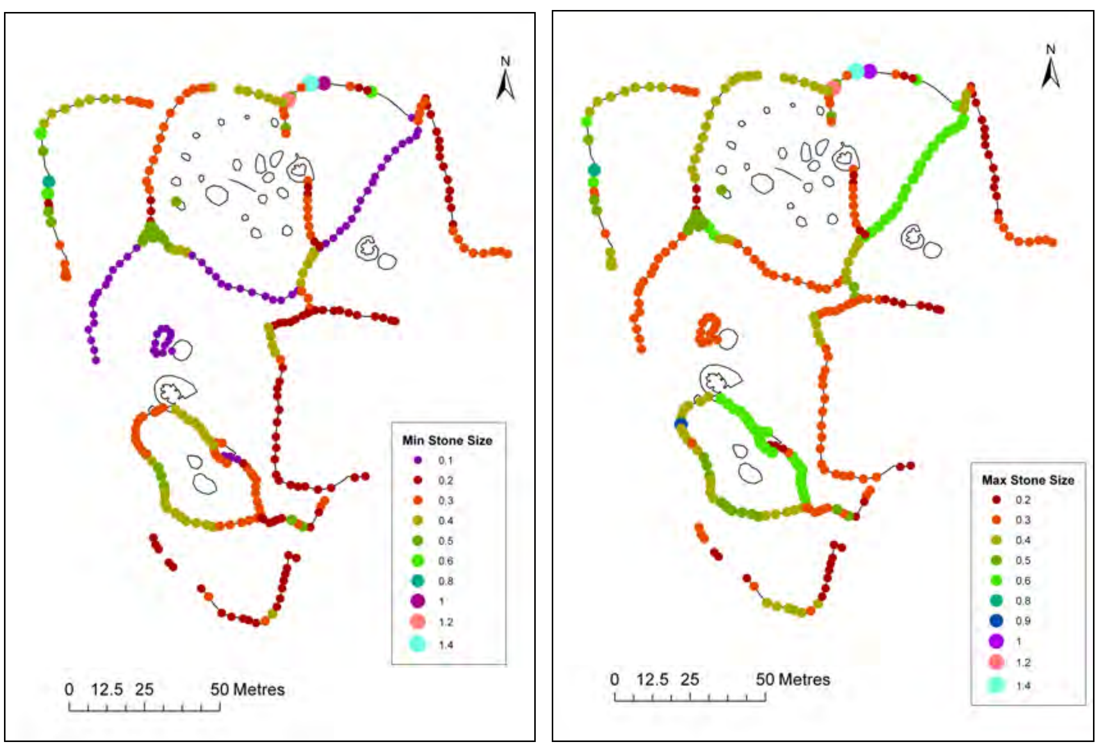


Fig. 6.33a and Fig 6.33b Minimum and Maximum Stone Sizes: Scord of Brouster Multiple Field System

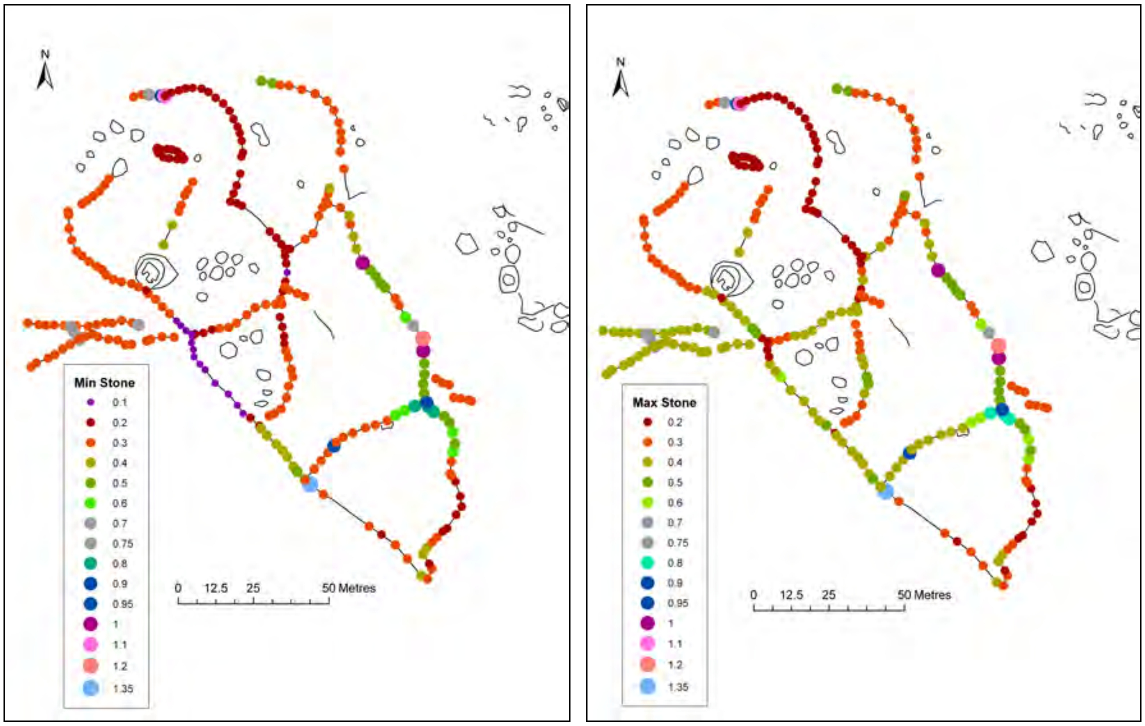


Fig. 6.33c and Fig 6.33d Minimum and Maximum Stone Sizes: Gallow Hill Multiple Field System.

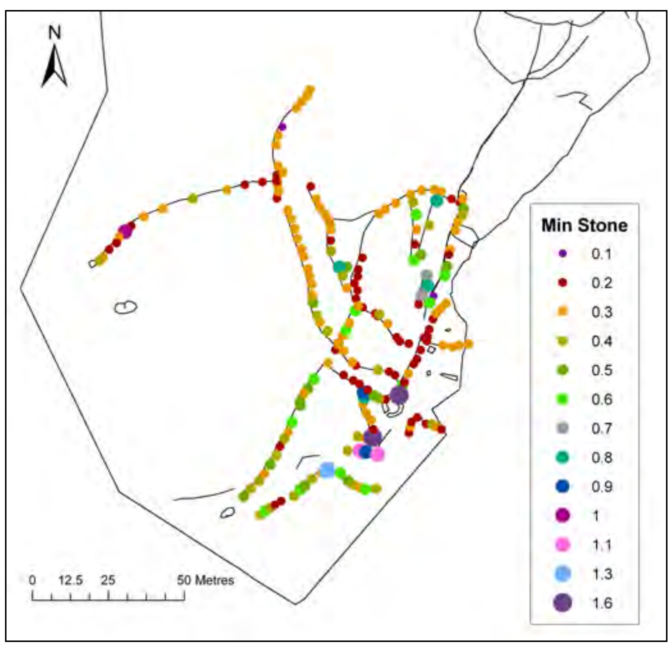


Fig. 6.33e Minimum Stone Sizes: Clevigarth Multiple Field System.

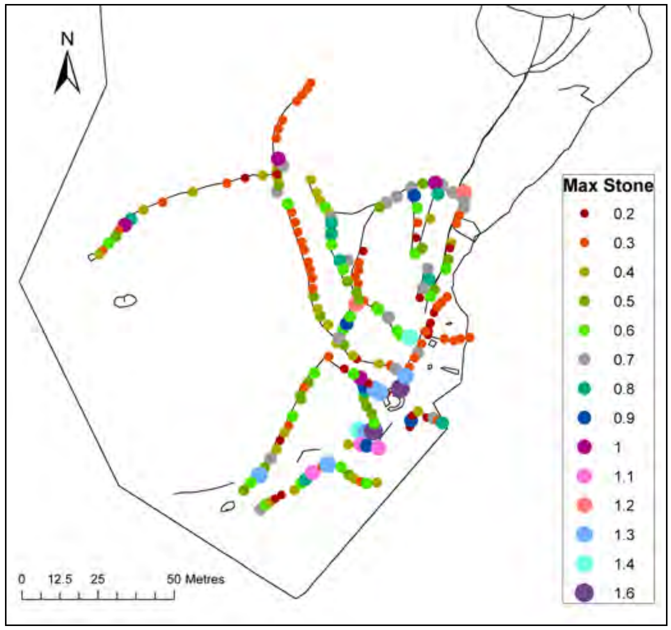


Fig. 6.33f Maximum Stone Sizes: Clevigarth Multiple Field System

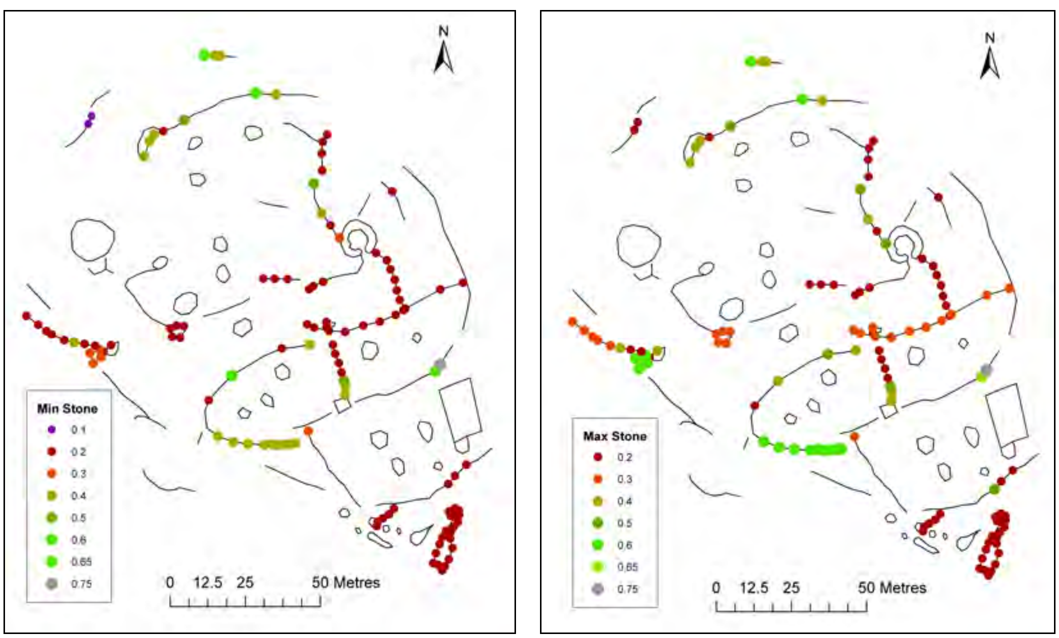


Fig. 6.33g & Fig 6.33h Minimum and Maximum Stone Sizes: Ness of Gruting Multiple Field System.

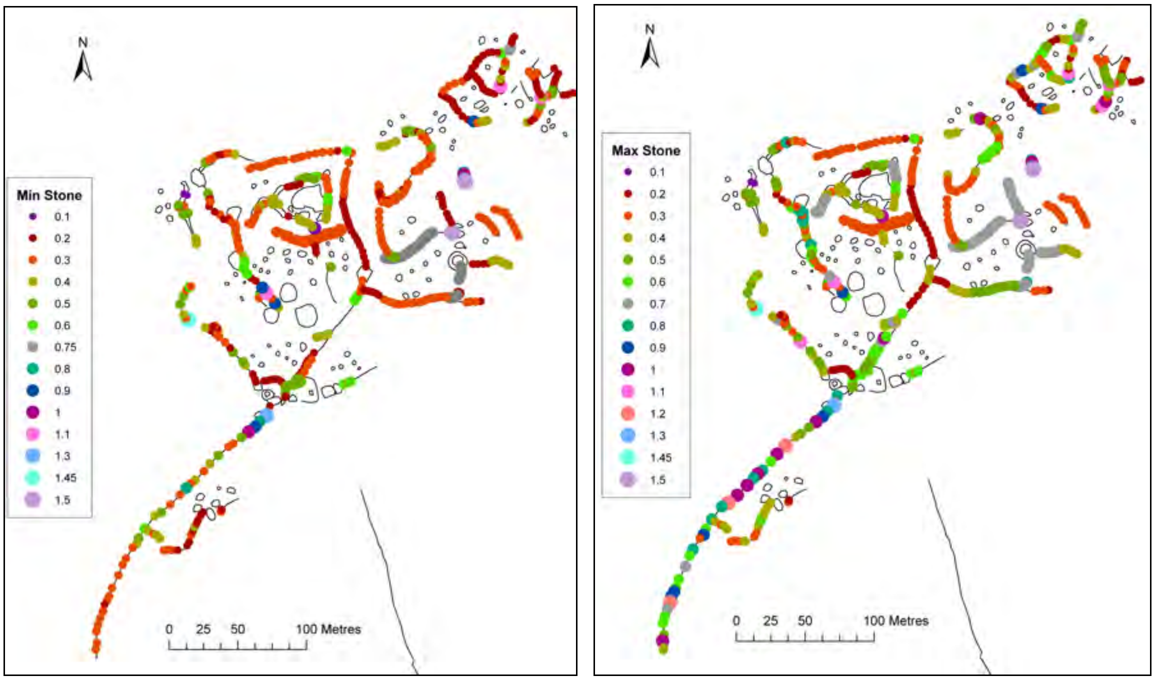


Fig. 6.33i & Fig 6.33j Minimum and Maximum Stone Sizes: Pinhoulland Multiple Field System.

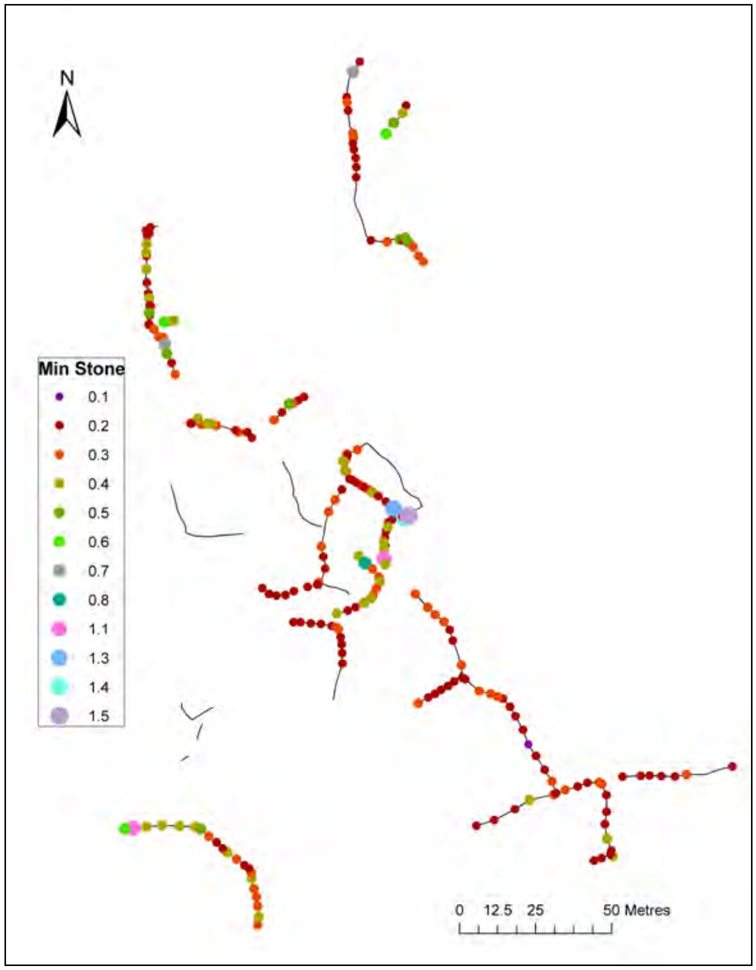


Fig. 6.33k Minimum Stone Sizes: Sumburgh Head Multiple Field System.

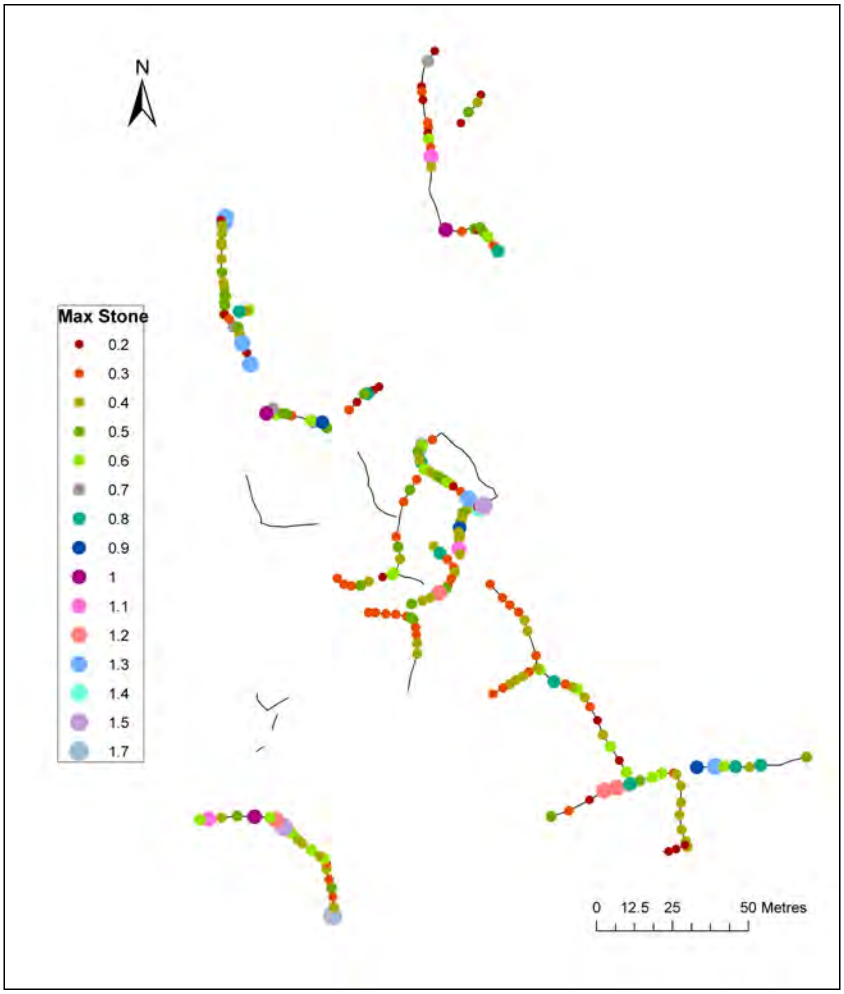


Fig 6.33l Maximum Stone Sizes: Sumburgh Head Multiple Field System.

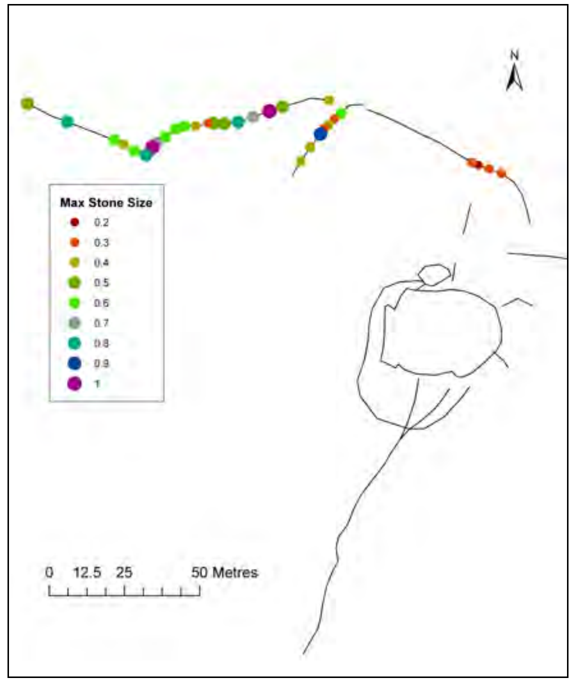
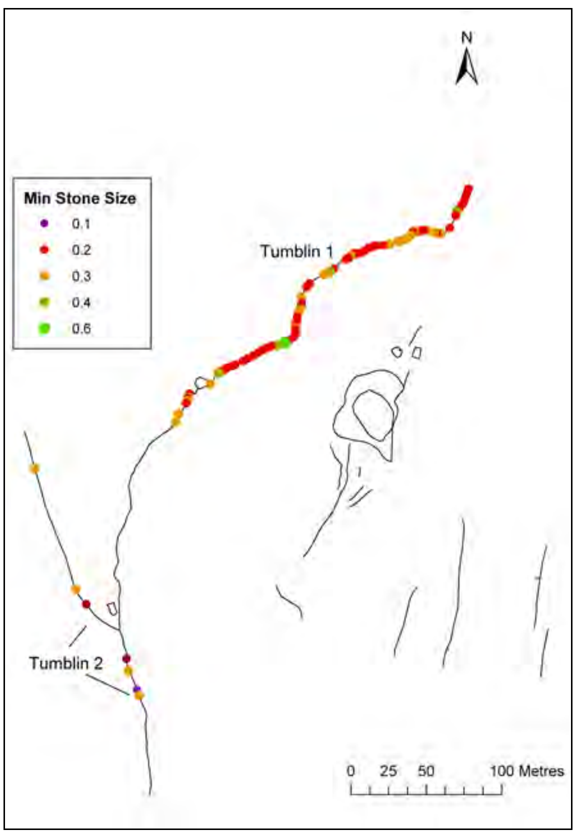


Fig. 6.34a Minimum Stone Sizes: Clevigarth Broch Field System. Fig. 6.34b Maximum Stone Sizes: Clevigarth Broch Field System.



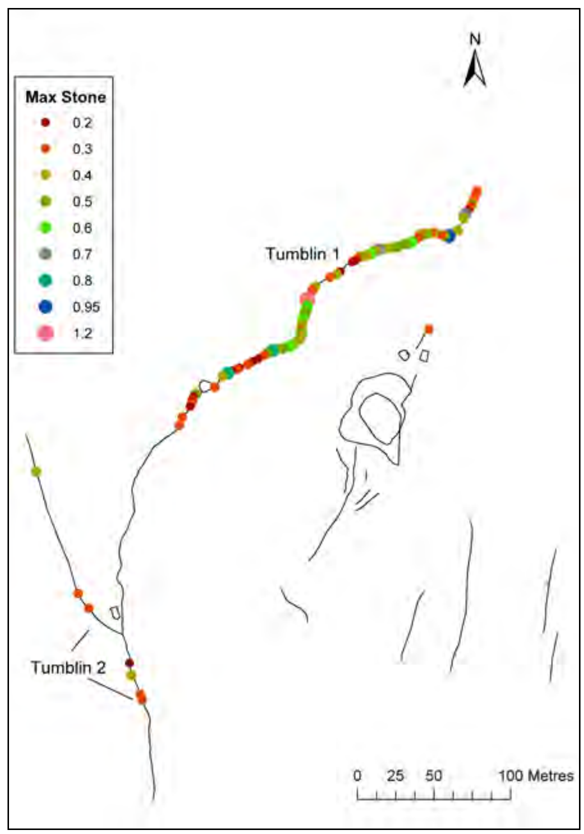


Fig. 6.34c Minimum Stone Sizes: Clevigarth Broch Field System. Fig. 6.34d Maximum Stone Sizes: Clevigarth Broch Field System.

Fig. 6.34e Minimum Stone Sizes: Sae Breck Broch Field System.

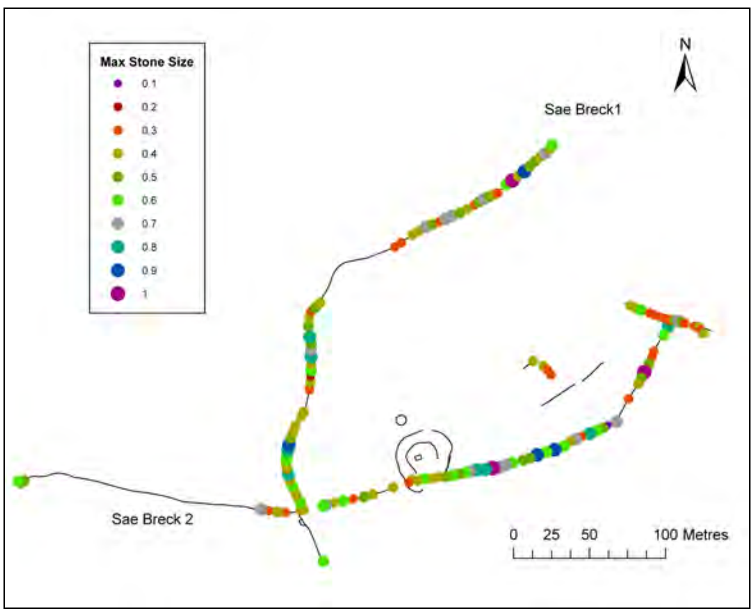


Fig. 6.34f Maximum Stone Sizes: Sae Breck Broch Field System.

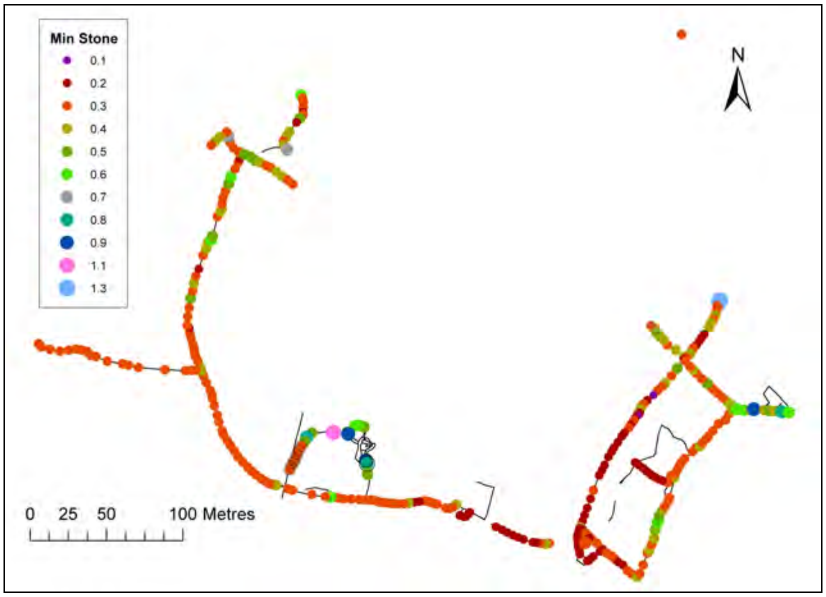


Fig. 6.35a Minimum Stone Sizes: Gardie Norse Field System.

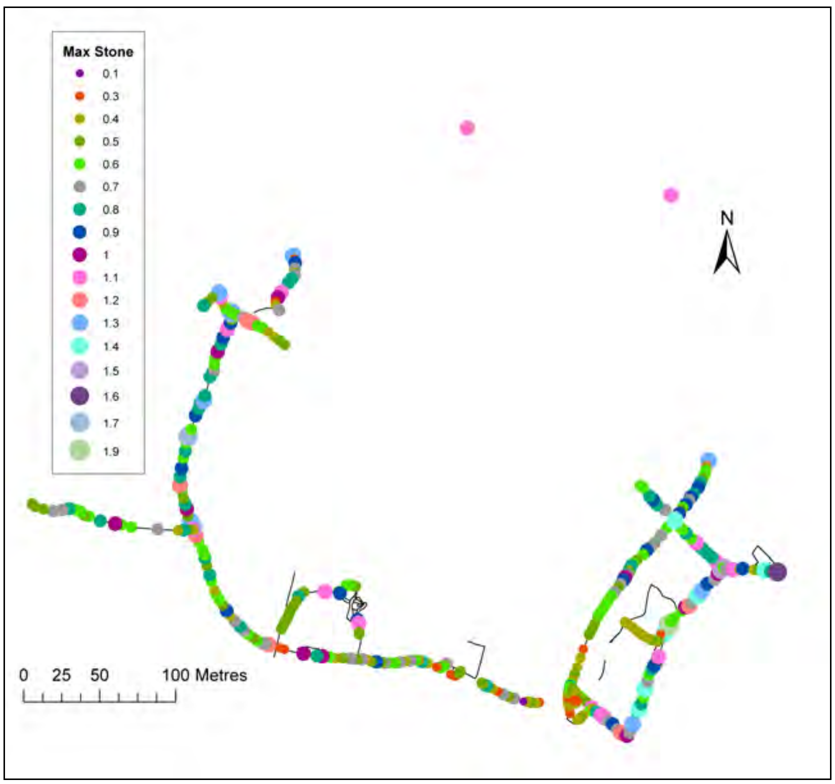
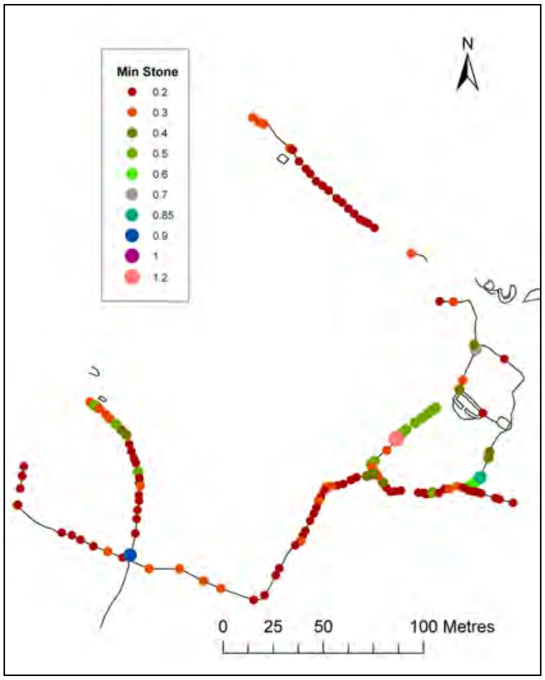


Fig. 6.35b Maximum Stone Sizes: Gardie Norse Field System.



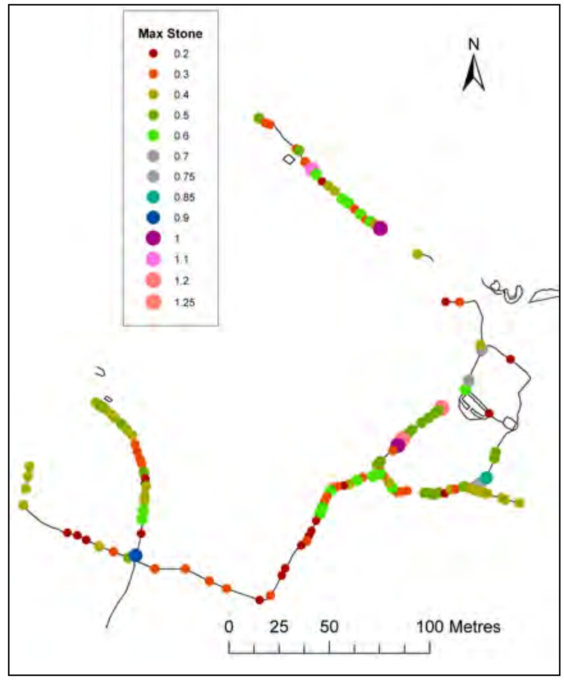
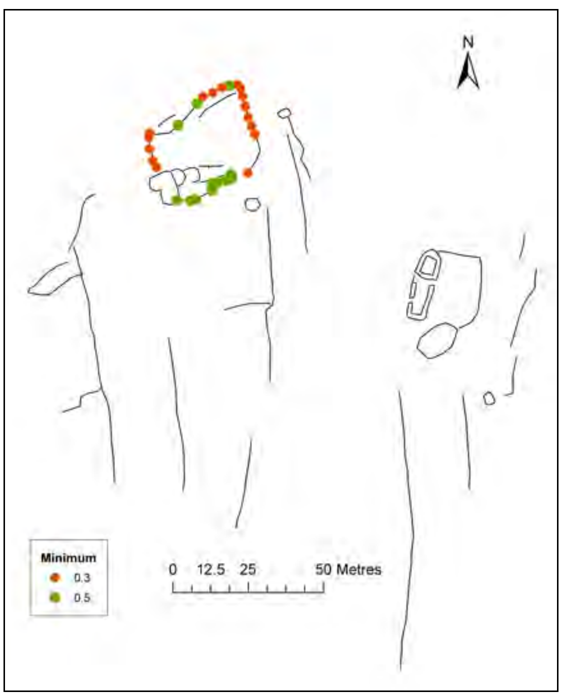


Fig. 6.35c Minimum Stone Sizes: Watlie Norse Field System. Fig. 6.35d Maximum Stone Sizes: Watlie Norse Field System.



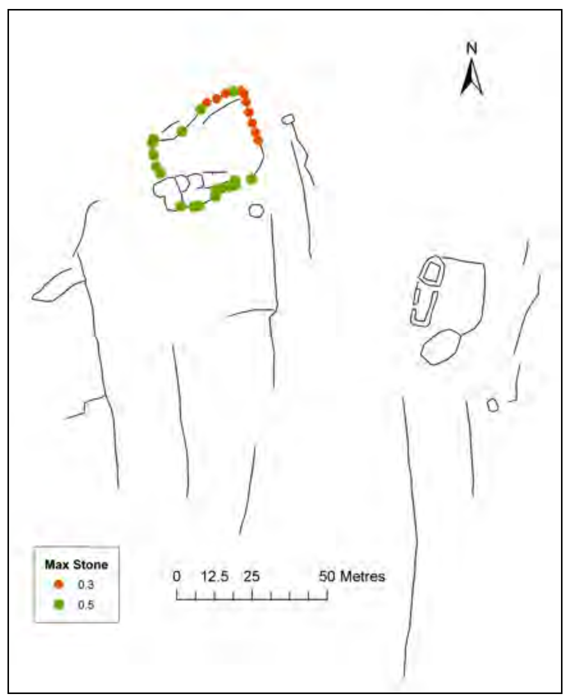


Fig. 6.35e Minimum Stone Sizes: Hamar Norse Field System. Fig. 6.35f Maximum Stone Sizes: Hamar Norse Field System.

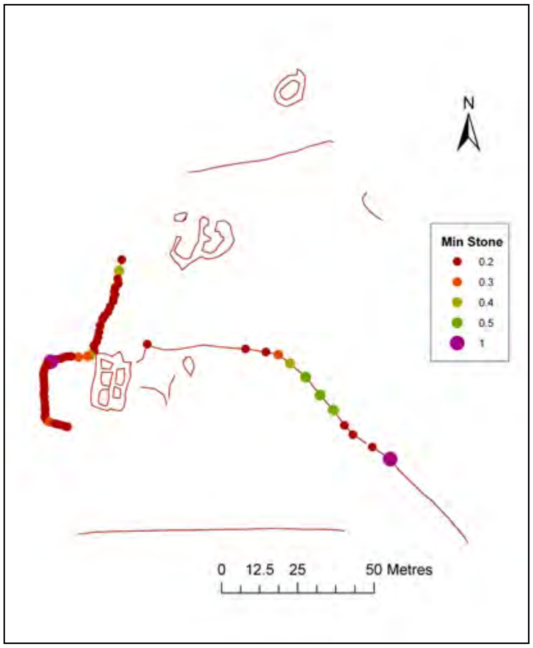


Fig. 6.35g Minimum Stone Sizes: Stove Norse Field System. Fig. 6.35fh Maximum Stone Sizes: Stove Norse Field System.

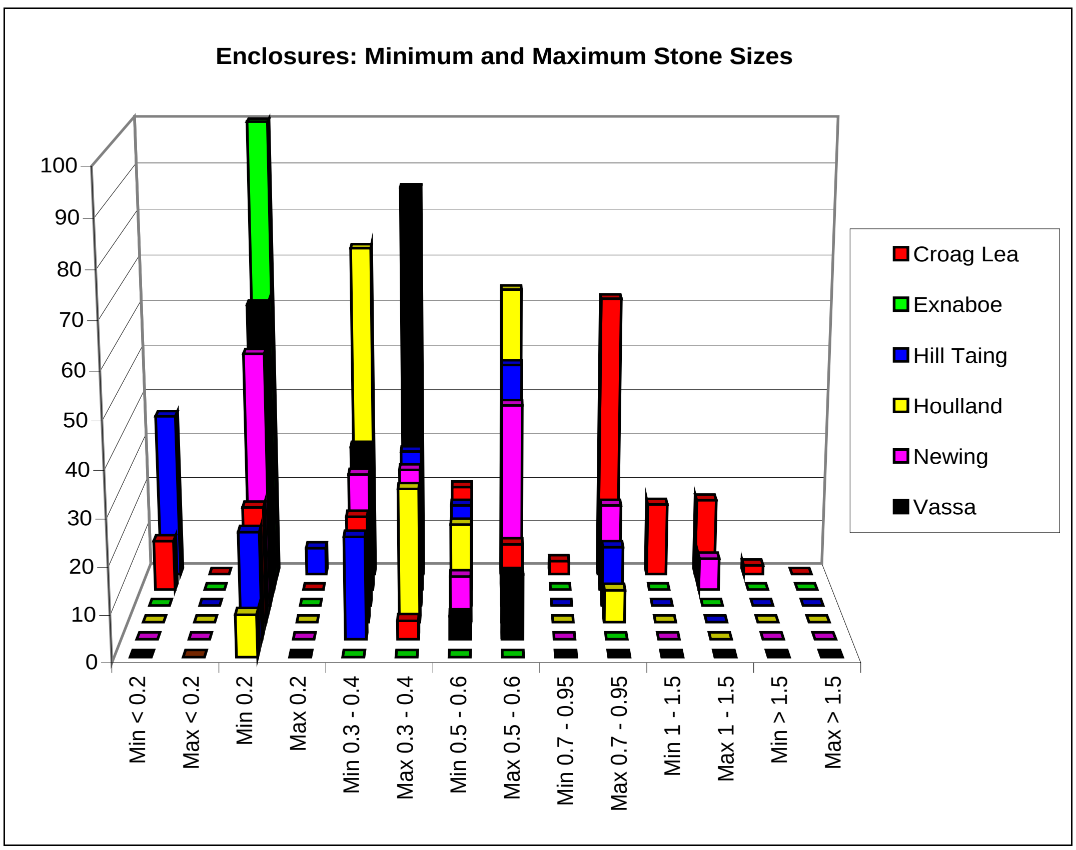


Fig 6.36a Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Homestead Enclosure

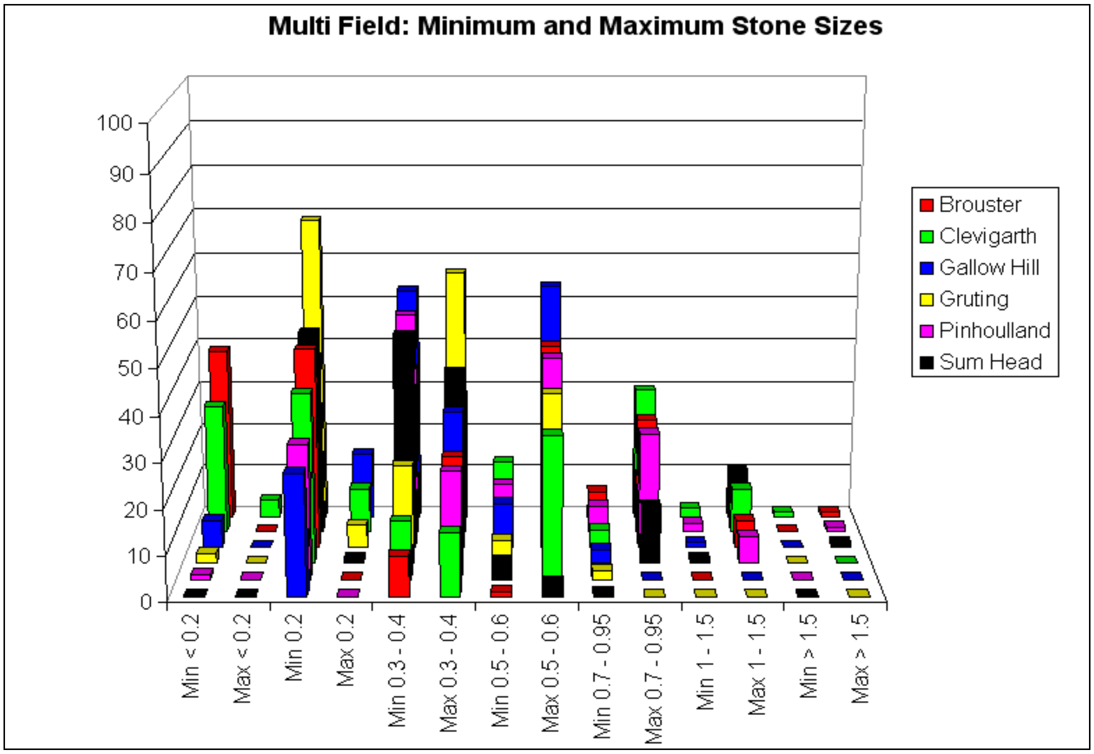


Fig 6.36b Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Multiple Field System

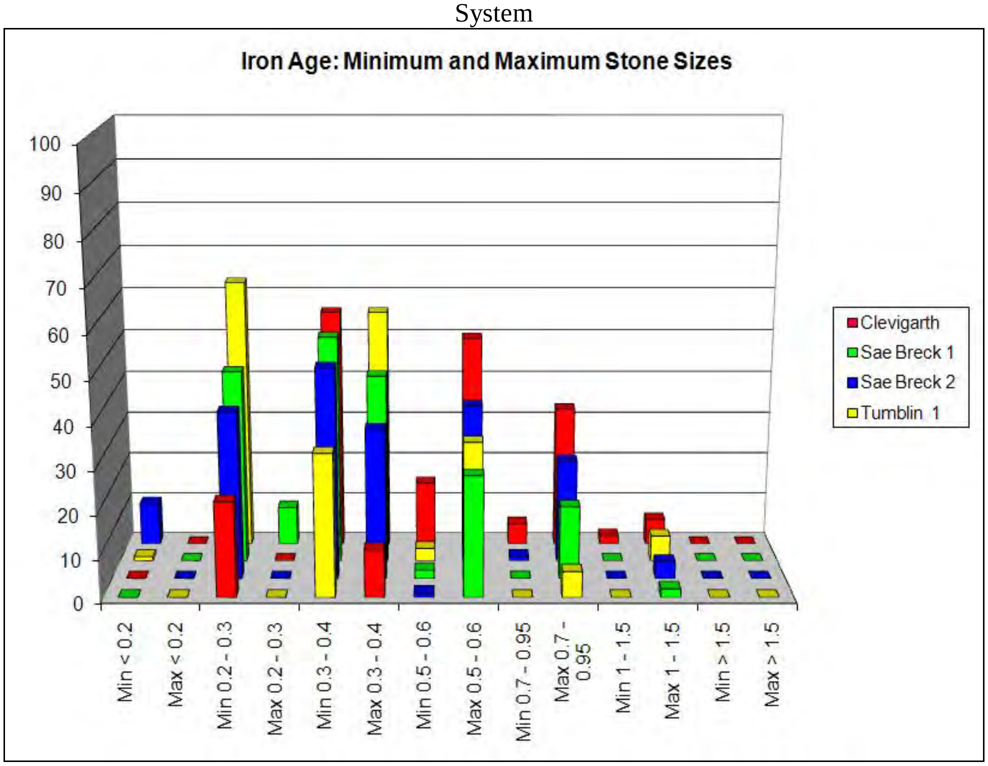


Fig 6.36c Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Iron Age Field System

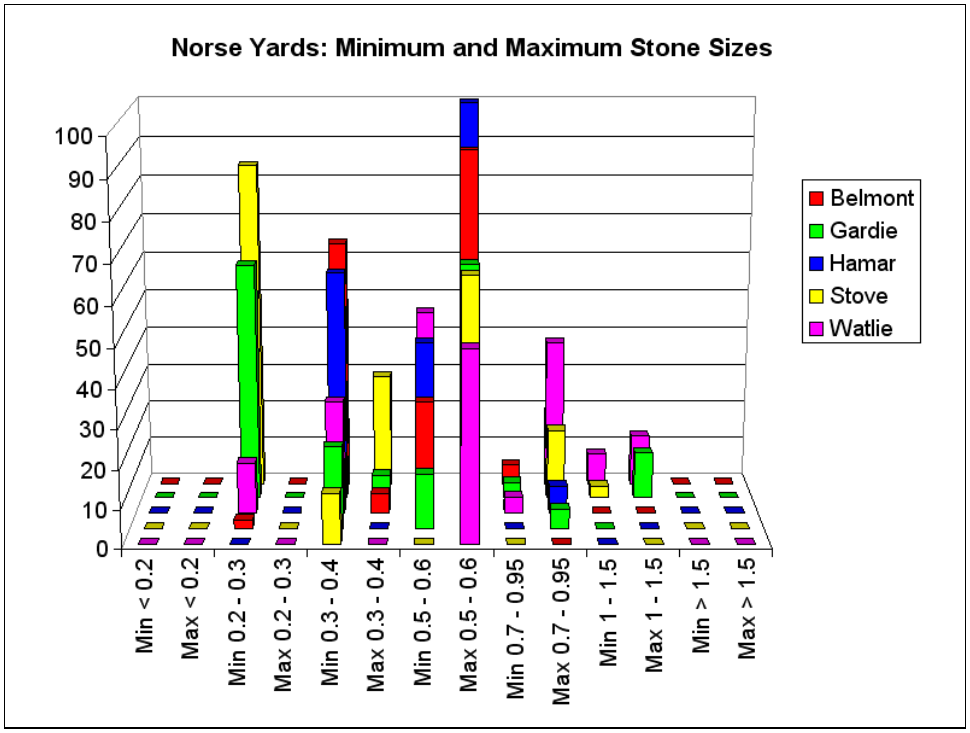


Fig 6.36d Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Norse Yard

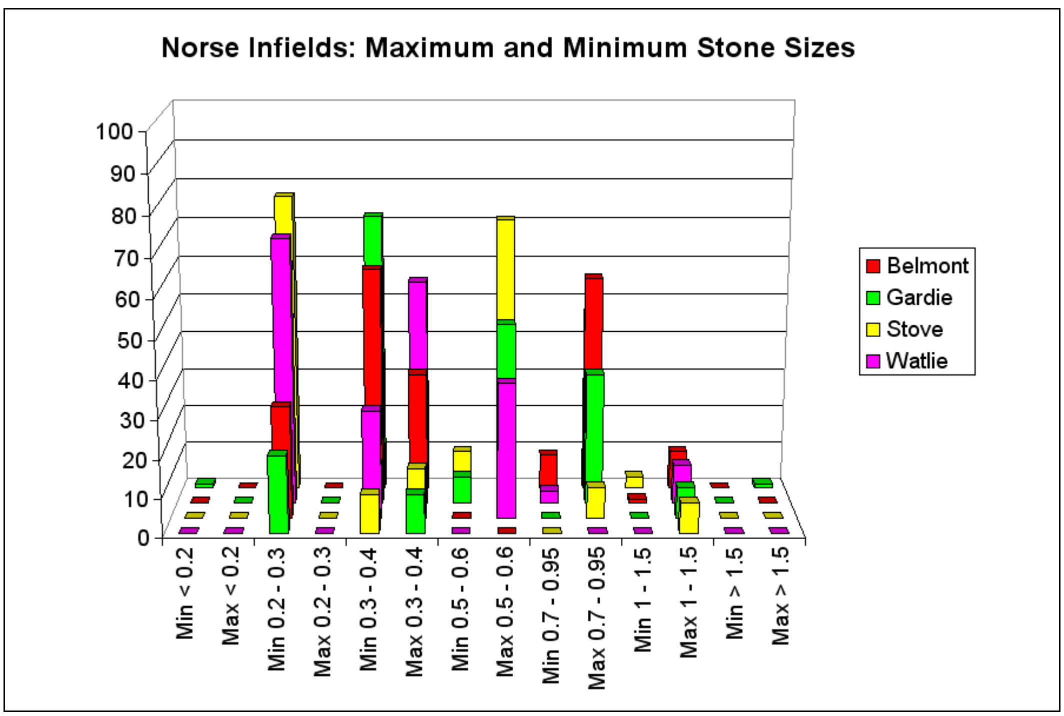


Fig 6.36e Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Norse Infield

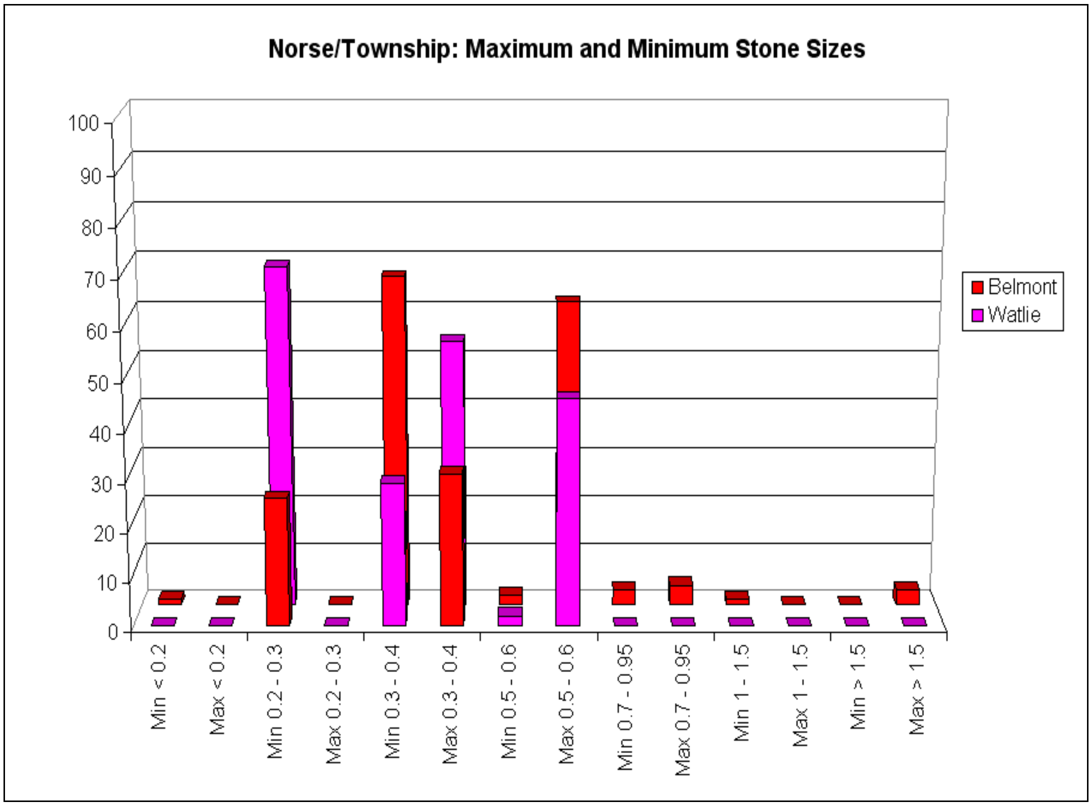


Fig 6.36f Graph showing percentage of points of Minimum and Maximum Stone Sizes, per Norse/Township boundary

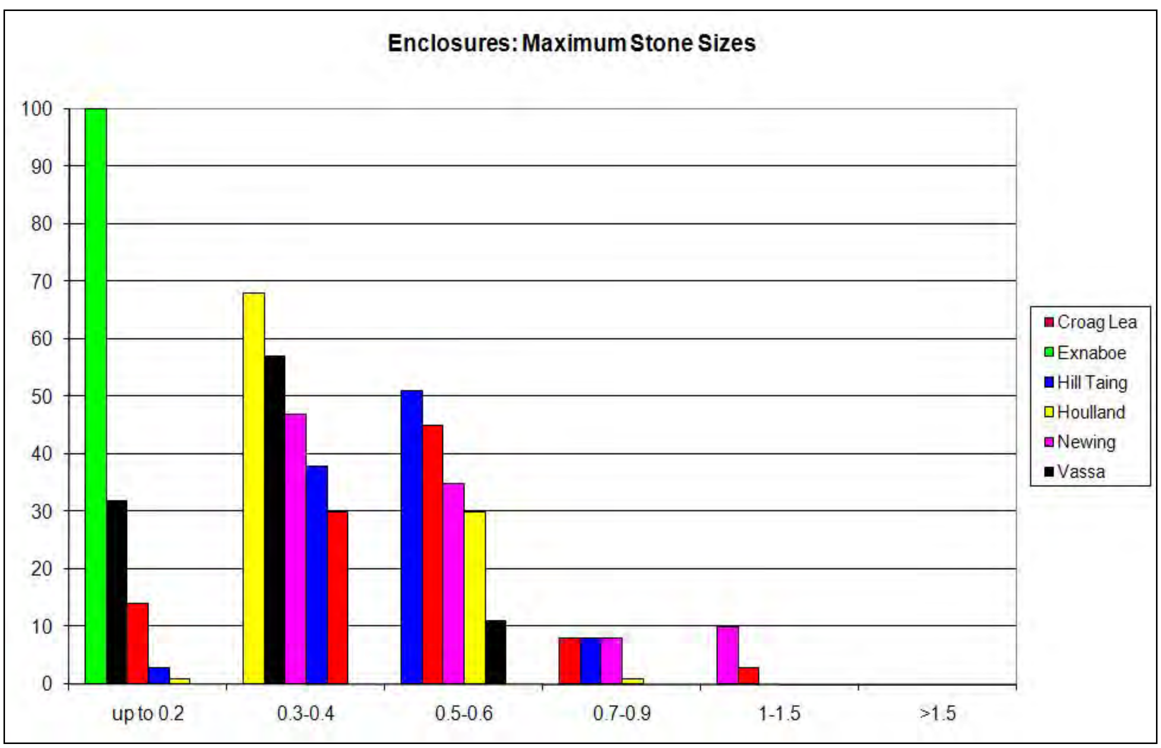


Fig 6.37a Graph showing percentage of Maximum Stone Sizes, per Homestead Enclosure

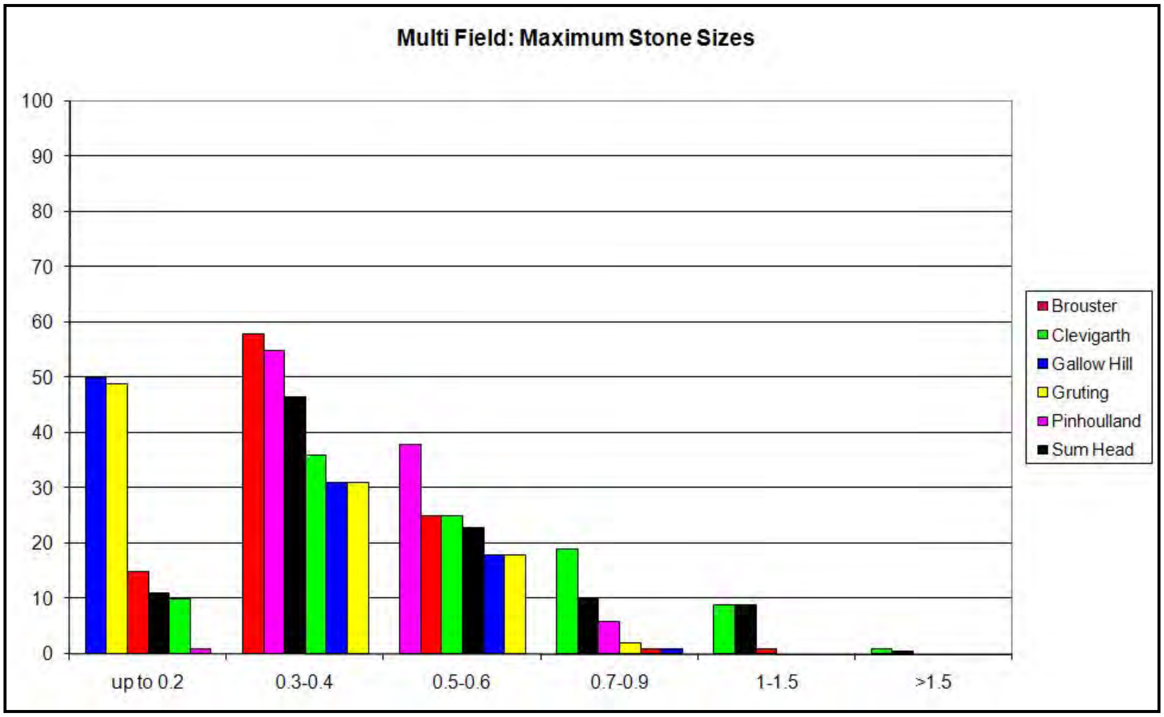


Fig 6.37b Graph showing percentage of Maximum Stone Sizes, per Multiple Field System

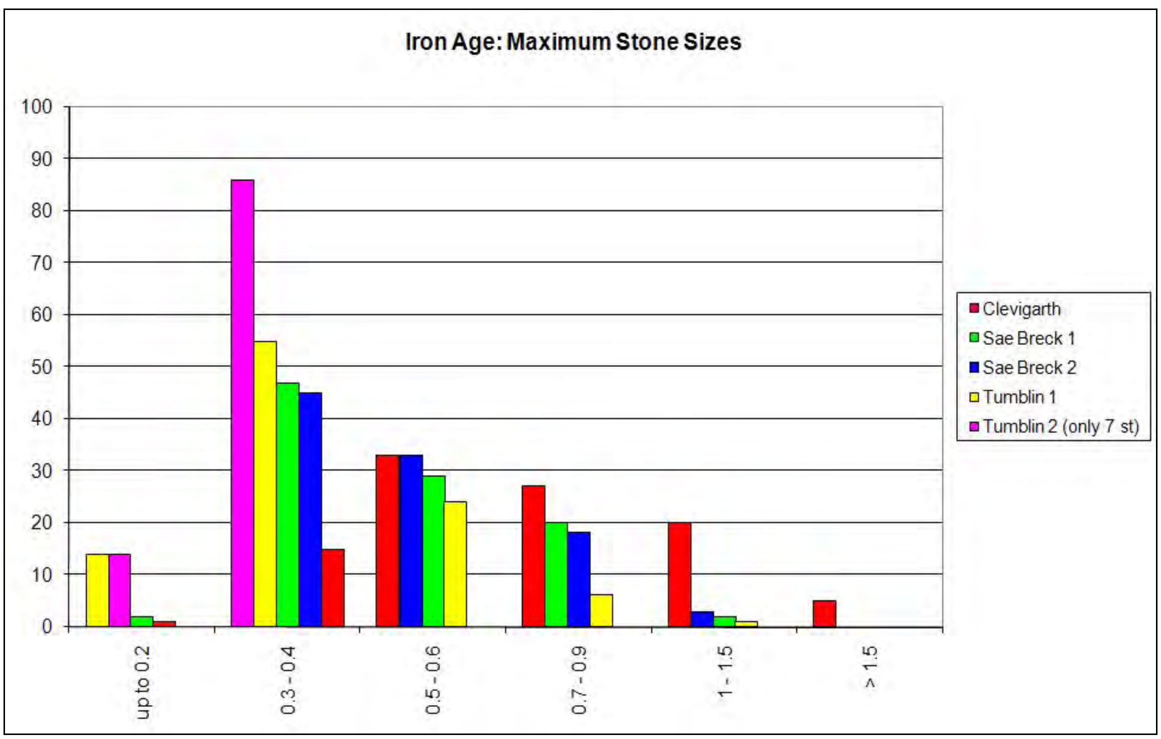


Fig 6.37c Graph showing percentage of Maximum Stone Sizes, per Iron Age Boundary

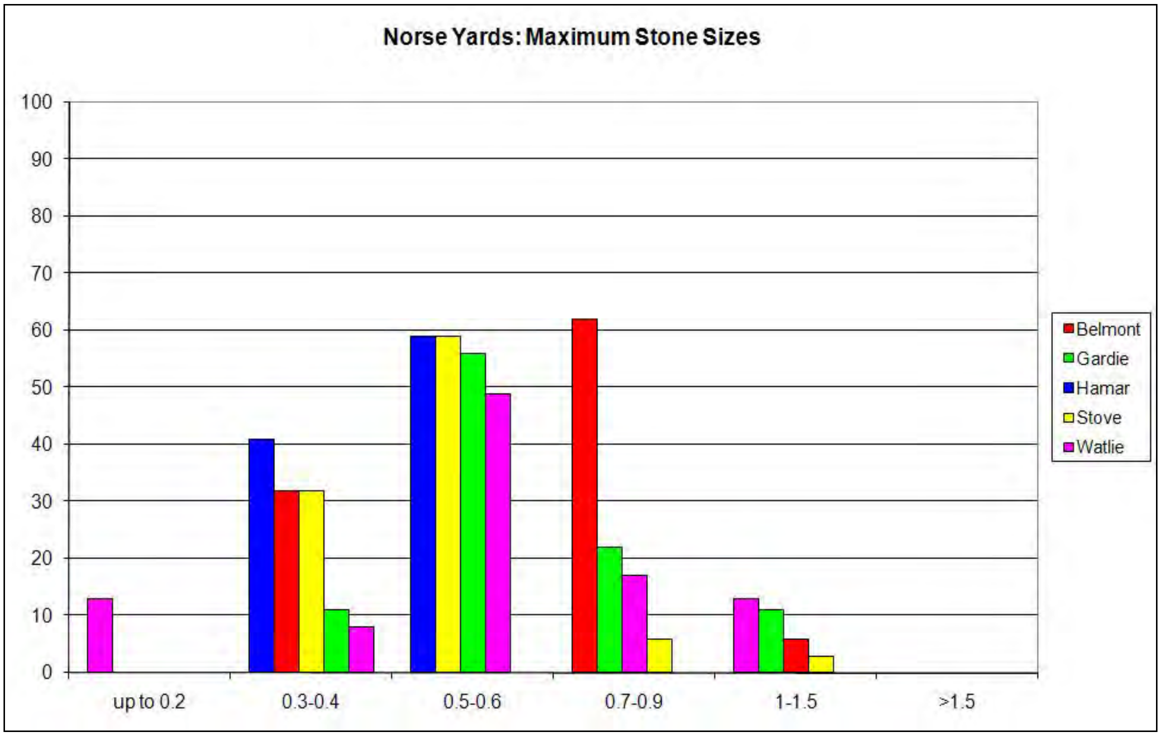


Fig 6.37d Graph showing percentage of Maximum Stone Sizes, per Norse Yard

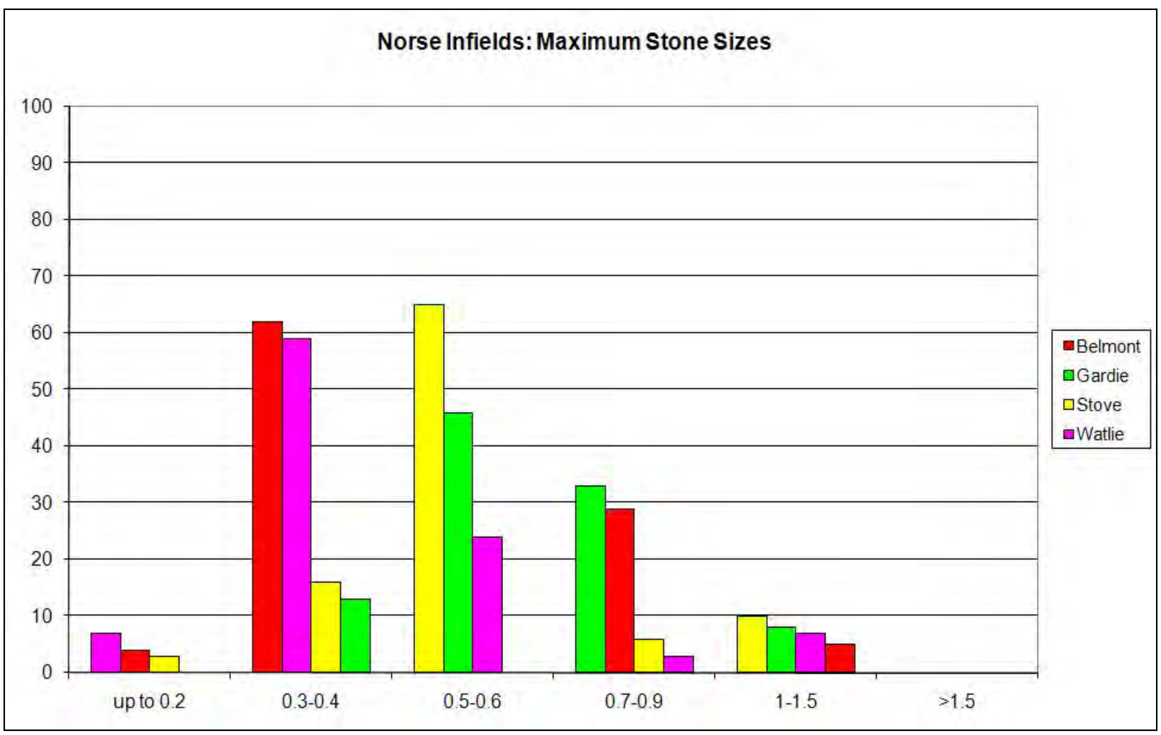


Fig 6.37e Graph showing percentage of Maximum Stone Sizes, per Norse Infield

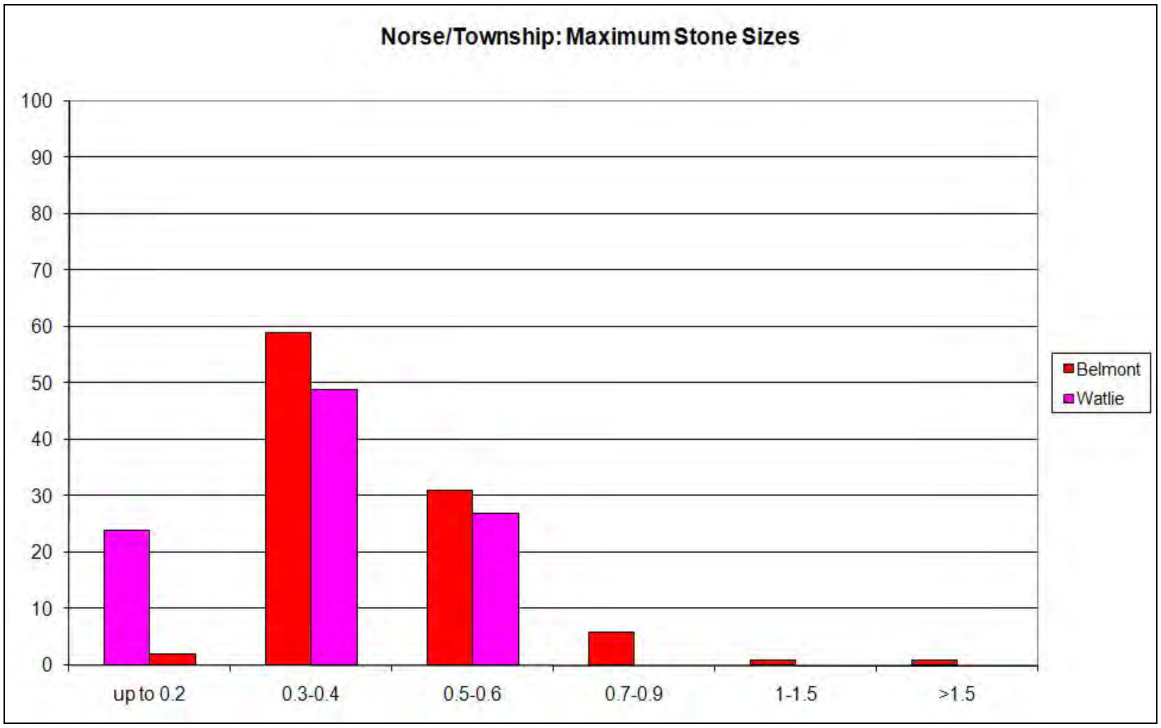


Fig 6.37f Graph showing percentage of Maximum Stone Sizes, per Norse Infield/Township

DISCUSSION OF RESULTS BY SITE

HOMESTEAD ENCLOSURES

Croag Lea

The feature type of the Croag Lea Enclosure incorporates similar amounts of dyke and bank which alternate frequently around the boundary. There are traces of a former fence having impinged on the site and the feature type changes at this point. However, the frequency of the changes within the boundary suggests that this is not significant.

The highest part of the feature boundary is internal, 0.5-0.6m high, accounting for 6% of the boundary. It is concentrated on either side of a gap in the west side, corresponding with a natural knoll just outside the Enclosure. It was predominantly dyke at this point. Feature heights were recorded as the stones were set into an earthwork. The gap, located to the west of the enclosure.

The angle of slope is surprisingly steep: 81% steep (45°) and 19% close to vertical (90°). The 90° stretches of boundary survive as dyke (therefore set into an earthwork), although there were also lengths of dyke with steep slopes.

The dominant direction of slope at Croag Lea is north (35%). The faces are of equal height for 44% of the boundary; 34% faces outside the Enclosure, 22% faces inwards. This is the opposite to the other five Enclosures, although there is no obvious reason for this. The majority of the inward facing boundary is at the southern end and therefore faces north.

The width of the earthwork component of the boundary at Croag Lea varies from <0.5m (29%) to 1.1-1.5m (19%). The widest section of boundary comprises both lynchets and banks, all occurring at the southern end.

The 22% of the boundary with continuous visible stone is divided into four lengths. These are all lengths of dyke; there are some lengths of dyke displaying discontinuous stone, accounting for 65% of the boundary (the other 13% containing no stone).

The maximum size of visible stone varies from 0.2-0.3m (14%) to 1-1.5m (3%). The two largest stones are adjacent, on the east side of the Enclosure, at the point where the boundary changes from dyke to bank. 56% of boundary contains stones larger than 0.5m. The majority of small stones occur in a length of bank on the northern side of the Enclosure. The discontinuous density of visible stone may indicate that the boundary may have originated as a bank, or may have been robbed.

There is considerable variation in the way that the boundary at Croag Lea survives but overall the survival of the Enclosure appears good. The principal face slopes steeply, the earthwork boundary has a max width of 1.5m with a high percentage of stone exceeding 0.5-0.6m. These factors combine to suggest that the Enclosure was not heavily robbed for stone: a proposition supported by the lack of any later stone structure in the vicinity and the survival of both orthostatic stones and a prehistoric house site within the Enclosure.

<u>Exnaboe</u>

Of all the Enclosures, only Exnaboe survives as a single feature type: bank. Today the enclosure falls within three fields: one supports short, intensively grazed, grass, one has longer grass and the third is on the scattald (common grazing) where the grass is unusually intensively grazed. The width of the bank is greatest (5m) to the west, crossed by a fence line; the bank south of the fence (4.1-5m) is wider than that to the north (3m). This makes it significantly wider than the other Enclosures. The wide bank therefore falls both within the area of low grazing intensity and within the more heavily grazed scattald. The broad width could be associated with fence construction, although the difference in width either side of the fence suggests that subsequent land management impacted on it. There is no equivalent difference at the other points where fence lines cross the boundary. The boundary is highest (0.5-0.6m externally) at the same point at which it is widest, which makes it less probable that the broad width is caused by damage. Two other external high points occur on the northeast (intensively grazed scattald) and south (less intensively grazed) sides of the Enclosure which suggests that current grazing regimes are not impacting the site. The dominant angle of slope is 33° (85%), possibly indicating slumping or damage. The 15% of the site that has a steep angle of slope may have always been steeper, or may have slumped least.

The dominant cardinal direction of slope face is west (43%); the rest of the boundary faces five of the seven other recorded compass points. The inside of the Enclosure is steeper then the outside (53%); 34% of the boundary is of equal height.

The 3% of the visible stone occurs at 3 points in the boundary: two coincide with where the modern fence line crosses it; the third lies between them, on the east side. A section excavated through the northern bank in 2003 (Turner and Rhodes, field notes) encountered no stone.

The lack of stone at Exnaboe contrasts with the other Enclosures in the study. This, together with the width of the bank (up to 4.6-5m wide for 2% of its extent) and the angle of slope (predominantly 33°) suggests that the Enclosure has been damaged since it was constructed. The fence lines crossing the Enclosure do not account for this: at other sites crossed by fences (e.g. Pinhoulland and Gallow Hill) such damage is very localised. The internal features (a probable house site) within the Enclosure survive as mounds. Since this is also devoid of visible stone, and there are crudely built sheep pens and plantiecrubs in the area, stone robbing is implicated.

<u>Hill of the Taing</u>

The Hill of the Taing Enclosure survives as banks, lynchets and dykes: together the dykes and discontinuous dykes total 65%. The lynchet is on the upper side of the site, at the foot of a natural slope. The northeast length resembles revetting along the base of the hillslope, with almost continuous stone possibly protecting the interior of the Enclosure from upslope slippage. It continues across the entire northern side, facing into the Enclosure. The boundary is at its highest (0.6m) here, and at the northeast corner, although the angle of slope is shallow. The length of steeper slope corresponds with a length of dyke set into an earthwork. (The smaller enclosure, to the east of the main site, was not included in the data presented, as it is not part of the Enclosure and may or may not be contemporary. The lynchet forming the west edge of this feature is partially defined by bedrock, and linked strongly to the topography. The line of stone below it is set orthostatically.)

The dominant compass direction is south (64%), corresponding with the 58% of the boundary facing into the Enclosure. The widest sections of the boundary (1.6-2m) are located on the west and north sides of the Enclosure, both sections being very short. The narrowest length (<0.5m) is located on the south side, primarily comprising discontinuous dyke set into a low bank.

The Hill of the Taing includes one large orthostat, on the east side of the Enclosure, immediately adjacent to the 7% of the boundary with very few stones visible. The majority of the boundary (58%) comprises lengths with discontinuous visible stone including the length of lynchet on the north side.

The maximum stone size ranges between 0.2-0.3m (3%) and 0.7-0.95m (8%) but includes one stone of 1m. (There are larger stones in the feature to the east.) The large stones within the Enclosure are part of the northwest dyke, where the stone is continuous.

The Enclosure at the Hill of the Taing therefore takes a variety of forms. The majority of the stone is between 0.5-0.6m (51%), 8% being larger than this. It appears that, if the structure was robbed of stone, this only occurred on the west side: a stone free bank, 0.3m maximum height. The width of the bank is ≤1.5m, other than two exceptions. Although it is not possible to determine whether the boundaries to the east are contemporary, the stone free area of the Enclosure is to the west, and therefore is unlikely caused by robbing for the small enclosure. The house site also includes large stones, supporting the premise that stone has not been removed.

Houlland

The majority of the Enclosure at Houlland survives as a bank (79%), lynchets and dykes occurring along the northern edge. The line of bank, projecting northwards from the west edge of the enclosure, may be an earlier alignment of the boundary. If so, the Enclosure would have been more rectangular than most Homestead Enclosures; any trace of a corresponding boundary return to the east has been obliterated by the fence and track, north of the site. However, the northern edge is constructed differently to the rest of the Enclosure; an alteration during its use might explain this. The northwest dyke, comprising continuous stone, springs from immediately north of the single othostat: the bank widens at this point and may have been the junction of two boundaries. The majority of the boundary includes discontinuous stone.

Both the lynchet and the bank face inwards, the short length of dyke in the northeast corner being the only outward facing section. The highest part of the Enclosure is on the interior face of the southern edge. The majority of Houlland had a shallow angle of slope, a further 36% being near vertical. This near vertical length fell into two sections: including the only stretch of lynchet and the potentially early projecting line of bank.

The widest part of the boundary at Houlland is the bank on the south side of the Enclosure (1.6-2m wide) and a point on the west side. Exactly half the boundary measures 0.5-1m, including the east and north sides, comprising both banks and dykes set into banks.

The majority of the stone within the Enclosure is 0.3-0.4m (73% minimum stone, 67% maximum) stone of 0.5-0.6m accounting for a further 30%. Stone size has no clear relationship with feature type, which is principally bank but includes lynchet and dyke on the northern edge. The density of visible stone is largely discontinuous and the maximum width is 1.6-2m. Other than Exnaboe, Houlland is the most internally consistent Homestead Enclosure (in terms of stone size, site type, slope angle and stone density). This suggests a single construction event, without repairs or micro-topography influencing methodology which would mean that the projecting length of dyke was never part of the Enclosure, but was perhaps part of an associated field system.

South Newing

The Enclosure at South Newing is dominated by lynchets. The site is on the steepest hillslope of any Enclosure. The lynchets face inwards at the top of the slope and outwards at the bottom, coincident with the topography. There is a break in the Enclosure on the southwest side, with lengths of discontinuous dyke on either side. The missing length of boundary probably contained stone robbed to build the plantiecrub which crosses the missing line of the Enclosure and which probably reused large stones within the boundary without moving them. Two possible lines of boundary are considered at the northeast corner, both surviving as lynchets. The most northerly is heavily coincident with the topography; the southerly lynchet is exceptionally straight and is also the narrowest length of boundary (<0.5m). Either, or both, these lines may have defined the edge of the Enclosure during its use.

The feature heights at South Newing differ markedly to those at the other Enclosure sites: 17% of the external boundary is 1-1.5m high (and one point internally); a further 60% stands 0.7-0.95m high externally. (Feature heights were only recordable for 27 points internally and 17 points externally.) The other Enclosures have a maximum height of 0.5-0.6m and, apart from Exnaboe, relate to the interior of the feature, the highest internal measurements being on the lynchet on the northeast side, which is also the widest section (1.1-1.5m). The highest external points were on the southern and eastern lynchets, strongly relating to the hillslope.

South Newing is unusual amongst the Enclosure sites as only 7% of the site has a shallow angle. The 53% which is close to vertical corresponds with lynchets on the north side of the site; those to the south slope steeply. There was no clear compass direction of face, the largest category being the 19% east facing boundary. 51% of the boundary faces into the Enclosure, the remaining 49% facing outwards: reflecting the topography.

The northern side of the Enclosure comprises continuous stone, found in 49% of the boundary, predominantly in lynchets but including a length of dyke. The lynchet at the lower edge is more variable in stone content. The maximum stone size ranges from 0.3-0.4m (30%) to 1-1.5m (7%). The small stone all occurs in conjunction with larger stones, the largest being located on the east and northeast sides, within areas of lynchet which contains discontinuous lengths of stone. South Newing is therefore dominated by lynchets which correspond with the natural terrain.

Vassa

Of all the Enclosures, Vassa is the most incomplete and differs from the others in that the house site sits outside the projected circumference. It is the most obviously disturbed site, within an area of peat cutting which affects the interior of the Enclosure. (The scars arising from this are shown on the plan). The boundary survives as a mix of bank, lynchet and dyke. At the disturbed south end the boundary survives as a bank: west of this, the boundary comprises a lynchet, to the east it remains as a dyke. The lynchet subsequently turns into a dyke, whilst the dyke becomes another length of bank not impacted by peat cutting. Therefore the impact of peat cutting on the boundary was minimal. The highest lengths of earthwork boundary were dispersed around the site.

The angle of slope at Vassa is primarily shallow. The 12% of the boundary close to vertical corresponds with a lynchet west of the disturbed area, but excludes the boundary beside the cut area: the opposite of what might be expected. The dominant direction of the slope at Vassa faces south (31%); 26% faces east. The boundary is 52% inward facing and 14% outward facing. The short length of outward facing boundary is located immediately west of the peat cutting against the south end of the Enclosure. The width of the boundary at Vassa ranges from 0.6-1.0m (54%) on the east edge to 1.1-1.5m (46%) to the west. The boundary adjacent to the scalped area comprises fairly continuous stone (8%). Continuous stone (14%) is found within a dyke to the northwest and in a short stretch within the bank on the east side.

There is stone within the entire length of the boundary. Of these, 32% of the largest stones are 0.2-0.3m in size, 57% are 0.3-0.4m and 11% are 0.5-0.6m, the smallest range of stone sizes of all the Enclosures. The largest stones are in the scalped area, possibly because the cover is disturbed, and at either end of the break in the northeast edge, in front of the house. It is possible that larger stones have been robbed from this gap but it may never have been closed or been closed with a fence, gate or less durable boundary, facilitating access between the house and Enclosure.

MULTIPLE FIELD SYSTEMS

Scord of Brouster

The Multiple Field System at the Scord of Brouster contains at least 8 fields. Within these, lynchets are the dominant feature type (68%). Fields F1 and F7 have concave boundaries, and are probably primary. Both have a relationship with house sites. The earliest excavated stone structure, "House 2", situated on the boundary between fields F1 and F2, overlay a wooden structure (Whittle, 1986: 137). Whittle thought that it might have had a specialist, rather than domestic, function, having no observable entrance or hearth. The earliest phase of House 2, dated to 3482 – 2942 cal BC. (All dates: Ashmore, 1999: 310-311). The second building was "House 1", the most elaborate of the buildings excavated, located in the centre of field F7, the construction being dated to 2895 – 2517 cal BC. House

1 may or may not post-date the construction of the surrounding boundary: there is no dating evidence from the boundaries. Both fields F1 and F7 are bounded by lynchets where the direction of face follows the slope of the land.

The boundary defining field F3 survives as a dyke, as does most of the boundary of F8. Field F2 has a greater variety of boundary type within a single field. The concave sections of the boundaries of F4 and F5 are both lynchets: field F6 has lynchets to the south and west but a bank to the north. The overall impression is of consistency within each field construction event, with differences between successive building events.

Rather than clarifying the situation, Whittle's excavations revealed a greater complexity of field wall construction than was apparent from the topographical remains (Whittle, 1986, 46). The excavations also revealed that some boundaries had more than one phase.

The feature heights of the Scord of Brouster demonstrate a close consistency between the internal and external sides. The majority of the boundaries have a max height of 0.4m, with many shared between fields. The field system includes substantial lynchets (up to1-1.5m high); the eastern boundary of F7 crosses a wider mound, broadening on both sides of the boundary, supporting Whittle's observations that former clearance cairns were incorporated into subsequent boundaries. The same boundary attains similar heights in a lynchet to the south. An exceptionally straight length of lynchet, aligned N-S, in the centre of the field system, also stands 1-1.5m high and faces east into F6. A short length of lynchet at the southeast end of F2 rises abruptly to 1-1.5m and falls away equally quickly.

The 11% of the near vertical boundary at the Scord of Brouster includes that in two trenches left open after Whittle's excavations: boundary junction BC10 and boundary B2 (Whittle, 1986: 4). There were an additional 15 boundary excavations carried out by Whittle's team which now display shallower slopes. Two near vertical faces survive in the dyke surrounding F3, two occur on the boundary of F7 and one is a single point along the northern boundary of F1.

The primary direction of slope face was east (53%), following the topographical direction of slope and including dykes, banks and lynchets. The greatest direction of the boundary faced inwards (44%); a further 28% of the boundary faced down slope.

The boundary widths ranged between <0.5m (17%) and 3.6-4m (3%): lynchets featured at both ends of the scale. The narrowest and the widest lengths are both found on the periphery of the system, including two long narrow lengths on the western edge, bounding fields F5 and F3. There are two short narrow lengths on the southeast side and the southernmost field, F8, is bounded by a narrow length of discontinuous dyke. The widest lengths are the northeast side of field F1 and the southwest edge of F8. The short stretches of boundary which contain no visible stone are also located at the limits of the field system. The boundary of field F7 contains continuous stone throughout its entire length; other stretches of continuous stone are scattered throughout the field system. Some of these relate to areas excavated by Whittle (1986); other previously excavated areas display both fairly continuous and discontinuous stones. The three largest stones occur in the northern boundary of field F1, within a lynchet. These are between 0.7-1.5m, occurring without evidence of smaller stones. The lengths of field system which have a minimum stone size of ≤0.1m all include larger stones. The greatest percentage of maximum stone size (58%) is 0.3-0.4m, which also accounts for 43% of the minimum stone size.

Clevigarth

In the Multiple Field System at Clevigarth, banks occur most frequently. There are few lynchets, but dykes form 30% of the boundaries. Two sides of field F3 are formed by banks, one of which is shared by field F2; the other boundaries comprise a mix of feature type. Shape Analysis has already indicated that this field system is atypical, and that field F4 was probably an Enclosure.

The feature height does not exceed 0.5-0.6m either internally or externally. Most of the boundaries in this field system are not shared. Lengths of boundary with steep slopes occur in four places, in banks, lynchets and dykes.

Sixty-percent of the boundary faced west, away from the cliff edge, 36% having faces of equal height. The majority of the field system has earthwork boundary widths of <0.5m to 1-1.5m (93%). Wider lengths of boundary, up to 5.1-5.5m, are located at the southern edge of the field system and are amongst the fragmentary lengths of boundary which may have been partly lost due to coastal erosion.

Clevigarth showed the highest proportion of boundary with discontinuous stone (53%). The augering programme demonstrated that the soils could exceed 0.65m, but they display only limited peat accumulation and the lack of visible stone is probably attributable to either construction or destruction. The stone sizes ranged between ≤0.2m (29% minimum and 15% maximum) and 1.6m (a single stone). Eight-percent of the maximum stone size measured 1-1.5m, the majority of large stone being located in small clusters throughout the field system including lengths of bank, dyke and discontinuous dyke, within all three field units. This suggests that the use of stone was pragmatic, taking advantage of the nearest available stone. Much of this may have been thrown up by the sea, which still continues and is particularly noticeable in the modern field, south of the site.

Gallow Hill

Gallow Hill demonstrates a similar pattern to the other Multiple Field Systems. Here lengths of boundary which could be expected to belong to one building event take a single form (e.g. NW-SE lynchet forming the eastern boundary of fields F4, F3 and F5). Additional lengths of boundary surrounding fields 5 and 3 are formed by banks, whereas the boundaries to fields F1 and F2 are more varied.

The internal feature height is higher than the external feature height. Here 22% of the internal boundary is between 0.5-0.6m high, in contrast with 4% of the external boundary. A further 19% of the internal feature height is greater than this, as is 4% of the external boundary. The five highest points on the boundary were all on the NW-SE boundary, the upper limit of the field system. The overall shape of the field system is long and thin, aligned down the hillslope, resulting in significant lengths of dyke, aligned NW-SE, not shared by more than one field.

The majority (65%) of dominant slope angle is shallow. At 29%, the percentage of steep boundary is slightly greater than at any of the other Multiple Field Systems. The boundary of field F2 is almost entirely shallow, which contrasts with the variable feature type within it. The lengths of boundary of each angle of slope are relatively long. The most common direction of face was southwest (26%). There was a very strong association between the faces of the boundary and the slope: 74% as facing downslope, a further 15% with faces of equal height.

The majority of Gallow Hill has earthwork boundary widths between <0.5m and 1.1-1.5m (78%). A further 18% measure between 1.6-2m and 3.1-3.5m. Of the remainder, 3% measures 3.6-4m and 1% measures 4.6-5m. The widest section of boundary in the heart of the field system, at the junction of the boundaries of three fields (F1, F2 and F3) which may have been convenient for field clearance. The widest points were scattered around the southern edge of F2, a bank/lynchet which may have incorporated earlier clearance cairns.

Gallow Hill is the only Multiple Field System where the amount of boundary with continuous stone (47%) exceeds the proportion containing discontinuous stone (38%). Gallow Hill also had the lowest proportion of boundary where no stone was visible (4%). This may have been due to the construction method but the hill appears scalped, and this may have revealed otherwise concealed stone.

At Gallow Hill the most commonly used stone size is 0.3-0.4m (56% minimum, 61% maximum). The largest stone was the 2% measuring 1-1.5m scattered throughout the field system, occurring singly or in pairs. The most northerly fields, highest up the hillslope, include more small stone (0.2 and 0.3m) than those lower down. However, there is no correlation between stone size and either feature type or density.

Ness of Gruting

At the Ness of Gruting banks and lynchets occur in similar quantities, with the amounts of dyke and discontinuous dyke accounting for less than 10% of boundary form. The lynchets show a very strong correlation with boundaries aligned across the natural slope, whereas banks correlate with boundaries aligned down the slope. Fields F2 and F3 are largely bounded by lynchets, as are F4 and F5, although the boundary between F4 and F5 aligned down the slope, comprises lengths of bank and dyke. The direction of face also equates with the direction of slope.

The majority of the field system has feature heights of 0.2-0.3m (67% internally, 59% externally). At the upper end of the range, 5% of the earthwork boundaries are more than 1.5m high externally. A further 8% externally, and 11% internally, stands 1-1.5m high, much of this at the upper end of that category. These higher lengths occur in four groups. One is situated at the end of a lynchet with an average width of 0.5m but where the height increases, the width broadens to 2m, adopting the characteristics of a mound. There are clearance cairns close by and it is possible that this end of the lynchet was used to dump stone either during its use or subsequently. The three other boundaries exceeding 1m are all lynchets exceeding 25m long, one at the edge of the system being approximately 50m long, bounding only one field, aligned down the slope. The two shorter lengths are aligned across the slope with fields on both sides.

There are two areas where the slope of the earthworks is close to vertical: a total of 6%.
The majority of the earthwork boundary (83%) is shallow. The steep length of slope corresponds with lynchets in the centre of the site. The most frequent direction of

dominant boundary face was south (46%). Here 72% of the boundary faced downslope further 4% facing across the slope. The dominant relationship appeared to be with natural slope.

The width of the earthwork features range from <0.5m (18%) to 3.6-4m (16%). The majority of the earthworks measure less than 2m (71%), with a further 13% being 2.1-3m. The widest sections of the field system are located at the northwest and southeast limits of the site. Two of the three lengths of bank comprise the edges of mounds or flattened banks. By contrast, the widest length of lynchet is situated in the centre of the field system.

The Ness of Gruting contains the greatest proportion of boundary which contains no visible stone (47%). Only the boundary at the northwest edge of the sites contains continuous stone; the peaty soils may conceal stone; a possibility supported by the visible stone being smaller than that in other Multiple Field Systems. A total of 49% of stone falls into the smallest maximum stone size category (≤0.2m), a further 31% measuring 0.3-0.4m. Much of the visible stone occurs within a band across the middle of the site, just south of the prehistoric house. These earthworks are primarily lynchets but there is no clear relationship between feature type and the presence or absence of visible stone.

Pinhoulland

In the Multiple Field System at Pinhoulland there are dykes around two fields F6 (surrounding the large house site) and F3; F5 is surrounded by banks. These contrast with fields F1, F2 and F4 which are very variable in their construction. Fields F1 and F2 are strongly influenced by the local topography: the southerly lynchets of both are situated at the edge of a natural terrace with a natural drop of up to 2m. The variable boundaries around the largest field, F4, support the possibility that it comprises more than one field.

The highest boundaries at Pinhoulland are concentrated in the lynchet between Fields F1 and F2 and the massive west side of the banks in Field F6, which also incorporates large stones. It is up to 8m wide and has a large mound in the northeast corner. The steepest bank is the near vertical, southern, length of the boundary of Field F6, the widest boundary being its west side. Ten-percent of the earthwork boundaries are close to vertical, concentrated in the southern boundary of F6. The 25% of steep slope is scattered throughout the field system in varying lengths. There is no clear relationship between angle of dominant slope and feature type.

There was no clear cardinal direction of principal face. The site included lengths of boundary which faced in every recorded direction. In terms of topographical direction of face, results also fall into each category: the largest category faced into the field system (39%), 23% faced down the slope. The smallest category was for the proportion of boundary which faced up the hill slope (2%), with a further 5% facing across the slope. The lynchet on the east side of field F4 and the bank on the west side of field F7 face each other. The area between them was insufficiently enclosed to be classified as a field for Shape Analysis, however it may have been incorporated. Today this space supports bog grassland and heather which, although dry, is poorer than the vegetation in the two fields bounding it. Nevertheless, the east boundary of field F4 traverses an area incorporating standing water, therefore the present vegetation and soils do not necessarily represent that of 3-4000 years ago. (This will be tested further by micromorphology.)

Pinhoulland comprises the greatest range of earthwork boundary widths of any site in the survey (<0.5m to 7.6-8m), the majority having a maximum width of 2m (83%): 0.3% measures 7.6-8m (west side of F6), the upper end of the range. Other fragmentary lengths of wide boundary within the site occur at a lynchet in field (F4), and a length of bank south of the principal field system.

The field boundaries at Pinhoulland included 30% having discontinuous stone. Of the remainder, 19% contained none and 21% contained very little visible stone. There was considerable internal consistency within individual boundaries which contrasted with other sites. At Pinhoulland 29% of the minimum stone size, and 12% of the maximum, is $\leq$0.2m. A further 52% of the minimum, and 42% of the maximum, stone size measures 0.3-0.4m. Much of this stone occurs in continuous lengths of boundary occurring in fields F1, F2, F3, F6, F7 and F8. The fields at the south end of the system, and the boundary projecting southwest from the southernmost tip of the field system, are more variable in the sizes of stone incorporated. It is possible therefore that, at Pinhoulland, there is a relationship between stone size and the construction of individual units within the field system. There is, however, no consistent relationship between feature type and stone size.

Sumburgh Head

Sumburgh Head is the only Multiple Field System with a dominant feature type: 68% lynchet. However, this is still less consistent than the Enclosures, half of which demonstrate higher percentages of dominant feature type. The banks in the field system are concentrated at the southern end. The direction of face is consistent with the considerable degree of slope on the site. Some of the lynchets demarcate the lower edge of a terrace cut into the hill. The potential of the hillslope was maximised, with even small areas being worked. Some of the site, particularly in the centre, is very ephemeral, perhaps as the soils are thin, possibly the result of turf stripping. The northern and southern ends of the site are better preserved and their authenticity is not in doubt. Shape analysis showed that these fields are generally smaller than the others in the class. The banks are on the lower, slightly more gentle, hillslopes.

The highest lengths of boundary relate to the edge of a terrace and an enclosure, both close to the centre of the field system. The near-vertical slope corresponds with a short length of dyke, also in the heart of the field system. The majority (62%) of the Sumburgh Head boundary faces west: a strong correspondence with the slope. The boundary widths at Sumburgh Head ranged from <0.5m (25%) to 4.6-5m (1%), the majority (81%) were ≤1.5m wide. The wide sections of boundary were scattered throughout the field system and occurred as anomalies within narrower boundaries.

The Sumburgh Head boundaries contain the highest proportion of discontinuous visible stone (59%) and a further 20% contains little stone. Since the hillside appears scalped, the lack of visible stone probably relates to a lack of stone used in construction (consistent with lynchets forming in consequence of cultivation) or possibly to stone robbing. The highest percentage of maximum stone measures 0.3-0.4m (45%) which also accounts for 47% of the minimum stone. Nineteen percent of the maximum stone measures 0.7+m, the largest stone being 1.7m. The large stone occurs throughout the field system.

Clevigarth: Broch Boundary

The broch related boundary at Clevigarth incorporates two types of feature type: bank on the eastern (coastal) and a dyke to the west. The boundaries associated with the other broch sites survive entirely as earthworks. Clevigarth also differs from the other broch sites in having very similar internal and external feature heights and there is no significant difference in the ground level either side of the boundary. An angle of slope and a width were recorded for less than 15 points (all 45%) and the majority are of equal height and slope; only four points had a measureable difference, occurring where the boundary curves inwards, not on the main E-W boundary.

Clevigarth is the only boundary in the Iron Age category with much continuous stone (36%); 28% of the boundary (mainly the east side) contained no visible stone. In all the Iron Age boundaries, the most common stone size at Clevigarth is 0.3-0.4m (37% maximum, 56% minimum). The total range of stone sizes is≤0.2m (12% maximum, 19% minimum) to 1-1.5m (5% maximum, 2% minimum). The largest stones occur either singly or in pairs throughout the dyke element of the boundary. The bank contains few small stones.

Tumblin

There is a marked difference in feature type between boundaries Tumblin 1 (81% lynchet) and Tumblin 2 (87% bank). The southernmost length of boundary has been classified with Tumblin 2 because it appears to be continuous on the ground; the feature type (bank) is also consistent. However, once mapped, Tumblin 1 appears continuous with the southern length of dyke, and includes short lengths of bank at the northern and southern limits, including at the point where the two dykes merge.

The internal feature heights at Tumblin reach a maximum of 0.3-0.4m (Tumblin 1, 13%; Tumblin 2, 51%). The greatest external height at Tumblin 1 is 1-1.5m (9%), being lower (0.7-0.95m) at Tumblin 2 (23%).

The most commonly occurring angle of dominant slope is shallow at both boundaries: Tumblin 1, 68%; Tumblin 2; 74%. Both include a significant percentage of steeper slope: Tumblin 1, 68%; Tumblin 2, 26%. Only Tumblin 1 had any slope which was near vertical (3%). The steeper lengths are scattered throughout the boundaries. At Tumblin 1, 93% of the dominant slope faces outwards; at Tumblin 2, 100% of the boundary faces outwards. The boundaries follow the contours of the hill with the result that, whilst the majority of the boundary faces west (59%) or northwest (24%), the boundary faces seven of the eight recorded compass points. Tumblin 2 follows the contours less closely, having dominant faces between south and west. The boundaries share an identical range of widths: <0.5m to 2.6-3m. However, Tumblin 1 includes 53% ≤1m; at Tumblin 2 the corresponding proportion is 8%, the majority of the feature (90%) being 1.1-2m wide.

At Tumblin 2, 93% of the boundary contains no visible stone; at Tumblin 1 the proportion is 47%, the largest category of stone density. At Tumblin 1 the visible stone was concentrated at the northern end although with several short lengths of different densities interspersed. The stone which exists at Tumblin 2 is small (≤0.4 m). The stone densities suggest that the boundary was constructed of turf (feals). In contrast, Tumblin 1 maximum stone range comparable with most of the other broch site investigated: between ≤0.2m and 1-1.5m.

Sae Breck

The boundary interpreted as contemporary with the broch (Sae Breck 1) survives as 84% lynchet. Short lengths of discontinuous dyke occur at three points within the boundary. Sae Breck 2 is 51% bank and 38% lynchet, the bank being concentrated on the western side of the broch mound, the less intensively cultivated slope. The stretch of Sae Breck 2, immediately west of the broch, is primarily discontinuous dyke, but where the boundary crosses the broch, it becomes a lynchet, with short lengths of bank and dyke interspersed.

The post-broch boundary, Sae Breck 2, is the only boundary associated with the Iron Age sites which has an internal feature height exceeding 0.4m: rising to 1-1.5m (6%) to the west. The majority of Sae Breck 1, (66%), has an internal feature height of 0.2-0.3m. Both the boundaries at Sae Breck have external feature heights ≤1-1.5m. Sae Breck 1 broadly follows the contour of the hill, whilst Sae Breck 2 is aligned across the slope, crossing the hill just below its summit.

The angle of dominant slope was similar for both boundaries, and was generally shallow (Sae Breck 1, 92%; Sae Breck 2, 83%). Each site included a small length of boundary with a near vertical slope. All the steeper lengths of Sae Breck 1 are east of the broch. The dominant aspects of slope at Sae Breck 1 are west (65%) and northwest (31%). At Sae Breck 2 they are southeast (38%), south (31%) and north (31%). The compass direction appears less important than the relational direction: at Sae Breck 1, 99% of the boundary faces away from the broch; at Sae Breck 2, 51% faces out.

The width of Sae Breck 1 varies between <0.5m (2%) and 3.6-4m (3%). The widest length occurs in a section of lynchet northwest of the broch. The range of values in Sae Breck 2 is greater: <0.5m (7%) to 4.6-5m (13%), broadening to the west.

Approximately a third of both boundaries at Sae Breck include lengths where no stone is visible. At Sae Breck 2 this is largely corresponds with a wide bank. There is continuous stone at the west extremity where the earthwork enters a loch. The lengths of boundary with differing stone densities are scattered throughout the site, there being no coincidence between stone density and feature type.

Both the boundary which surrounds the broch and the boundary which post-dates it, include similar percentages of stone sizes in every category (e.g. maximum stone: 0.5-0.6m, Sae Breck 1, 29%; Sae Breck 2, 33%). The pattern for minimum stone size is even closer: 44% measuring ≤0.2m, and 54% measuring 0.3-0.4m, for both boundaries. This suggests that the stone source is the same for both, the field and the loch shore providing possible sources with a high reliance on turf/earth construction.

NORSE BOUNDARIES

<u>Belmont</u>

The two yards at Belmont are considered separately in terms of feature types: the northern yard comprises 60% dykes, the remainder surviving as a lynchet. The extant boundary interpreted as the southern Belmont yard is 73% dyke, although incomplete. The length of lynchet within the north yard is aligned down, rather than along, the hillslope. The lynchet is shared with the infield and faces into the yard, but there is no great overall difference between the internal and external heights. The dominant aspect of the yards is southwest (46%), the greatest proportion facing down the slope (48%).

The infield boundary at Belmont (excluding the township boundary, which forms the east side of the infield) survives as 67% bank, 3% lynchet and 30% dyke. The bank and short length of lynchet are predominantly to the west, upslope, side of the site. The northern and southern boundaries both comprise dykes. The length of infield boundary reused for the township boundary survives as 60% dyke and 36% bank, contrasting with the rest of the infield. The bank component is at the south end of the infield/township boundary, interrupted only by a short length of lynchet. Immediately south of the junction of the township and the infield boundary, the township boundary reverts to dyke.

The feature heights of the infield boundaries at Belmont were recorded as “in” and “out” as this was very clearly defined. The results are similar for both, the internal face being slightly higher overall (16% of the internal face and 3% of the external face exceed 0.7m). Ten-percent of the internal face of the infield is between 1-1.5m high. The external face was dominant, situated at a break of slope, the infield being on higher ground: perhaps to demarcate a different use of the (today much) wetter land below, possibly water meadows, or to exclude the bog.

The near-vertical lengths of township/infield boundary coincide with the highest points on the dyke (up to 1.75m externally). This is not the case on the infield boundary. The majority of the infield faces west (38%) and south (34%); the yards face northwest – southwest but are only fragmentary. Thirty-nine percent has faces of equal height; 35% faces into the infield. The township/infield boundary predominantly faces west (75%), the direction of slope (recorded as 52%). The post-medieval township was below the boundary, the Norse site was above it.

The widths of the two Norse yard boundaries at Belmont are between <0.5m and 3.6-4m, the major proportion (79%) being ≤2m wide. The infield boundaries share similar ranges: between <0.5m and 3.6-4m. The infield/ township boundary is slightly narrower, up to 2.6-3m. Belmont is the only infield with any boundary wider than 2.5m; (14% between 2.6-4m wide). The wide lengths occur at five locations, all on the upper (east) side and there is some coincidence between these and high points: in four cases the wider areas take the form of a dyke within an earthwork, with continuous stone visible; a bank with fairly continuous stone visible in the fifth.

Of the yard boundaries 37% included continuous stone and 31% fairly continuous stone. Nineteen percent of the boundary was stone-free; some lengths of boundary were entirely missing. Thirty-percent of the infield boundary comprised bank without stone; another 31% is discontinuous stone within lengths of bank. The continuous stone correlates with the dyke. The infield/ township boundary is 53% continuous stone (in bank and lynchets at the south end of the site and dyke at the north end) and 34% discontinuous. The infield/township boundary changes character at/near either end of the infield, the township dyke continuing stone free at the northern end and changing to continuous stone to the south.

The stone size in the yards range between ≤0.2m and 1-1.5m. The majority of stone is either 0.3-0.4m (64% minimum, 43% maximum,) or 0.5-0.6m (25% minimum, 52% maximum). The range of stone in the infield boundary is the same (although the percentages are different). The Belmont infield/township boundary contained the greatest range of stone sizes of all the Norse sites, one measuring 2.2m. The large stones occur in small groups within the boundary.

<u>Gardie</u>

The yard at Gardie is varied in its construction, with lengths of dyke interspersed with lynchets forming the east and west boundaries. The southern edge of the yard survives as a bank, although the infield boundary continues on either side as dykes. This is consistent with the yard pre-dating the infield, but may also reflect a difference in function between the two areas. The post-Norse land use of the site is unlikely to explain a difference in survival. The yard has slightly lower internal faces than external ones. There are only two directions of face in the yard boundaries: north (64%) and west (36%). The boundary has dominant faces which are 49% internal and 38% external. The infield boundary at Gardie is 84% dyke, an additional 6% formed by short lengths of coursed wall within the east boundary. The feature height measurement only applies to 10% of the total site: of this, the external face is higher than the interior.

The angle of slope of the majority of the yard and infield boundaries is shallow; however, the portion of boundary which they share has a steeper slope. The vertical slope occurs to the east. The principal direction of slope face is north; 55% of the faces are of equal height on either side and 39% face inwards, including the faces aligned down the slope. Gardie has a maximum infield width of 2m; it rises to 1m high only at one place: within the boundary of the western intake of land comprising continuous dyke, constructed of small stone. The width of the intake boundary is 0.7m. Of all the Norse sites in the study, Gardie has the smallest range of boundary widths for both yards and infields (0.6 to 2.5m), the most common width being 0.6-1m (57% yard and 79% infield).

At Gardie, 49% of the yard boundary contains no visible stone; 20% (28 points) includes continuous stone. In contrast, the percentage of continuous stone in the infield boundary is high (64%). The majority of the infield boundary is classed as dyke; the yard is more varied, both in site type and stone density. The field boundary shared between the infield and yard is dominated by discontinuous stone, unlike the rest of the infield boundary.

The most commonly occurring maximum stone in the yard measured 0.5-0.6m (50%; 14 points). None of the stone was small and only 11% maximum and 61% minimum stone measured 0.3-0.4m. Twenty-five percent maximum stone measured 0.7-0.95m, 14% (4 points) measured 1-1.5m. The range of stone in the infield was from ≤0.2m (21% minimum) to 1-1.5m (8% maximum), most commonly 0.3-0.4m minimum stone size (72%); and 0.5-0.6m maximum stone size (46%).

<u>Hamar</u>

There are two longhouses at Hamar, each associated with its own yard. The northern yard (Upper Hamar) survives as lynchets, 84%, with banks accounting for the other 16%. At Lower Hamar the amounts of bank (55%) and lynchet (45%) are more equal. Lower

Hamar has been stripped for turf, which might have altered field form (potentially lynchet to bank). This yard is aligned down the slope. The slope at Upper Hamar is considerably steeper. Excavation has revealed a greater depth of deposit at Upper Hamar (Bond *et al.*, 2012) the site is less visible in the landscape because it was not scalped.

The combined heights of the yards at Hamar are lower externally than internally. The scalped yard boundaries at Lower Hamar are shallow; Upper Hamar displays more variety, including 5% near vertical and 32% steep. A total of 51% of the two yards face east, however the Lower Hamar yard has only one long side surviving, facing east. Although the greatest proportion of the boundaries recorded face inwards (43%), another 13% are recorded as downslope; therefore about half face out.

The widths of the yard boundaries lie between <0.5m (29%) and 3.1-3.5m (5%). Of these, the majority are $\leq$1.5m. The Upper yard accounts for values <0.5m whereas, with one exception, the higher boundaries are at Lower Hamar. There is no stone visible in the Lower yard; the 59% of boundary containing very few stones coincides entirely with the larger, higher, yard. None of this exceeds 0.5-0.6m (59% maximum and 41% minimum); the remainder is 0.3-0.4m. In contrast, the Lower Hamar longhouse walls survive well although the western side room was largely robbed.

Stove

The yard boundary at Stove is 85% dyke, and appears to have been incorporated into a later field dyke in use in the relatively recent past; it appears on the First Edition (1878)

Ordnance Survey map. Stove has the most fragmentary survival of infield boundary of all the Norse sites recorded as bank (75%) which contrasts strongly with the yard.

The height of the yard is broadly lower inside than out. The infield boundary is similar at the upper range (≥0.7 – 0.95m), but the internal face is somewhat lower (68% internal face is ≤0.3m compared with 34% of the external face). The highest point of the infield boundary is 1-1.1m high; occurring at two separate points along the boundary, north of the house. Part survives externally as a faced dyke, but the internal face survives as an irregular, grass-covered, bank, 0.8-1.4m wide.

The yard boundary is mostly dyke and therefore the angle of slope was recorded for less than 10 points. The infield boundary was predominantly shallow. The yard at Stove had faces within a 90° arc: north to west. Of the infield 93% lies within a 90° arc, NE-NW.

The width of the Stove yard boundaries lie between 0.6-1m (81%) and 2.1-2.5m (3%). The infield varies between <0.5m (12%) and 2.1-2.5m (15%), the greatest proportion measuring 1.1-1.5m (39%). The northern boundary is narrowest, and not necessarily Norse, given the proximity of features of possible prehistoric date.

The yard at Stove includes 88% continuous stone (33 total points). The infield boundary is more varied: 42% continuous stone, 42% containing no stone.

The Norse yard at Stove contains stone of 0.3-0.4m to 1-1.5m. The most commonly occurring stone size is 0.5-0.6m. The infield includes stone of ≤0.2m to 1-1.5m.

Watlie

The two yards at Watlie are both dominated by lynchets, aligned along the slope, Watlie South including boundary created by the foot of an almost vertical rock outcrop. There is a strong correlation between the lynchets and the hillslope. The boundaries aligned down the slope take different forms: a bank to the north; the foot of a rock outcrop to the south. (The township dyke is situated above the outcrop, at its edge.) The central, shared, boundary is also a dyke.

The feature heights of the yards are strikingly similar internally and externally. Five percent of the internal face exceeds 1-1.5m high and none of the external face does. The dominant direction of face of both yards was west (64%): a total of 98% faced between north and west. Both yards are sub-rectangular and share a similar alignment.

Watlie is the only infield with no dominant feature type. South of the yards, the infield boundary merges with the later township boundary: a short length of dyke then returns toward loch edge. The northwest boundary is absent, being formed by the water's edge. The location of the township boundary, and the absence of evidence of another boundary to the south, suggests that the township and infield boundaries were coincident. The township boundary is 100% dyke, the stone frequently set into earthworks which have height up to 1.5m, the majority being between 0.5–0.95m.

The site at Watlie was the most diverse of all the sites investigated in terms of angle of slope. The northern yard is predominantly shallow, whereas the 29% of the southern yard is near vertical. The northern infield boundary is also predominantly shallow, contrasting with the boundary shared with the township which comprises fairly continuous dyke, the stones being set into a bank creating near vertical faces. The infield boundary faces south (59%), the remainder facing east and west and faces inwards (69%; 24% being of equal height). The township/infield boundary is aligned 28% southwest, with faces towards seven of the eight compass points recorded: none faces northwest. This equates to 42% facing away from the enclosed land, a further 31% facing downslope. The outward facing boundary faces the opposite direction to the township and the infield, as well as facing away from the natural hillslope.

The widths of the boundaries at Watlie show considerable consistency: the yards and infields are up to 2.1-2.5m (3%) wide, the largest category at being 1.1-1.5m (33% at both). The infield/township dyke is slightly wider (up to 2.6-3m), the also measuring 1.1-1.5m (55%).

Of the two yards at Watlie, 64% contained no stone. The lynchet shared between the southern yard, the infield and the later township includes a high percentage of discontinuous stone (66%). The other lengths of infield boundary vary in the amount of stone visible. The Watlie yards are the only ones to include stones recorded as ≤0.2m . Stone was recorded at 31 points, the majority within the southern enclosure, partly coinciding with the infield/township boundary. The most common stone size is 0.5-0.6m, the largest being 1-1.5m. The range of stone in the infields is from ≤0.2m to 1-1.5m, the most commonly occurring maximum stone size was 0.3-0.4m (59%). The infield/township is constructed with relatively small stones (between $\leq$0.2m and 0.5-0.6m). This, in part, reflects the high turf (feal) content of the dyke.

SUMMARY OF RESULTS

Table 6.4 (below) presents the results of the boundary analysis. This demonstrates that there are no defining field form characteristics or set of characteristics relating to boundary type. However, recurring characteristics have been identified within classes of field form. These are summarised as:

Feature type

No single feature type characterises any particular field form however there is a dominant feature type at each individual Enclosure, Iron Age boundary and Norse boundaries. This is not the case for the Multiple Field Systems; however, individual elements within them display consistency. It is possible that the occurrence of a dominant feature type indicates a single construction event.

Table 6.4 Summary of Results of Boundary Analysis

	Enclosures	Multi Field Systems	Iron Age	Norse Yards	Norse Infields	Infields/Township
Feature Type	4- Earthworks 80+% 3 dominated by single type (2 bank, 1 lynchet); 1 cont/discont dykes; 1 even: banks/dyke 1 mixed – peat cut	Consistency within individual field system (2 banks, 1 lynchet) All – combined earthworks 60-88%)	Dominated by single type	3 – dominated by single feature type (dykes) 1 – fragmentary, more equally distributed (mixed, earthworks dominate) 1 – mixed earthworks	3 dominated by single type (1 dyke; 2 banks) 1 total earthworks dominate	Dykes dominant 1 – 100% 1 – 60%
Feature Height	(earthworks 31-100%) Most common:0.2-0.4m (1 up to 1-1.5m) 2 highest v influenced by topography 3 lower inside, 1 higher, 1 little difference	(earthworks 60-80%, Int/ext ambiguous) Majority 0.2-0.6m; 3 (2 ext, 1 int) exceed 1.5m (2-5%) Little diff int and ext: 1 high ext (slope influence), 1 high int. No clear pattern	0.2-0.3 is most common, Up to 1.5m little difference internal and external	4 of 5 – up to 1.15m 2- inside higher than out 1-outside height 2- little difference	1.5m max; majority ≤0.5m	Belmont ≤0.5m-1.5m (lower %) Watlie ≥0.5m
Slope Angle	4 shallow, 1 steep, 1 near vertical (topography)	All – 60%+ shallow 4 – nr vertical (1-11%)	All predominantly shallow	Shallow – all but 1 more than 60% 2 include nr vertical	Shallow most common, only 2 have any near vertical (c25%)	Bel – 43% shallow, 17% nr vertical; Watlie – 4% shallow, 50% nr vertical
Direction of Slope Face	5 – in (of these: 1 in & out close; 1 in & equal close) 1 - equal	Down 3; in 2; equal 1 3 - hillslope strongly influences direction 2 no strong direction	External facing, downslope dominates (at 3 more than 90%)	1 aspect & face shared. Out 2; In 2; Down 1	3- Equal dominant 1- In	1 - Down & Equal 1- Down & Out
Cardinal direction	3 – south; 1- west 1 – south & west close 1 - north	2-West; 1-East 1-South; 1-Varied	3-West (Post-Norse SB2 more varied)	1-North; 1-East; 1-West; 1-N&W; 1- SW	1-South; 1- North; 1-NW&NE; 1-S&W	1-West 1-Very varied (SW max at 28%)
Feature	4- 50%+ 0.6-1m	All – greatest % = 0.6-	2 up to 4m	Different ranges: max between	1 v. consistent, 79%	Different ranges:

Width	1 exceeds 2m (2-5m = 20%)	1m 2- up to 4m 3- up to 5m 1- has 1% 5.5m	1 up to 2.5m (P-N SB2 up to 5.5m) 1 not counted (≤10pts)	2m and 5m most common at all is 0.6-1m	0.6-1m Other wider range up to 4m	up to 3.5m 1- 0.6-5m (59%) 1- 1.1-1.5m (56%)
Density of Stone	All – Discontinuous is dominant	4 – discont stone (other 2 similar amounts but 1 has more continuous, 1 has more no-stone)	4- between 34-94% no stone; 1 exception= 36% cont (Clev)	Norse – most inconsistent 2 - continuous stone (37 & 88%) 2- no visible stone (49 & 64%) 1- few/no stone	Norse – most inconsistent: 1- discontinuous; 2- no visible stone 1- visible stone	1 - 53% continuous 1 – 66% discontinuous
Min-Max Stone	0.3-0.6m max is most common (68% - 97%)	0.3-0.4m most common; (68 – 97%) 1 largely no stone	All 0.3-0.4m most common (37% - 58%) 2 up to 1-1.5m (86%)	All: 0.5-0.6m max most common 4: 0.3-0.4m min most common	Max stone size – varies Most common max size: 2 – 0.3-0.4m; 2 – 0.5-0.6m	0.3-0.4 most common. Bel up to 1.9m; Wat 0.6m max stone size

Dimensions (Height and Width)

Only one Enclosure has a feature height greater than 0.6m (South Newing), and only Exnaboe has a boundary width greater than 2m. The combination suggests that this class was never particularly massive. Most of the high points of the Multiple Field Systems, (scattered throughout the boundaries) and of Exnaboe, coincide with the widest points. The broch boundaries are more substantial constructions in both height and width. The Norse sites show the greatest variation where the land appears to have been stripped (Hamar and Belmont).

Internal and External Feature Height

The Enclosures and Norse Yards show only small differences between faces and which is the greater is not consistent. There is no clear pattern relating to the Multiple Field Systems.

Angle of Slope

The only site type dominated by near vertical faces is the Norse/Township category. The other boundaries are primarily shallow.

Direction of Slope Face

The Enclosures favour an inside face; the Multiple Fields and Iron Age boundaries favour a downhill direction of face. The Norse yards show less consistency.

Half the Enclosures have south facing slopes dominant, and these are the only site type which indicate any preferred direction of slope face.

Density and Stone Size

The Enclosures and Multiple Field Systems favour discontinuous stone and the Iron Age boundaries favour no stone, whilst the Norse sites are less consistent. The most common stone size is 0.3-0.4m for most site types, which probably equates with the most useful size of field stone, although the Norse yards favour slightly larger stone. The upper range of stone is similar at most sites, with only 2 Multiple Field Systems, and one Norse/Township boundary including stone exceeding 1.5m.

There is considerable consistency in some of these results, the significance of which will be explored in Chapter 10.

Chapter 7: Results and Discussion 5 – Field Soil Survey

AIMS

The purpose of undertaking a programme of field soil survey was to understand the quality and depth of soils at each of the field systems in the study. This would provide the basis for selecting sites for micromorphology based examination. The augering programme therefore sought to:

1. Examine the soil resources of the land around the settlement sites
2. Record any evidence of human activity in the soils that was visible to the naked eye
3. To determine which sites were most likely to repay further examination by test pitting and micromorphology.

METHODS

Each of the surveyed field systems was augered using a Dutch auger. Although the sites were located throughout Shetland, over a range of geomorphological situations, most were on hillslopes with varying degrees of peaty vegetation. In order to maximise the value of the programme, augering was carried out at points determined by the field system morphology and background topography. Cores were taken on both sides of physical boundaries (eg: dyke, lynchet, break of slope) since the existence of a boundary suggested a possible change in land management. No cores were taken from archaeological structures. The precise locations of the auger samples were influenced by ground conditions: areas of standing water and saturated bog were avoided where possible. Wherever soil depth was found to be less than 15cm, three auger samples were taken in the vicinity, the deepest being recorded. This was done to ensure that results were not impaired by stones or other objects within the soil.

The soils sampled were described in terms of colour, matrix, depth and inclusions. These results were then compared with those from the other sites in the same category. The preparation of more detailed field descriptions was reserved until soil pits were subsequently excavated. The diagrams which present the results (below) are numbered to facilitate a rapid visual assessment of each site. Where matrices appear to be composed of broadly similar material, they were assigned the same Roman numeral. Each set of numerals refers only to that site: they have not been applied between sites and so direct inter-site comparisons cannot be made on the basis of numeral alone.

The augering programme was predominantly undertaken during 2006/early 2007 with up to 2 days spent at any single site. The constraints of part time study, and the unpredictability of the weather in Shetland, meant that the sites were examined under a variety of light and weather conditions. The time of year and surface conditions were noted for each site but, interestingly, this was not necessarily reflected in the water content below ground, even within bogs.

RESULTS

Key to Maps: House sites and other potential archaeological buildings are depicted in green. Later structures, such as plantiecrubs, are shown in brown. These structures may conceal earlier ones beneath them but are not themselves contemporary with the remains being studied. In two cases (Gardie and Sumburgh Head) detail has been added from the Ordnance Survey maps, as this contributes to an understanding of the plotted features. The description for each field system includes descriptions taken from both the Macaulay

Institute for Soil Research 1:250,000 Soil map and 1:250,000 Land Capability for Agriculture map.

HOMESTEAD ENCLOSURES

Croag Lea

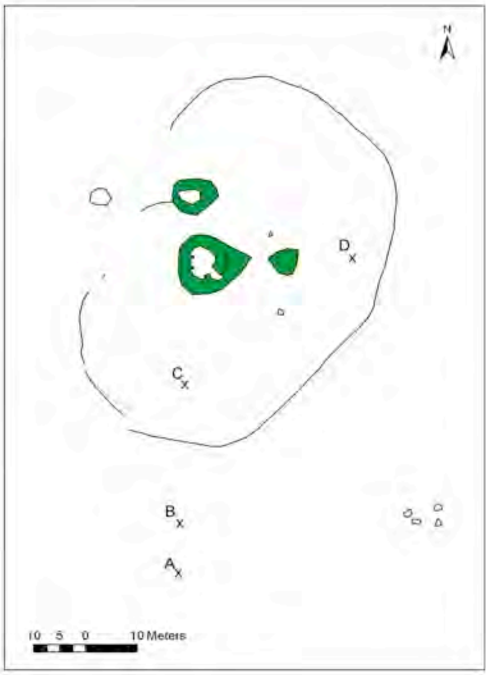


Fig 7.1a: Positions of Croag Lea augers

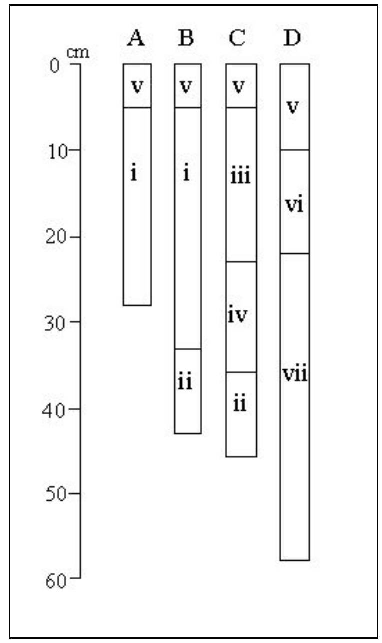


Fig 7.1b: Results of Croag Lea augers by Munsell colour

Soil	Deep Peat. (Blanket peat)		
Land	Dominated by plant communities with low grazing values (inc. blanket bog)		
v	Mat grass, wavy hair grass and some moor rush with a few patches of sphagnum on the wetter ground.		
i	10 YR 2/1 black	Very peaty, crumbly; mottles 5YR 5/8 yellowish red, up to 20% organic Crumbly top, more compact lower down, includes a quartz fragment	damp
ii	5YR 2.5/2	Sandy silt, no humic inclusions. B&C contain charcoal	Drier than i
iii	10YR 2/1 black	Very peaty, crumbly; mottles 5YR 5/8 yellowish red, up to 20% organic	Slightly damp
iv	7.5YR 3/1 very dark grey	Less peaty, more sandy. Includes mottles of clay: 2.5YR 5/1 grey and 7/1 light grey. Less organic (c5%). Leached.	Drier than iii
vi	10YR 2/1 black	Predominantly root material	saturated
vii	black	Peat. waterlogged, semi-liquid, with strong unpleasant odour, dark flecks at the base – charcoal or manganese.	sodden

Table 7.1 Croag Lea Auger Descriptions

The ground surface at Croag Lea ranged from fairly dry to wet underfoot. The soils are peaty, with peat in the process of formation as well as ready formed. There is dark material, either charcoal or manganese, at the base of both columns B and C, ie: both within and outside the enclosure. Column C (within the enclosure) includes a somewhat leached B horizon above the horizon containing charcoal/manganese. Ai, Bi, Ciii and Dvi are all very similar layers of peat. Column C appears to be a podzol in which Civ is leached, the ferrohumic material (iron stained organic matter) being redeposited in the "basal" horizon, recorded as Cii. There are only two horizons in Column B; the leached horizon appears to be absent. However, the basal horizon is ferrohumic and the peat overlying it is mottled in a way which indicates ferrous mobility.

<u>Exnaboe</u>

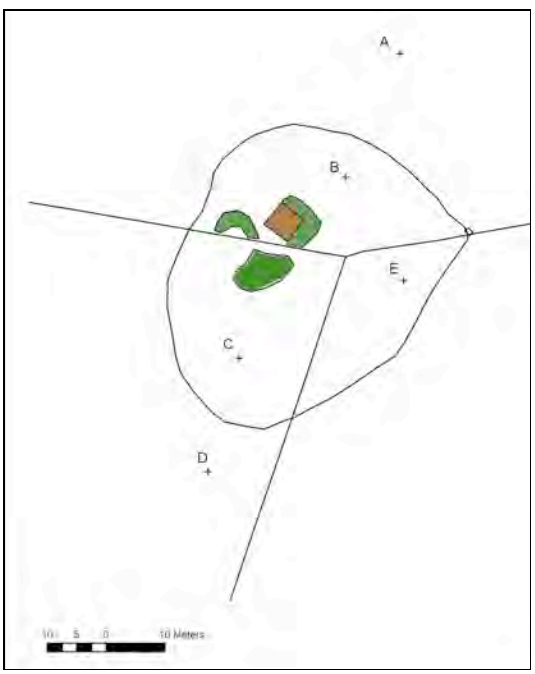


Fig 7.2a: Positions of Exnaboe augers

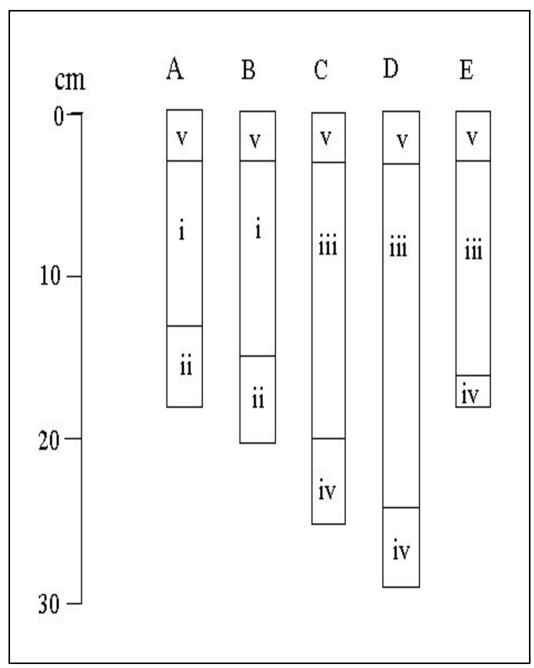


Fig 7.2b: Results of Exnaboe augers by Munsell colour

Soil	Drifts derived from sandstones, flagstones and conglomerates; peaty gleys, non calcareous gleys, peat and saline gleys. (arable, permanent pasture, maritime communities)		
Land	High proportions of palatable herbage in the sward, particularly the better grasses of meadow grass: bent grassland, bent-fescue grassland		
v	Grass, cultivated within 3 separate fields. A and B vegetation is closely grazed, longer but poorer, with some moor rush on enclosed fields		
i	10YR 2/1 black	Silty loam, rich, humic, contains worms	
ii	10YR 5/3 brown	Sandy silt matrix with stones up to 2cm some with iron coatings	
iii	10YR 2/2 very dark brown	Sandy silt, less rich than i, roots up to 10%, crumby matrix, friable, plastic	
iv	10YR 5/6 yellowish brown mixed with 10YR 2/2 very dark brown	Very sandy, mixed with sandy silt, containing stones up to 0.25cm.	

Table 7.2 Exnaboe Auger Descriptions

Exnaboe Enclosure is trisected by fences: the area to the north comprises short-cropped scattald, although visited in spring before the ESA restrictive period when grazing on the scattald might be expected to increase. The southeast segment has the wettest ground surface and the densest moor rush. Iron leaching was observed in the soils on the scattald with redeposition visible as iron coatings on stone. None of the soils at the site are peaty, however there appears to be a distinction between the auger soil samples taken on the scattald and those on the enclosed land. There is no distinction to the naked eye between the soils within and outwith the enclosure. The soil classification suggests that the land would support arable use if appropriately managed.

Hill of the Taing

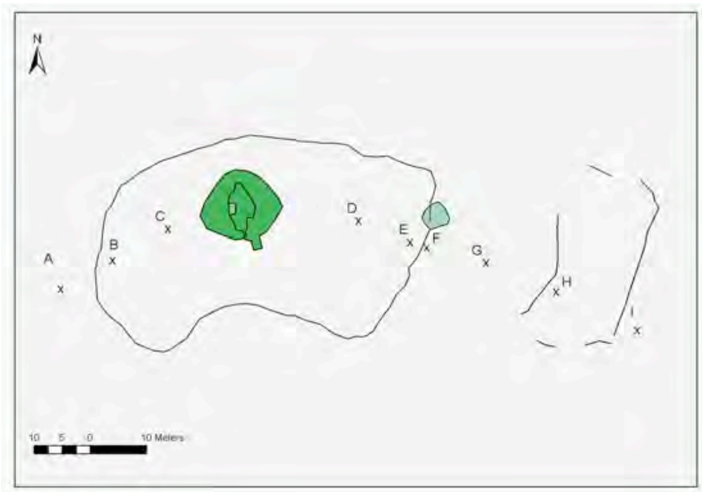


Fig 7.3a: Positions of Hill of the Taing augers taken.

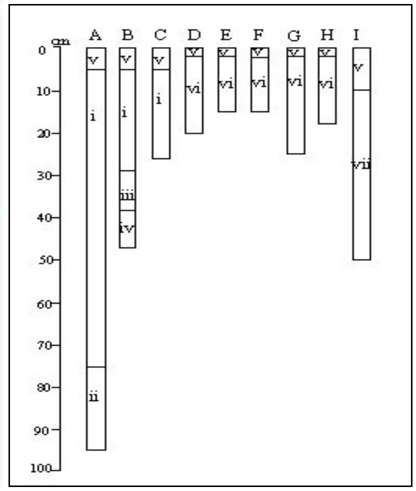


Fig 7.3b: Results of augers by Munsell Colour

Soil	Drift from schists, gneisses, granulites and quartzites. Peaty gleys, peat, some peaty podzols and peaty rankers.		
Land	Capable of use as improved grassland, unsuitable for arable. Liable to serious trafficability and poaching therefore cannot support high stock densities.		
v	A-C,I Spagnum, hair moss and moor rush D-H short mat grass		
i	10YR 3/2 black	Humic silty peat	
ii	10YR 3/1 very dark grey	Includes yellow sandy fragments (rotted stone), organics and possibly charcoal	
iii	7.5YR 3/2 dark brown	Humic peaty silt	
iv	10 YR 3/2 black	Humic peaty silt	saturated
vi	10YR 3/1 very dark grey	Humic peaty silt, ranker	
vii	5YR 2.5/1 black	Pure peat	

Table 7.3: Hill of the Taing Auger Descriptions.

The Hill of the Taing Enclosure is, today, the most remote of the sites under consideration: it is in the scattald and each auger core revealed very peaty material, the depth of peat being greater outside the anthropogenic areas. Seven of the nine cores comprise a single horizon with the characteristics of a peaty ranker. Of the exceptions, Column B contains two horizons of peaty silt, the lowest of which is saturated; Column A includes a surviving B horizon.

Houlland

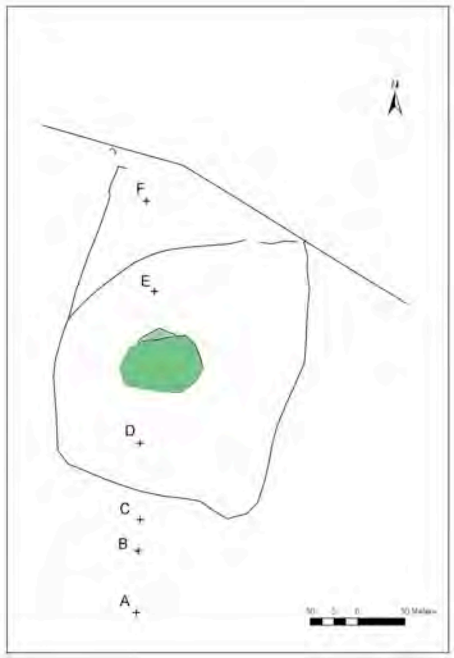


Fig 7.4a: Positions of Houlland augers

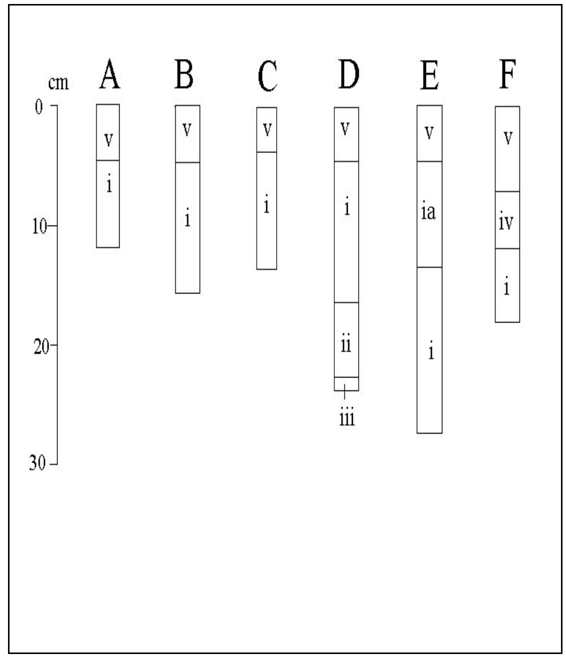


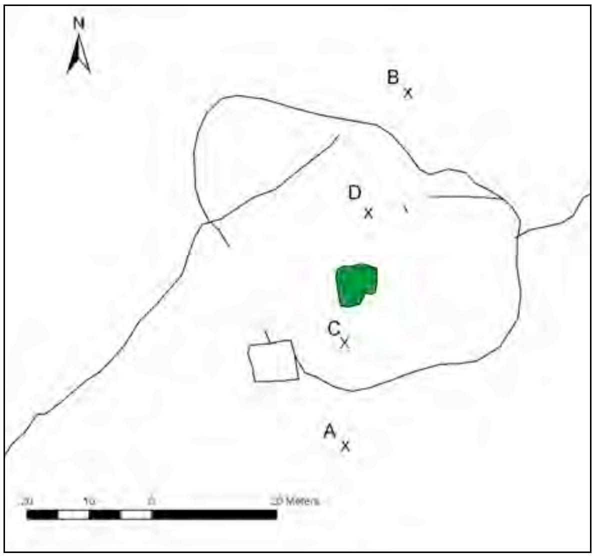
Fig 7.4b: Results of Houlland augers by Munsell Colour

Soil	Drift from schists, gneisses, granulites and quartzites. Peaty gleys, peat, some peaty podzols and peaty rankers.		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	Short grazed grass: sheep fescue and mat grass		
i	7.5YR 2.5/2 very dark brown	Slightly sandy loam, worms present	
ia	7.5YR 2.5/2 very dark brown	Slightly sandy loam, worms present	saturated
ii	10YR 6/2 brownish grey	Sandy loam, friable, some dark flecks – charcoal or manganese.	
iii	10YR 6/2 brownish grey	Sandy loam, friable, inclusions: orangey stone (iron stained?)	
iv	5YR 2.5/1 black	Black peat, very friable	

Table 7.4 Houlland Auger Descriptions.

The Homestead Enclosure at Houlland is situated on enclosed land, currently used as improved grazings and being relatively flat. It is surrounded by rocky, unimproved, rough grazings. Peat has begun to form in the area immediately adjacent to the fenced track to the north of the site and the upper horizon here, Column F, is waterlogged. The A horizon in each of the other cores is similar. D, which is within the enclosure, is the only core which included additional soil horizons. These could include elements from a relict soil and include dark flecks, possibly charcoal. There is some leaching of iron to the base of the core.

South Newing



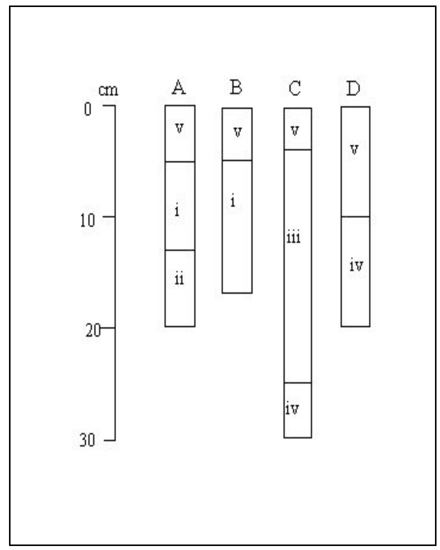


Fig 7.5a: Positions of Newing augers

Fig 7.5b: Results of Newing augers by Munsell colour

Soil	Drift from schists, gneisses, granulites and quartzites. Peaty gleys, peat, some peaty podzols and peaty rankers.		
Land	Capable of use as improved grassland, unsuitable for arable. Liable to seriously trafficability and poaching therefore cannot support high stock densities.		
v	Mat grass and small bog plants		
i	2.5 YR 2.5/2 black	Slightly sandy peaty silt	wet
ii	10YR 2/2 very dark brown	Sandy peaty silt	damp
iii	2.5 YR 2.5/1 reddish black	Sandy peaty silt. Contains a sliver of sand 7.5YR 5/6.	damp
iv	7.5YR 5/2 brown, mottled with black	Sandy silt D includes a quartz chip	

Table 7.5 Newing Auger Descriptions

The enclosure at South Newing lies on enclosed land which slopes steeply and is therefore moderately well drained. Peat is forming across the site, however the soils within the enclosure have a higher sand content than those outside it. Core C, within the enclosure, includes a sharp division with a sandier soil introduced. In a relict soil, this type of mark would be suggestive of spade cultivation, but this occurs in the A horizon and not the underlying material, therefore the cut is not likely be of any great antiquity.

Vassa

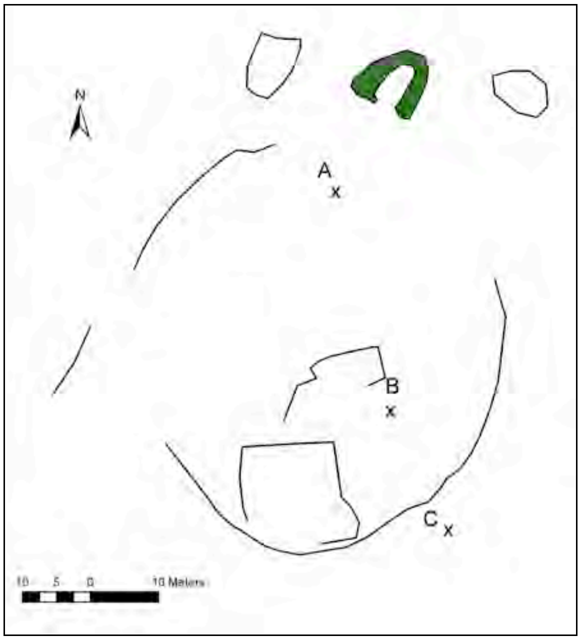


Fig 7.6a: Positions of Vassa augers

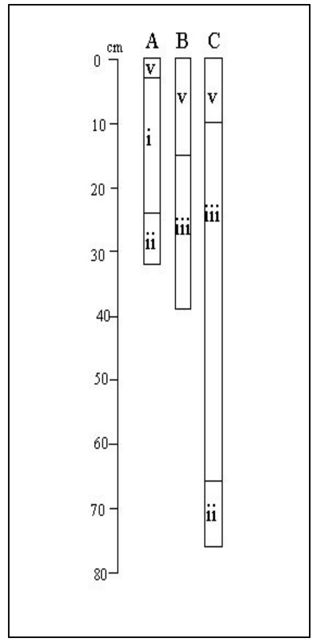


Fig 7.6b: Results of Vassa augers by Munsell colour

Soil	Drift from schists, gneisses, granulites and quartzites. Peaty gleys, peat, some peaty podzols and peaty rankers.		
Land	Capable of use as improved grassland, unsuitable for arable. Liable to seriously trafficability and poaching therefore cannot support high stock densities.		
v	Sphagnum and heather. Surface dry		
i	5YR 2.5/1 black	Rich, crumbly humic peat, slightly silty	
ii	7.5YR 2.5/1 black	Silt containing grits including quartz and charcoal	Drier than i
iii	5YR 3/2 dark reddish brown	Peat, waterlogged, semi-liquid, with strong unpleasant odour dark flecks at the base – charcoal?	sodden

Table 7.6 Vassa Auger Descriptions

The enclosure at Vassa is on enclosed, unimproved, land. Each auger revealed a peaty soil. The surface of the site has been partially scalped in the more recent past (the cuts are relatively sharp). The irregular patches mapped within the enclosure show the landscape scars associated with this.

<u>MULTIPLE FIELD SYSTEM</u>

<u>Clevigarth</u>

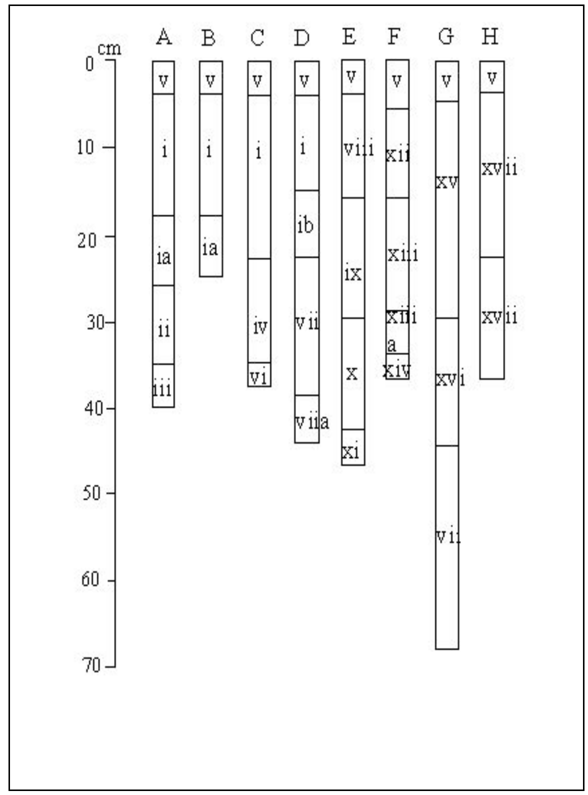


Fig 7.7a: Positions of Clevigarth augers Fig 7.7b: Results of Clevigarth augers by Munsell colour

Table 7.7 Clevigarth Auger Descriptions

Soil	Drifts derived from sandstones, flagstones and conglomerates: peaty gleys, non calcareous gleys, peat and saline gleys. (arable, permanent pasture, maritime communities)		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	A-D short maritime heath, dry; E-G heather and moor rush		
i	7.5YR 2.5/1 black	Slightly sandy loam, contains worms. Bound by roots.	
ia	7.5YR 2.5/1 black	Slightly sandy loam, contains worms. Fewer roots, fairly loose matrix, crumby	
ib	7.5YR 2.5/1 black	Sandy silt with grains of quartz	
ii	7.5YR 5/4 brown	Sandy loam, more compact than that either above or below	
iii	7.5YR 4/6 strong brown	Sandy loam with small grits, includes a stone c.4cm	Damp
iv	7.5YR 6/2 pinkish grey (predominantly) 7.5 YR 3/3 dark brown (flecks)	Silty sand	
vi	7.5YR 4/3 brown	Gritty sandy silt, small grains visible, quartz?	
vii	7.5 YR 5/8 strong brown with vertical columns of 7.5YR 2.5/1 black & iron inclusions	Matrix: compact sandy silt containing small grits. Vertical columns: looser and more sandy than matrix	

viia	7.5 YR 5/8 strong brown	Compact sand with traces of iron in it	Wet
viii	7.5 YR 3/2 dark brown	Sandy silt, friable, fairly compact, visible quartz grains	
ix	7.5 YR 2.5/2 very dark brown	Sandy loam, contains patches of grit and patches of gritty sand (7.5YR 5/8 strong brown)	
x	7.5 YR 5/6 strong brown	Very clean, compact, sand	
xi	7.5 YR 6/2 pinkish grey 7.5 YR 5/4 brown	Compact sand	
xii	10 YR 3/2 very dark greyish brown	Silty sand containing quartz grits, root bound	
xiii	10 YR 3/3 dark brown	Silty sandy containing many quartz grits, root bound	
xiiia	10 YR 3/3 dark brown	Silty sand	
xiv	10 YR 4/2 dark greyish brown with a few mottles 7.5YR 5/8 strong brown	Silty sand, a few stones up to 0.5cm	
xv	10 YR 4/2 dark greyish brown	Very sandy silt, friable, containing stones up to 2cm	
xvi	10 YR 6/3 pale brown	Slightly silty sand	
xvii	10 YR 2/2 very dark brown	Gritty sand with few roots and little structure	Wet
xviii	10 YR 2/2 very dark brown & 10 YR 3/3 dark brown mottles	Gritty sand with few roots and mottles of sand and stones up to 1.5cm	

The soils in the Neolithic/Bronze Age area of Clevigarth are generally well developed. Most of the augers showed at least three horizons and were between 35-40 cm deep. The soils within this are quite varied. Iron is mobile and deposited in the lowest horizon of auger column D which is wet. Columns E and F are both on sand but F also shows some movement of iron. H, which lies outside the Neolithic/Bronze Age field system, is the only auger column to have a wet A horizon.

Of all the sites sampled for the Late Neolithic/Bronze Age period, the remains at Clevigarth deviate from the "typical" field system for the period. The field boundaries enclose irregular fields of a range of shapes, including several which are more curvilinear than is typical of sites of this period and there is a possible (auger column D) between the house and the enclosure (which contains auger column G). The variety of soils and the potential for differential land use suggests that this site might repay micromorphological investigation; some work has already been undertaken in the immediate vicinity of the broch (Guttmann, 2008).

Gallow Hill

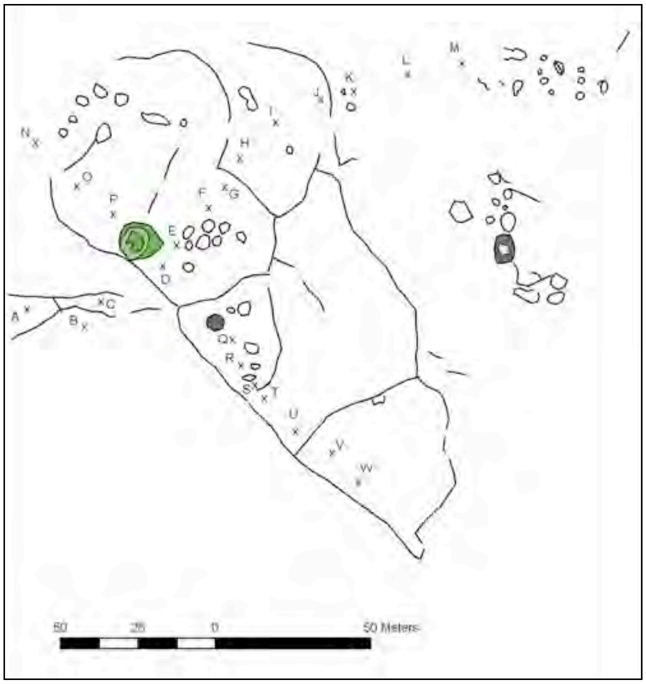


Fig 7.8a: Positions of Gallow Hill augers

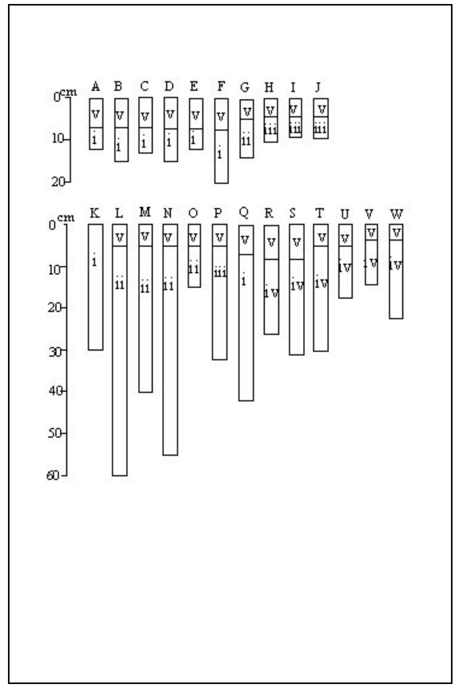


Fig 7.8b: Results of Gallow Hill augers by Munsell colour

Soil	Drift derived from sandstones with acid schists and granites: Peaty gleys, peaty podzols, peat and rankers		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	A-F,L-N, P,R-T,V,W-Y: Sphagnum, hair moss and moor rush. K: mound of sphagnum G-J: O,Q,U,Z-AA: mat grass, dry sphagnum which is 50% dead		
i	10YR 2/1 black	Silty peat, humic, root bound	
ii	7.5YR 2.5/1 black	Sandy peaty silt, fairly compact, crumby, up to 20% root material L: extremely loose and very wet	
iii	7.5YR 2.5/2 very dark brown	Sandy peaty silt, root bound espec at top, but otherwise loose	
iv	10YR 2.5/2 black	Silty peat, crumbly. S, V: very root bound	U&W: damp
vi	7.5YR 3/1 very dark grey	Sand and some possible charcoal	
vii	2.5YR 2.5/1 reddish black	Sandy silt. Loose crumbs	Fairly dry
viii	10YR 2.5/1 black 2.5YR 2.5/1 reddish black	Mottled. The black comprises a sticky silt, the red is looser. Organic inclusions and small stone.	
ix	10YR 2.5/1 black	A loose crumbly mouldy koos peat	dry

Table 7.8 Gallow Hill Auger Descriptions

The soils at Gallow Hill are very uniform across the site. Many are very shallow and all comprise peat and peaty podzols.

Ness of Gruting

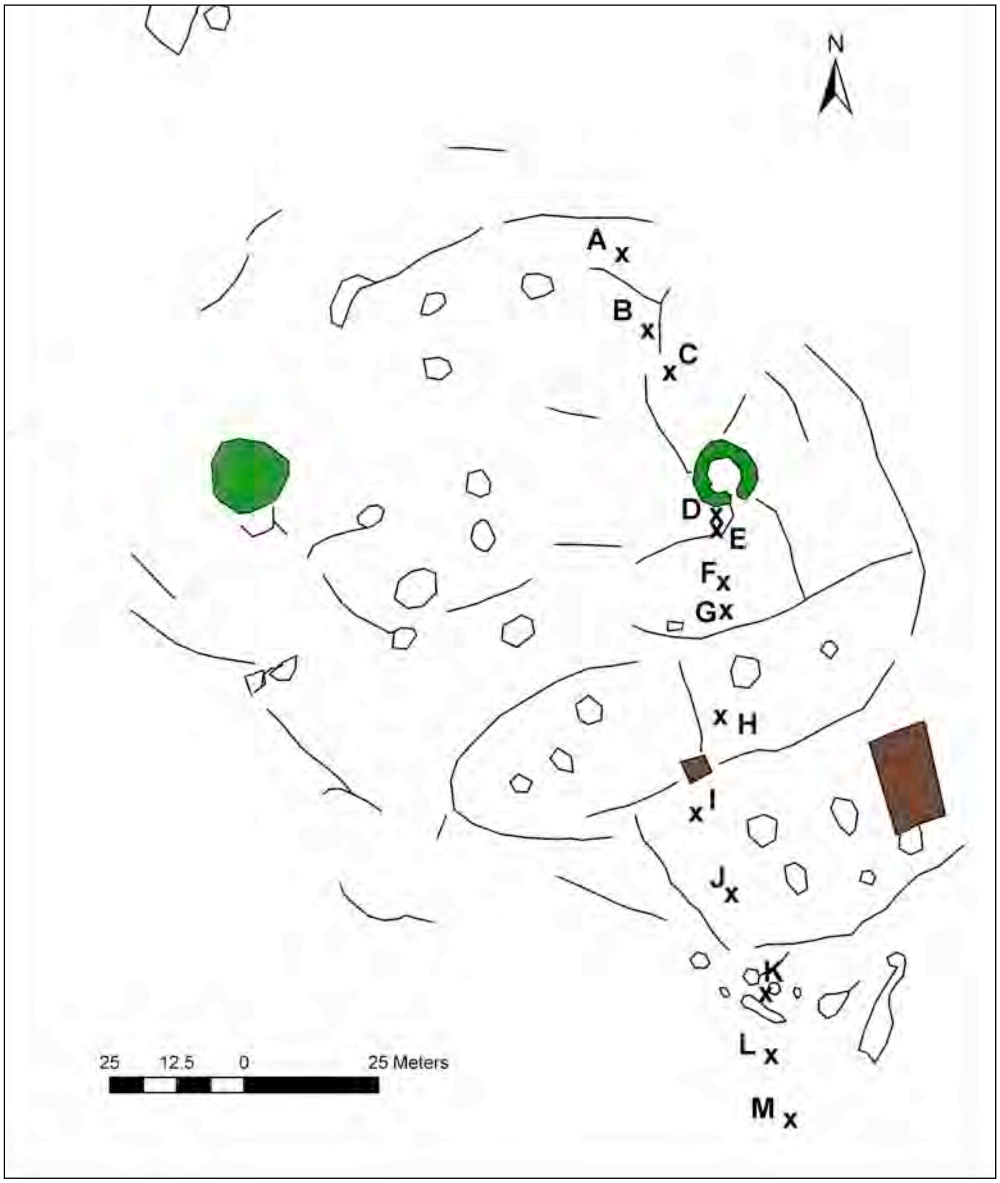


Fig 7.9a: Positions of Ness of Gruting augers

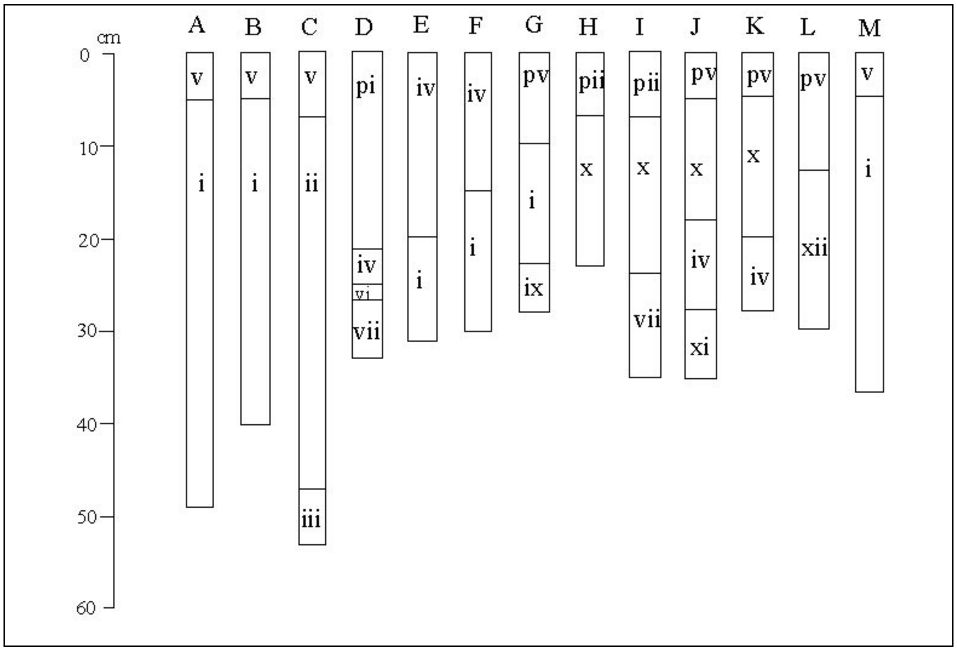


Fig 7.9b: Results of Ness of Gruting augers by Munsell colour

Soil	Drift derived from sandstones with acid schists and granites: Peaty gleys, peaty podzols, peat and rankers		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	Mat grass, some sphagnum		Damp
pv	Very humic peat		Damp
i	2.5 YR 2.5/1 reddish black	Peaty clay silt	Wet
pi	5 YR 4/4 reddish brown	Peat	Wet
pii	7.5YR 4/2 brown	Peat	Wet
ii	50% 5YR 2.5/1 black 50% 7.5 YR 3/2 dark brown	Peat, almost liquid, malodourous, dark brown is 50-75% at different points, gleyed	Sodden
iii	5 YR 4/6 yellowish red	Peaty clay silt with rotted stone inclusions	Wet
iv	5 YR 2.5/1 black	Peaty clay silt	Wet K is dry
vi	2.5 YR 4/8 red 5 YR 3/ 4 dark reddish brown mottles	Peaty clay silt with humic inclusions, mottled,	Wet
vii	5 YR 2.5/2 dark reddish brown	Peaty clay silt, humic inclusions and some lighter, rotting, stone	Wet
viii	7.5 YR 3/2 dark brown	Peaty clay silt, includes some plant material	Wet
ix	7.5 YR 6/1 grey	Peaty silt with some grey mottles, gleyed	Wet
x	7.5 YR 2.5/1 black	Peaty clay silt	Wet I= saturated
xi	5 YR 4/1 dark grey	Peaty silt	Wet
xii	2.5 YR 2.5/1 black 5 YR 2.5/1 reddish black	Black silty peat with reddish black mottles,	Damp

Table 7.9 Ness of Gruting Auger Descriptions

The soils at the Ness of Gruting comprise peat and peaty podzols, reflected in all the auger samples. Where there are several horizons, such as in J, these represent horizons within the peat. Some of the horizons demonstrate iron movement.

Pinhoulland

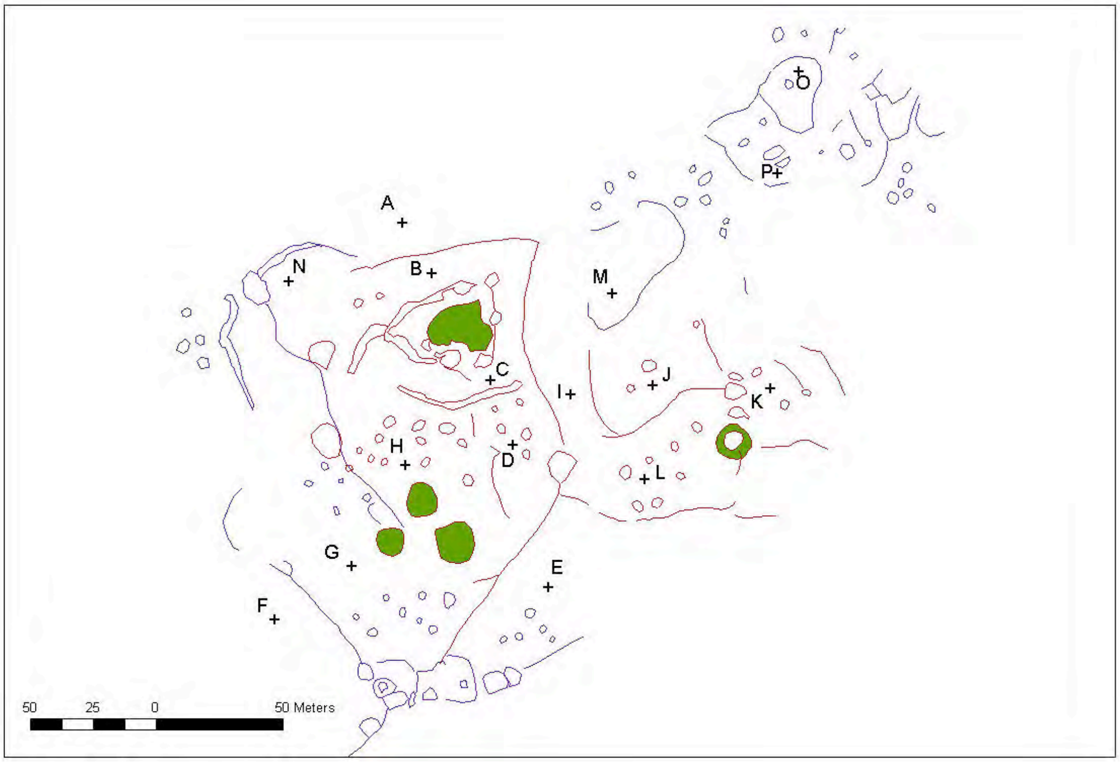


Fig 7.10a: Positions of Pinhoulland augers.

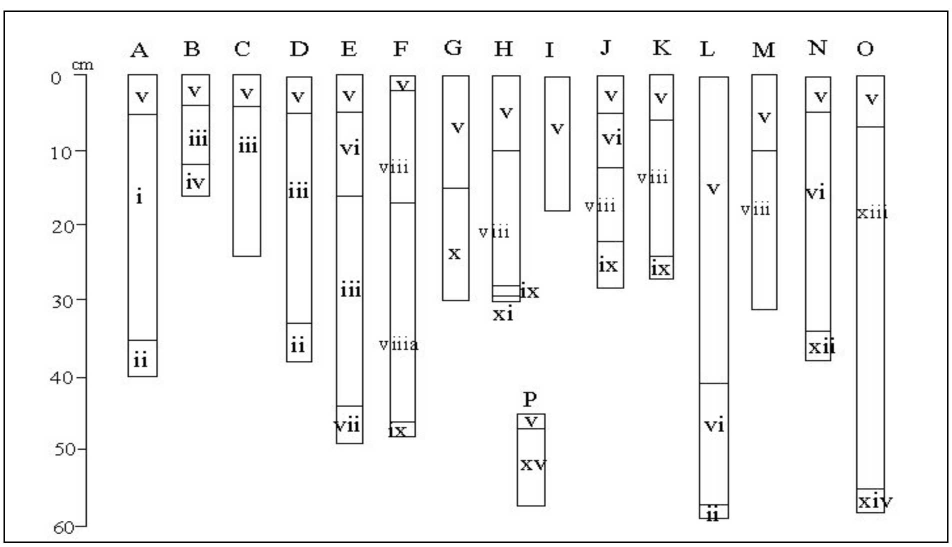


Fig 7.10b:Results of Pinhoulland augers by Munsell colour

Soil	Drift derived from sandstones with acid schists and granites: Peaty gleys, peaty podzols, peat and rankers		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	A-B,L,N,P: mat grass, sphagnum, moss. C-K,M,O: moor rush, moss and sphagnum. Ground: damp to sodden.		
i	2.5Y 2.5/1 black 2.5YR 2.5/1 reddish black	Peat, black with reddish mottles and with organic inclusions, slightly plastic, weak structure, fairly compact	damp
ii	7.5YR 3/2 dark brown	Sandy silt containing grits, plastic, very firm structure. Some mottles 7.5YR 4/4 brown. A stone, 2cm.	
iii	2.5Y 2.5/1 black	Sandy silt, 10% roots, fairly compact as a result, contains many worms	D-saturated
iiia	2.5YR 2.5/1 black	Sandy silt, fewer roots, looser, no visible inclusions	
vi	2.5YR 2.5/1 reddish black	Peat, firm, crumby L includes mottles of black in the lower 10cm.	
vii	2.5Y 2.5/1 black 7.5YR 4/4 brown	Mainly black, slightly gritty, peat with mottles, fairly compact, bound by some roots	
viii	10YR 2/1 black	Peat with 20-25% root and vegetation, very vacuous.	
viiia	10YR 2/1 black	Peat, very liquid	
ix	7.5YR 4/3 brown	Clay peat, sticky. J includes granular flecks of 10YR 8/1 white.	
x	5YR 2/2 dark reddish brown	Up to 50% rotting sphagnum moss, and brown peat with the consistency and odour of faeces	
xi	10YR 8/1 white	Hard, non plastic, clay containing grits	
xii	7.5YR 4/3 brown 10R 8/1 white	Slightly sandy clay with traces of white clay.	
xiii	2.5YR 2.5/2 very dusky red	Very plastic peat, held together by roots	
xiv	5YR 3/1 very dark grey	Very plastic peat, no visible roots	
xv	10YR 4/2 dark greyish brown	Slightly sandy silt, firm (base is looser). 10% root material. Includes worms, tiny gritty iron deposits at base.	

Table 7.10 Pinhoulland Auger Descriptions

Pinhoulland is a wet site with soils largely comprising peat and peaty podzols: however, there is a variety of soil colours (possibly explained by local differences in vegetation and moisture content, but possibly related to use). Each of auger columns B-E include a sandy silt horizon and display iron and manganese movement through the soil profile. The variety of the results would make Pinhoulland a candidate site for micromorphological work.

Scord of Brouster

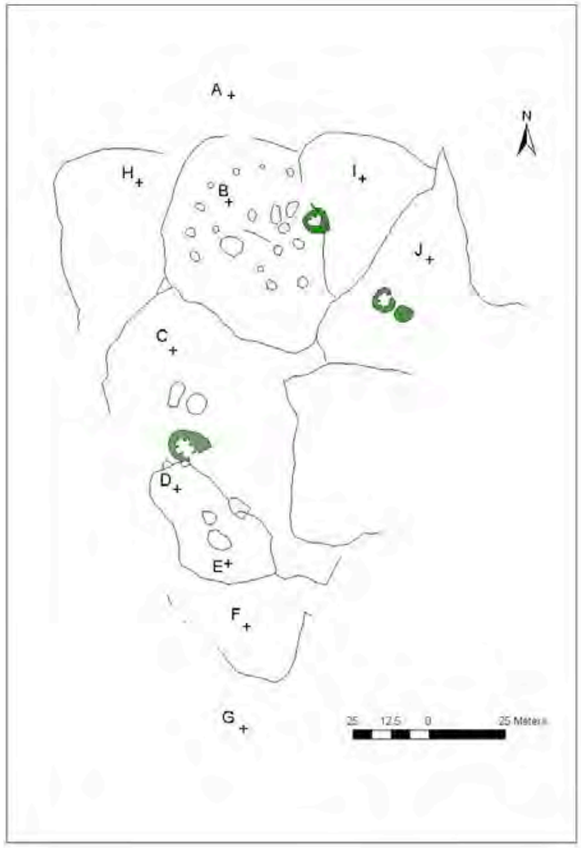


Fig 7.11a: Positions of Scord of Brouster augers.

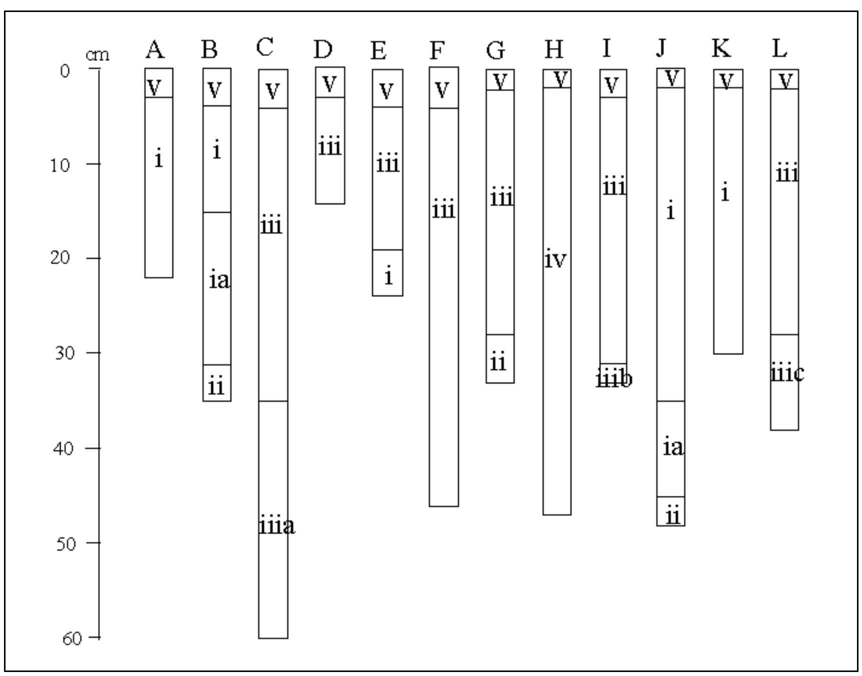


Fig 7.11b: Results of Scord of Brouster augers by Munsell colour

Soil	Drift derived from sandstones with acid schists and granites: Peaty gleys, peaty podzols, peat and rankers		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	Moor rush, some sphagnum, damp C: includes heather		
i	10YR 2/2 brown	Peat which is more than 20% roots. Moderately compact structure because root bound.	
ia	10YR 2/2 brown	Peat with a max 20% roots. Fairly compact. J: soft, very friable, peat	J: damp
ii	10YR 6/3 pale brown	Peat containing rotted stone and grit up to 1cm.	
iii	10YR 1/2 black	Peat, soft, malodourous, plastic, friable. Organic content up to 60% I: organic content less than 5%, roots	damp
iiia	10YR 1/2 black	Peat, soft, malodourous, plastic, friable. Organic content up to 60%	saturated
iiib	10YR 1/2 black	Peat, soft, plastic, friable. Organic content less than 5%, roots. Includes small grits.	
iiic	10YR 1/2 black	Peat, soft, root bound, c30%	wet
iv	10YR 1/2 black 2.5YR 2.5/4 dark reddish brown	Very loose peat, very soft, up to 30% mottles of red throughout	

Table 7.11 Scord of Brouster Auger Descriptions

Scord of Brouster is a damp site comprising peat, peaty rankers and peaty podzols. There is little variation apparent within the site. It would appear to be unpromising with regard to exploring the prehistoric land management of the soils, but Romans (1986:125-131) examined 12 soil samples from the site. His findings included bleached rim development within the peaty podzols. Most of Romans' samples were taken from anthropogenic contexts and relict soils under, or within, archaeological features (dykes, houses, clearance cairns, etc). He also identified iron and manganese mottling and concretions in many of his thin sections, some of which lay below a thin iron pan. The existence of this previous work, which was most successful beneath excavated features, makes this a less attractive candidate site.

<u>Sumburgh Head</u>

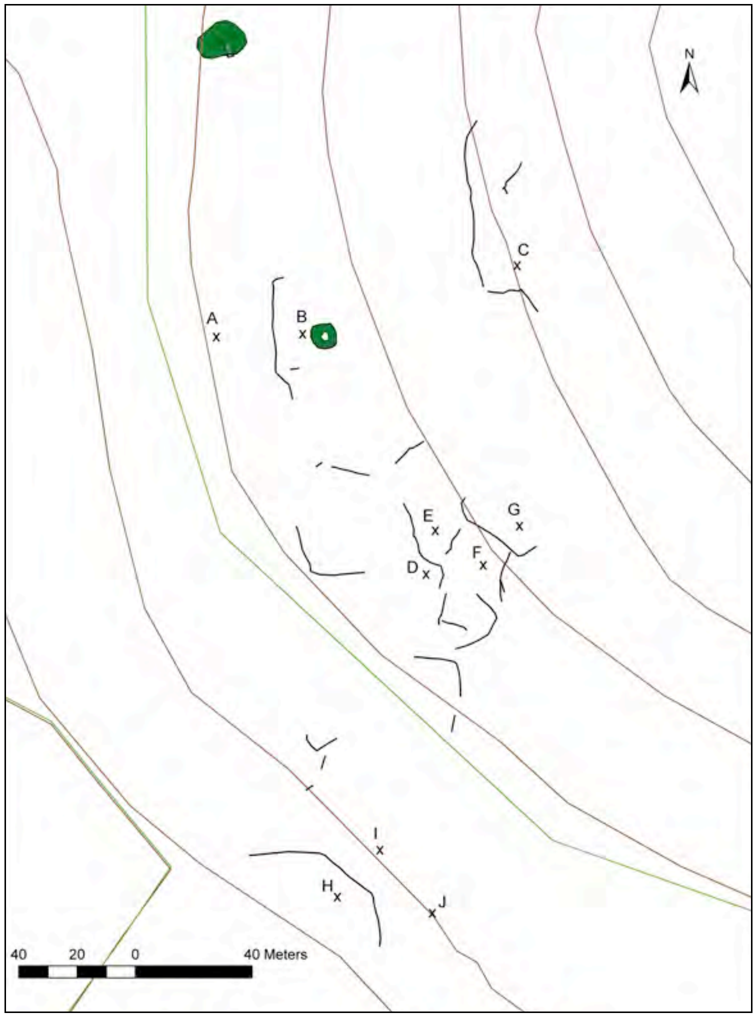


Fig 7.12a Positions of Sumburgh Head augers. (Brown lines are contours, green represents current road. OS map)

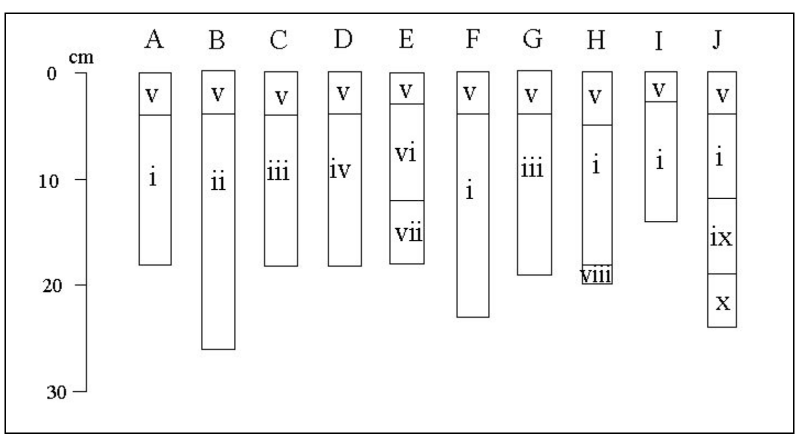


Fig 7.12b Results of Sumburgh Head augers by Munsell colour

Soil	Drift derived from sandstones, flagstones and conglomerates: peaty gleys, peaty podzols, (Undulating, non rocky)		
Land	High proportions of palatable herbage in the sward, particularly the better grasses of meadow grass: bent grassland, bent-fescue grassland		
v	Short maritime grass vegetation		
i	7.5 YR 3/2 dark brown	Slightly sandy silt, plastic	Damp
ii	7.5 YR 2.5/5 very dark brown	Rich, humic, sandy silt. Plastic	Damp
iii	10 YR 3/2 very dark greyish brown	Sandy silty clay, plastic, slightly crumby, slightly loose. Looks very depleted but contains charcoal flecks	Damp
iv	10 YR 2/1 black	Slightly sandy silt, organic, plastic	Wet
vi	10 YR 2/2 very dark brown	Slightly sandy silt, crumby, fairly organic, plastic	Damp
vii	10 YR 2/2 very dark brown 7.5 YR 5/8 strong brown	Slightly sandy silt, crumby, fairly organic, plastic mixed with grittier sandy silt including stone up to 1.5cm	Damp
viii	7.5 YR 3/2 dark brown 10 YR 5/8 yellowish brown	Silty sand with a few patches of sandy, slightly peaty silt	Dry
ix	10 YR 5/1 grey 5YR 5/6 yellowish red flecks	Slightly sandy clay, fairly plastic, compact with flecks of iron pan	Dry
x	10 YR 5/1 grey matrix 7.5 YR 3/2 dark brown	Silty sand with a few patches of dark brown sandy, slightly peaty silt	dry

Table 7.12 Sumburgh Head Auger Descriptions

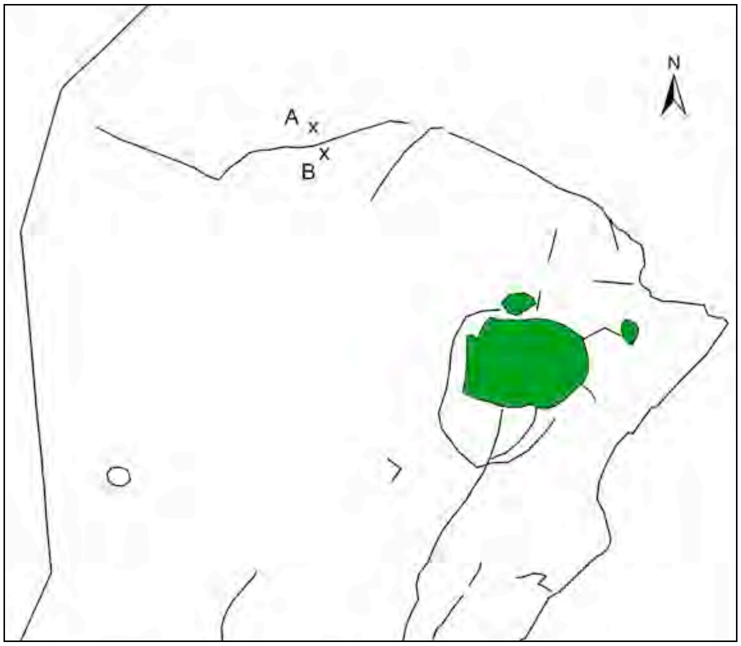
The soils on Sumburgh Head/Compass Head are very thin and appear to have been scalped. Auger column J, on the lowest edge of the site, is the only complete soil profile. It contains evidence of iron movement down through the B horizon to the base which is slightly peaty.

IRON AGE

Clevigarth

Sections were excavated in the vicinity of the broch at Clevigarth as part of wider investigations within the Old Scatness and Jarlshof Environs Project in 2003. Clevigarth was examined within that context to provide comparisons with excavations at Old Scatness and Jarlshof brochs, as it has less obvious arable land and fewer surrounding buildings. The two relevant sections were dug stratigraphically by the author with assistance from two undergraduate students. The results shown below were therefore recorded from the section. The result of Core A includes a sloping divison between iii and iv to represent the variation within the section. Column A was recorded during excavation as CGB03 Area3 and

Column B as CGB03 Area 2. There was an immediate contrast apparent and kubiena samples were obtained whilst the soil pits were open.



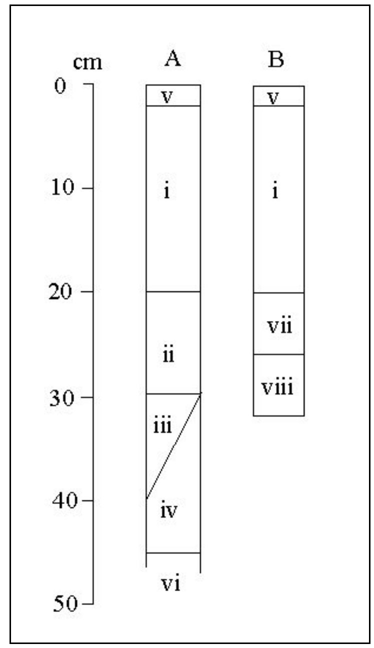


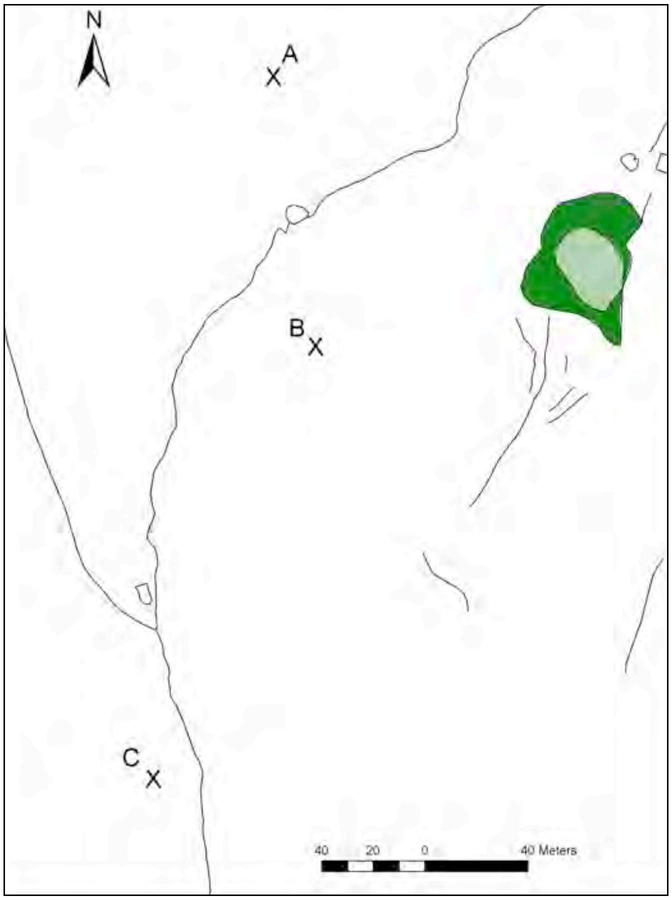
Fig 7.13a: Positions of Clevigarth augers (Iron Age). Fig 7.13b: Results of Clevigarth augers (Iron Age) by Munsell colour (green represents the broch and two other potential house sites)

Soil	Drifts derived from sandstones, flagstones and conglomerates: peaty gleys, non calcareous gleys, peat and saline gleys. (arable, permanent pasture, maritime communities)		
Land	Capable of use as improved grassland, unsuitable for arable. Moderate or low trafficability but satisfactory stocking rates are achievable.		
v	Maritime heath		
i	10 YR 2/2 very dark brown 10 YR 2/1 black (mottles)	Sandy clay loam (sand is coarse), soft, friable, weak platey structure, darker mottles are caused by roots	Dry
ii	10 YR 3/2 very dark greyish brown 10 YR 2/1 black (mottles)	Very coarse sandy loam, slightly hard, very friable, faint mottles	Dry
iii	10 YR 3/2 very dark greyish brown 5 YR 2/1 black (mottles)	Sandy loam with over 15% sharp mottles,slightly hard, very friable	Dry
iv	5YR 4/1 dark grey	Silty clay loam, hard, very firm	Dry
vi	5 YR 5/3 reddish brown	Sandy silty loam with much stone and rotted stone, very hard, very firm	Dry
vii	7.5 YR 3/ 4 dark brown	Slightly sandy loam, hard, firm, includes flecks of black and "red" (strong brown)- charcoal and ash?	Dry
viii	7.5 YR 4/6 strong brown	Loam, hard, firm, fairly homogeneous with charcoal	Dry
"Natural" subsoil: 7.5 YR 4/2 brown & &.5 YR 7/8 reddish yellow		Clay with rotting sandstone inclusions	Dry

Table 7.13 Clevigarth (Iron Age) Auger Descriptions

There are discernible differences between the soils found on either side of the dyke interpreted as being associated with the broch.

Tumblin



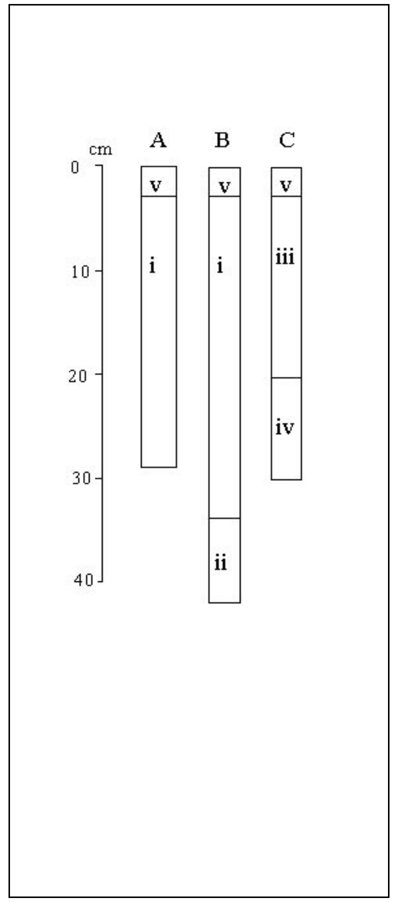


Fig 7.14a: Positions of Tumblin augers. Fig 7.14b: Results of Tumblin augers by Munsell colour.

Soil	Drift from schists, gneisses, granulites and quartzites. Peaty gleys, peat, some peaty podzols and peaty rankers.		
Land	Land suited to improved grassland and rough grazings. Serious trafficability and poaching difficulties. Land cannot support high stock densities without damage.		
v	Wet mat grass and sphagnum		
i	5 YR 2.5/1 black	Silty sandy peat, very friable, little structure other than in the top 5cm due to worm activity. Roots up to 30%	A=sodden B=damp
ii	5 YR 2.5/1 black 10 YR 6/4 light yellowish brown 5YR 5/6 yellowish red	Mottled: black silty sandy, gritty peat; yellowish brown gritty clay; iron	Fairly dry
iii	10 YR 3/2 very dark greyish brown	Silty sandy peaty clay. 2-5% root material, fairly friable, little visible structure	Damp
iv	5YR 5/6 yellowish red 10 YR 6/4 light yellowish brown	Gritty clay and rotted stone measuring up to 5cm. Some decaying vegetation. 30% iron.	Damp

Table 7.14 Tumblin Auger Descriptions

The soils at Tumblin are very wet peaty podzols. The base of auger B shows the redeposition of leached iron and manganese.

VIKING/NORSE

Belmont

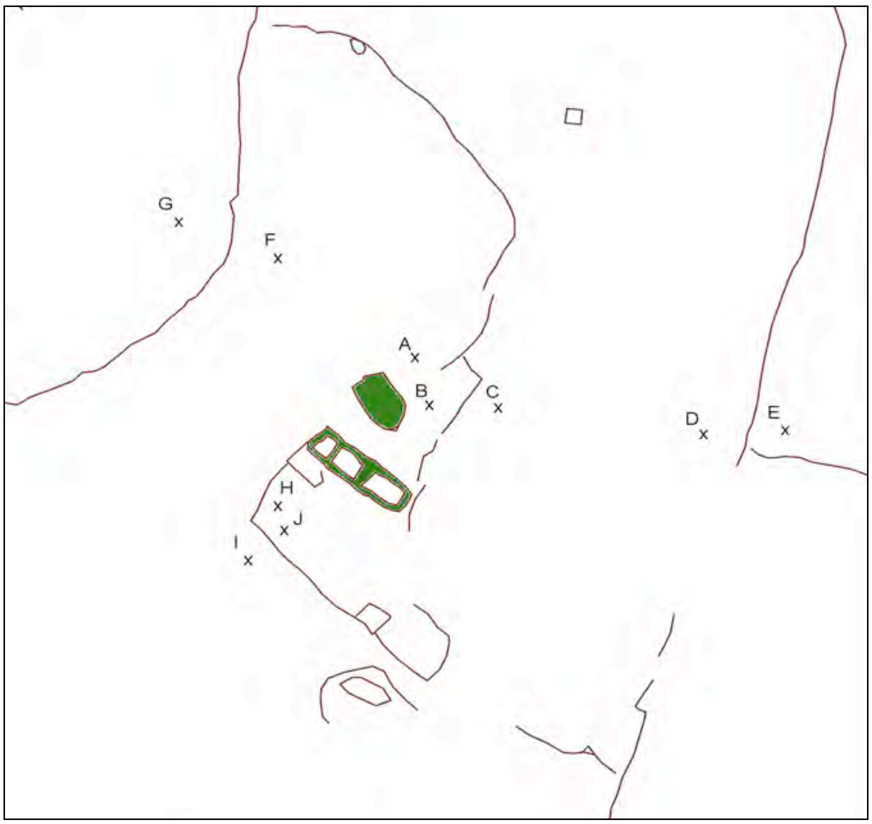


Fig 7.15a: Positions of Belmont augers.

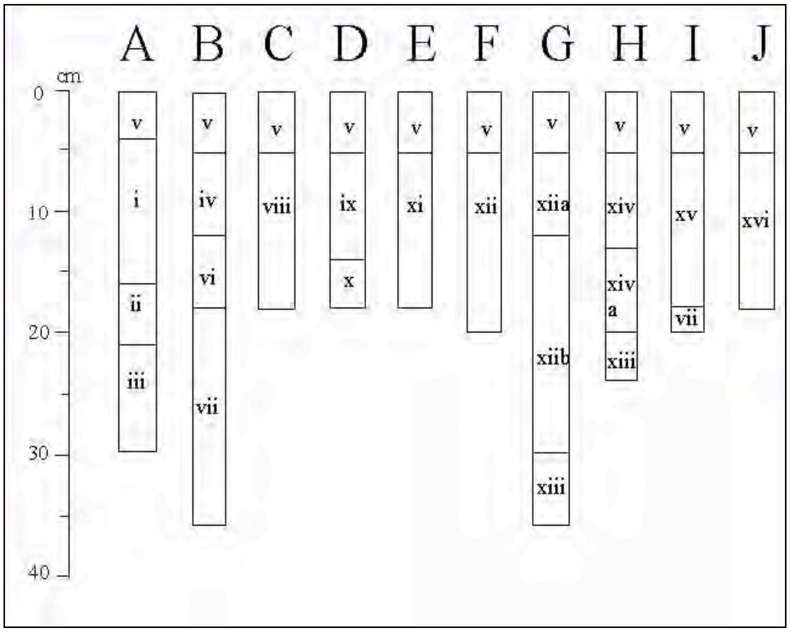


Fig 7.15b: Results of Belmont augers by Munsell colour.

Table 7.15 Belmont Auger Descriptions

Soil	Magnesium gleys: some brown magnesium soils and gley rankers		
Land	Capable of use only as rough grazings. Moderate quality herbage		
v	A,D,F: short, grazed mat grass, moor rush and small plants B,C: moist surface, vegetation includes heather, sphagnum E,H,I: moor rush H close to standing water		
i	2.5YR 2.5/1 reddish black	Friable, peaty loam, very rich, fairly compact Includes brown smears of decaying organic matter, charcoal flecks	
ii	10YR 4/2 dark greyish brown	Peaty loam, less friable than above	
iii	2.5YR 3/3 dark reddish brown	Slightly sandy, smeary loam, contains charcoal, possibly burnt	
iv	5YR 3/1 very dark grey	Sandy peaty loam, 20-25% roots, fairly friable	
vi	2.5YR 3/3 dark reddish brown	Peaty loam and grits, possibly rotted stone	
vii	Gley1 7/1 light greenish grey	Includes orange mottles and black flecks, possibly charcoal. Coarse sandy clay, compact, hard, crumbles with pressure. Not plastic	Dry, but bottom 4cm saturated – in standing water
viii	7.5YR 3/2 dark brown	Slightly plastic silty loam with small granular orange flecks (iron?), stone up to 3cm	
ix	2.5YR 2.5/2 very dusky red	Slightly sandy peaty loam. Worm activity, looks rich, fairly plastic.	
x	2.5YR 2.5/2 very dusky red	As ix but containing a large proportion of rotted orange gritty stone/iron coatings and some blue/white gritty mottles. Stone up to 1cm.	
xi	10YR 3/3 dark brown	Slightly sandy peaty loam, fairly plastic, c1% orange, gritty rotted stone/iron coatings	damp
xii	10YR 3/2 very dark greyish brown	Slightly sandy peaty loam, fairly anerobic, plastic	moist
xiia	10YR 3/2 very dark greyish brown	As xii but saturated	saturated
xiib	10YR 3/2 very dark greyish brown	As xii, up to 20% roots with c1% rotted yellowy stone and one quartz fragment (0.5cm)	

xiii	10YR 4/2 dark greyish brown	Slightly sandy peaty loam, moderately compact, less plastic than xii, including black flecks (possibly charcoal) H: more compact and including white/grey rotted stone	
xiv	5YR 2.5/1 black	Silty peat, up to 20% roots	saturated
xiva	5YR 2.5/1 black	As xiv but with fewer roots and little structure	
xv	10YR 3/2 very dark greyish brown	Very slightly sandy peaty loam, up to 20% roots	
xvi	10yr 2/2 very dark brown	Peat with a fleck of black, up to 20% roots	

The site at Belmont is situated at 20m AOD, on very abraded land, in the scattald. The site is generally damp, locally wet and supports bog vegetation. The soils are peaty podzols, many being thin, with outcropping rock frequent. Movement of iron and manganese was observed in the soils at the base of the columns (B and I). These were gleyed and contained redeposited iron inclusions.

Gardie

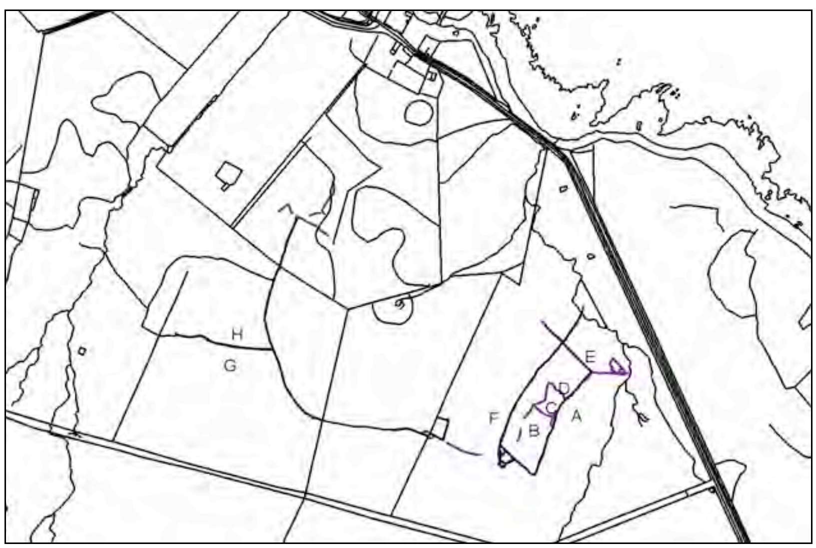


Fig 7.16a: Positions of Gardie augers.

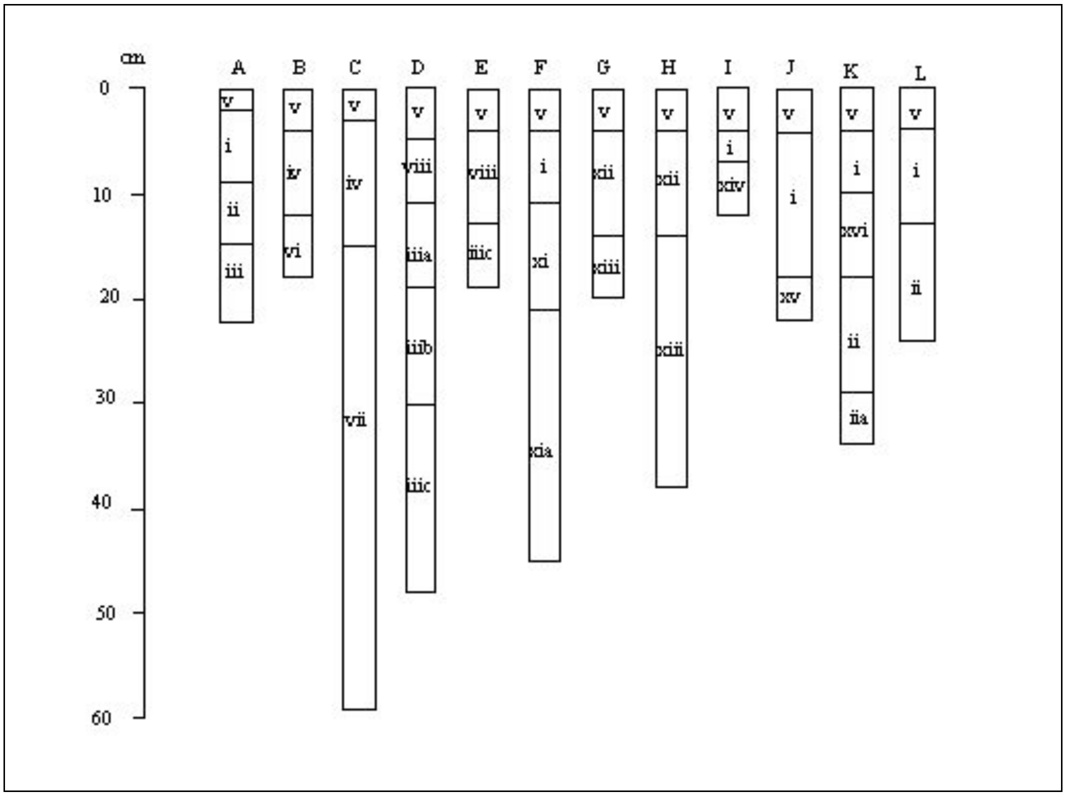


Fig 7.16b: Results of Gardie augers by Munsell colour

Table 7.16 Gardie Auger Descriptions

Soil	Magnesium gleys: some brown magnesium soils and gley rankers		
Land	Capable of use only as rough grazings. Moderate quality herbage		
v	Low peat bog vegetation: Sphagnum, hair moss and mat grass, max 3cm high. D: puddles of standing water on surface		
i	10YR 2/1 black	Compact peaty loam, no grains, roots up to 40%. Plastic, includes black flecking – vegetation or charcoal	moist
ii	10YR 3/2 dark greyish brown	More crumby peaty loam, roots, 5-10% K: includes hard lumps of strong brown iron coated stone	
iia	10YR 3/2 dark greyish brown	Peaty loam, roots, 5-10% includes strong brown iron coated stone	saturated
iii	10YR 4/6 dark yellowish brown 2.5YR 5/2 greyish brown 10YR 6/6 brownish yellow	Compact clay loam Clay smears Silty sand mottles in lowest 2cm	
iiia	10YR 4/6 dark yellowish brown	Gritty silty loam (iron?)	
iiib	2.5YR 5/2 greyish brown	Clay	
iiic	10YR 4/6 dark yellowish brown	Gritty silty loam (iron?)	
iv	10YR 3/1 very dark grey	Almost pure peat with smears of slightly sandy silt. Roots c10%. Loose. Includes charcoal flecks	C is wetter than B
vi	7.5YR 4/3 brown	Gritty peaty loam, grits 10-12mm. Mottles: 10YR 6/6 brownish yellow	
vii	10YR 5/6 yellowish brown	Peaty loamy grit, loose, includes rotted stone. Lowest 10cm contains iron pan up to 2cm thick. Well sorted.	
viii	10YR 2/2 very dark brown	Peat, root bound	saturated

ix	10YR 2/1 black Mottles: 10YR 3/6 dark yellowish brown	Peaty loam, c. 25% humic including a root of c.7mm diam. Mottles: av 10mm x 3mm Rotting stone: 10YR 5/1 grey, c15mm diam.	
x	10YR 3/4 dark yellowish brown	Peaty loam, containing mottles and grits of iron	
xi	10YR 4/6 dark yellowish brown	High iron content, sharp grits in a peaty matrix	
xii	10 YR 2/2 very dark brown patches of 10YR 2/1 black	5-10% roots, clayey peat, friable. G: Includes a fleck of charcoal and live worms	moist
xiii	10YR 4/4 dark yellowish brown	Sandy clay, crumb structure and very loose Inclusions: flecks of clay, 10YR 5/6 strong brown In lowest 2 cm: clayey, rotted bedrock 10YR 6/2 light brownish grey H: strong brown clay 30%, light brownish grey 2%	
xiv	10YR 2/1 very dark brown	Peaty loam, includes flecks of strong brown clay	
xv	10YR 5/6 strong brown bedrock 10YR 6/2 light brownish grey	(thin layer of charcoal at the interface above this) mix of two colours of clayey material containing small grits, rarely up to 5mm.	
xvi	5YR 2.5/2 dark reddish brown	Pliable silty, peaty clay Includes streaks of 5YR 3/ 4 dark reddish brown	damp

The soils at Gardie include peaty podzols and peat. Much of the site is generally very wet underfoot. There is a lot of iron movement through the soils and considerable variation in the peat throughout the site. Where the C horizon is not predominantly peaty, it includes clays and grits with inclusions.

<u>Hamar</u>

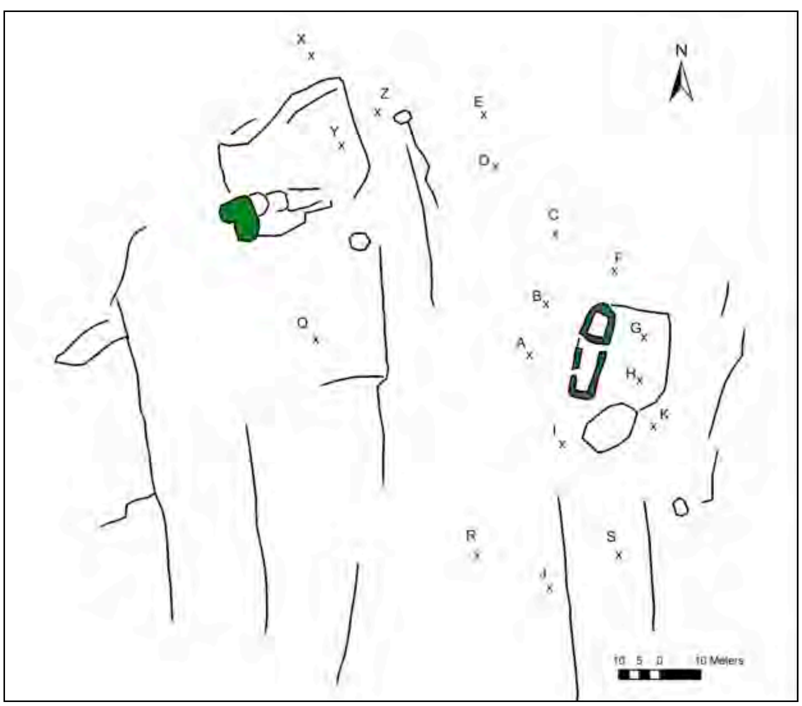


Fig 7.17a: Positions of Hamar augers.

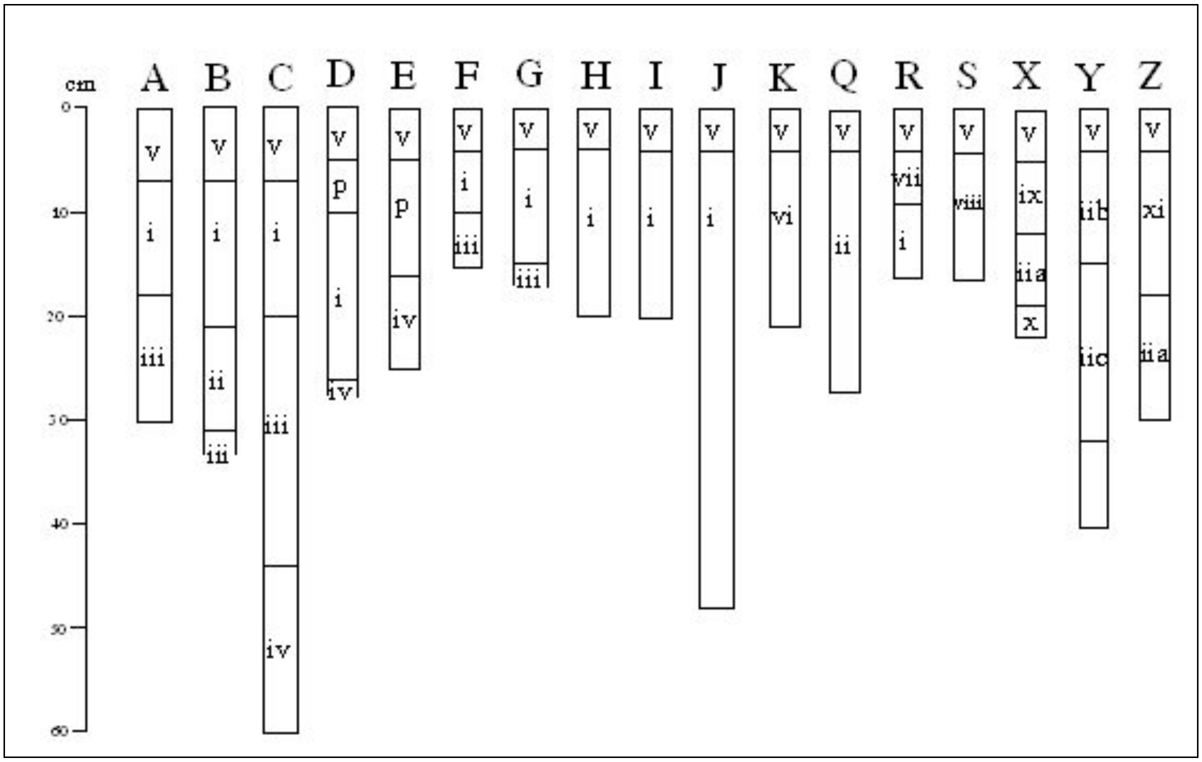


Fig 7.17b: Results of Hamar augers by Munsell colour

Table 7.17 Hamar Auger Descriptions

Soil	Magnesian gleys, some brown magnesium soils. Rich rough grassland		
Land	Land suited to improved grassland and rough grazings. Serious trafficability and poaching difficulties. Land cannot support high stock densities without damage.		
v	Long grass		
p	peat		
i	10 YR 4/4 dark yellowish brown	Silty clay, root bound	
ii	10 YR 3/ 4 dark yellowish brown	Silty clay with charcoal flecks. Patches of iron staining.	
iia	10 YR 3/ 4 dark yellowish brown	Silty clay. Patches of iron staining.	
iib	10 YR 3/ 4 dark yellowish brown	Silty clay with horizontal bands of iron staining up to 1.5cm with small black grits (manganese, charcoal?) which smear with pressure.	
iic	10 YR 3/ 4 dark yellowish brown	Silty clay. Patches of iron staining. Includes stones up to 2.2cm long with iron coatings.	
iii	10 YR 4/4 dark yellowish brown	Subsoil. Silty clay, root bound containing densely packed angular stone 15 - 25cm, some with iron coatings (Z).	
iv	10 YR 4/4 dark yellowish brown with stone resembling soapstone	Fragments of stone which closely resembles soapstone, in the same matrix which overlies it.	
vi	10YR 3/4 dark yellowish brown 10 YR 4/4 dark yellowish brown mottles	Mottled, silty clay, contains ash and significant pieces of charcoal up to 1.3cm long	
vii	10 YR 3/3 very dark brown	Silty clay with a lot of vegetation, root bound	
viii	10 YR 3/3 very dark brown predominantly. 10 YR 4/4 dark	Sandy silt, loose structure, soft, some root material, small mottles, fleck of charcoal	

	yellowish brown mottles		
ix	10 YR 2/2 very dark brown	Clayey silt, loose structure, soft, contains some root material	
x	10 YR 5/8 dark yellowish brown 10 YR 6/3 light brownish grey10YR	Very silty clay	
xi	7.5 YR 4/3 brown 10 YR 3/3 dark brown	Silty clay with charcoal flecks and black root fragments with bands of iron staining up to 1.5cm. Small black grits (manganese, charcoal?) which smear with pressure. Crumbly matrix, at top end bound by roots	

The principal longhouse (Lower Hamar) is situated at 30m AOD. The area immediately around it and below it has been scalped; only a thin layer of soil (essentially the turf line) survives, directly overlying the subsoil. The parent material contains serpentinite and fractures easily; it is hard to determine whether the lowest context Column C contained hill wash or friable bedrock. This material was not sampled to its base.

Further away from the principal longhouse the soils deepen. They contain charcoal, as do the auger columns (Q and S) to the southwest. Auger K also contains charcoal, the soils there possibly being protected from stripping due to the proximity of a natural outcrop. There is evidence of considerable iron movement within all the soils and some manganese present. The location of the auger monoliths to the north, in the lea of a hillock and on a slight platform, may similarly have afforded some protection from the general scalping of the area.

The vertical lines shown on the plan represent low lynchets. These may have been created by post-medieval rigs but it is also possible that these result from the removal of the topsoil.

<u>Stove</u>

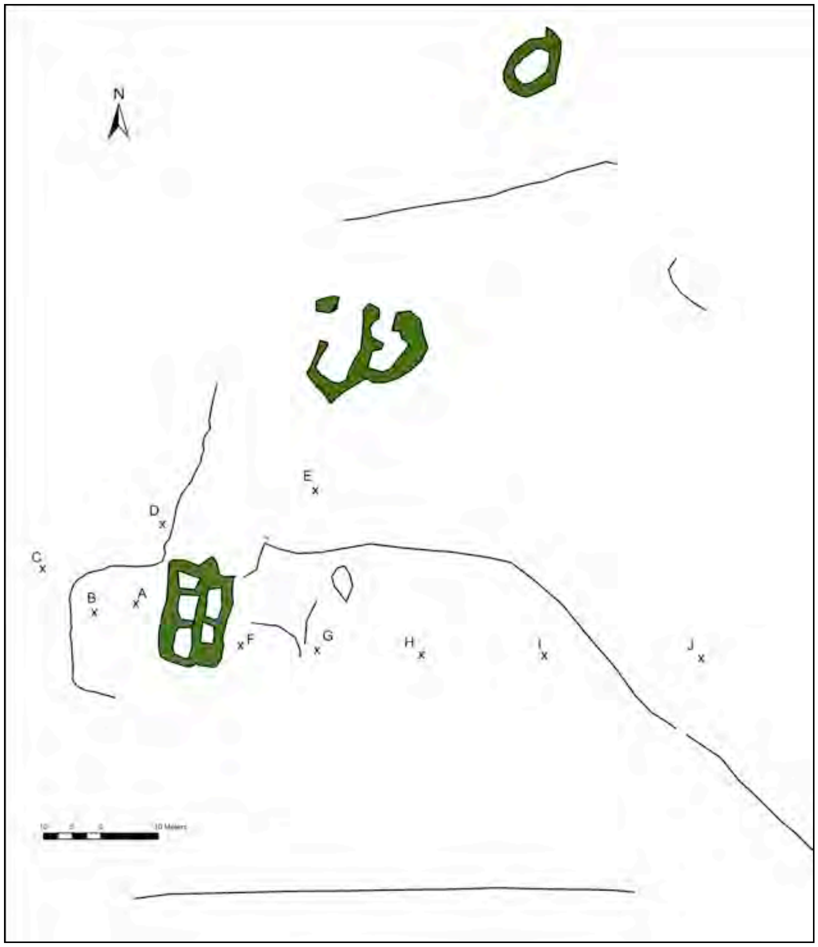
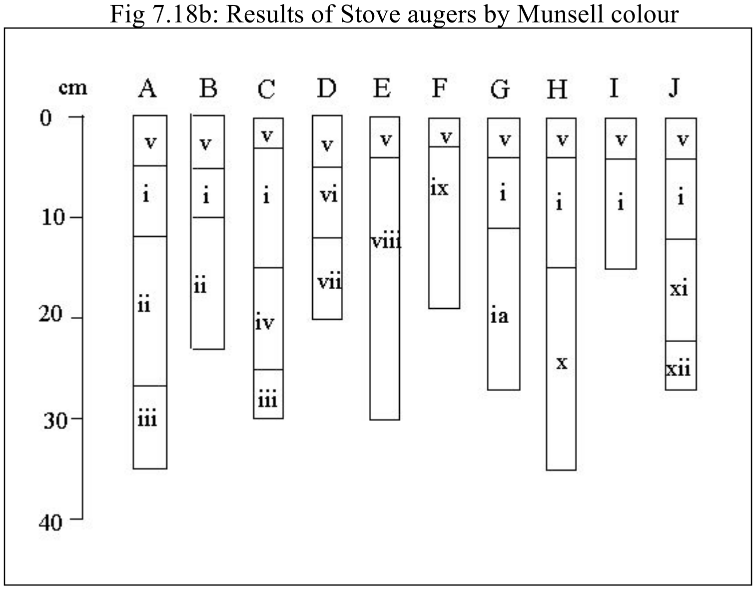


Fig 7.18a: Positions of Stove augers.

Fig 7.18b: Results of Stove augers by Munsell colour



Soil	Magnesian gleys, some brown magnesium soils. Rich rough grassland		
Land	Land suited to improved grassland and rough grazings. Serious trafficability and poaching difficulties. Land cannot support high stock densities without damage.		
v	Short grazed grass (mat grass and sheeps fescue) C: moor rush		
i	10YR 3/2 very dark greyish brown	Silty peat, no sand or grit inclusions, cloddy structure, roots up to 20%	saturated
ia	10YR 3/2 very dark greyish brown	Silty peat, crumb structure, less organic and including stones up to 2.5cm	
ii	10YR 5/2 greyish brown	Silty peat with small grits, cloddy structure, roots up to 10%, stone up to 1.5cm B: includes c 5% small iron frags	wet
iii	2.5Y 7/2 light grey	Gritty clay?, compact c1% orange mottles, (iron stain) and small sharp iron grits	
iv	2.5Y 6/1 grey	Clay? and up to 20% iron mottles, 5YR 4/6 yellowish red	
vi	7.5YR 2.5/1 black	Silty peat, slightly crumby 7.5YR 5/6 strong brown, sandy mottles	
vii	5YR 2.5/1 black	Silty peat, crumby, 5-10% roots	damp
viii	5YR 2.5/2 dark reddish brown	Slightly sandy peaty silt, c5% roots, bottom 5cm also includes stones up to 2cm	moist
ix	10YR 4/2 dark greyish brown	Silty peat with high organic content	damp
x	10YR 4/1 dark grey	Sandy silty peat with stones up to 2.5cm, plastic	lowest 6cm: standing water
xi	2.5YR 4/2 dark greyish brown	Silty peat with coarse sand/grit, stones up to 0.6cm, very sharp boundary with xii	saturated
xii	2.5YR 6/2 light brownish grey	Grit and very coarse sand in silty peat matrix which appears very gleyed, includes stones up to 1.5cm	saturated

Table 7.18 Stove Auger Descriptions

Stove is situated at approx 25m AOD on improved grassland but Columns D and C, immediately northeast of the site are located on very wet, unimproved land. All the soils comprise peat and peaty podzols and have iron leaching through them. In cases where a B horizon was identified, it contained small grits which include iron, within a clay or silty peat matrix.

Watlie

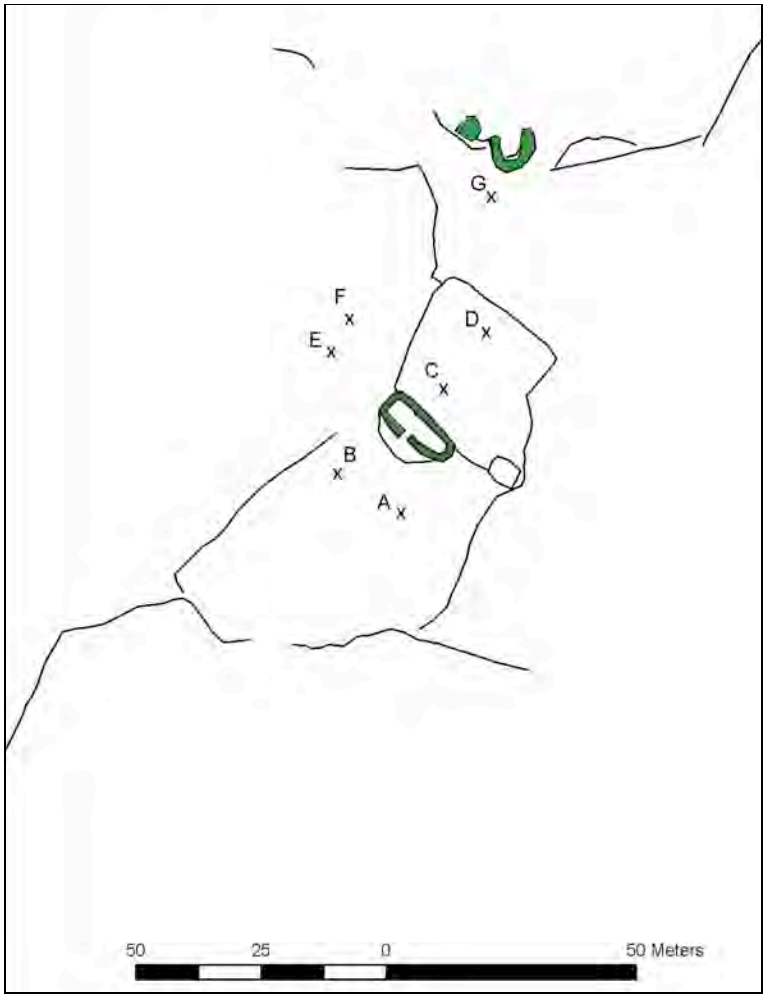


Fig 7.19a: Positions of Watlie augers.

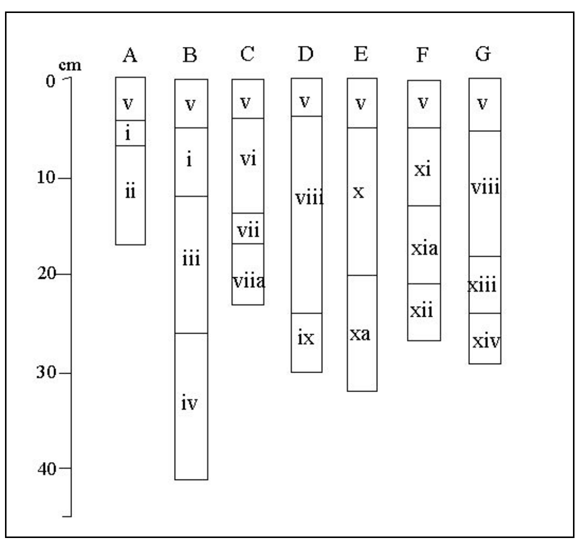


Fig 7.19b: Results of Watlie augers by Munsell colour

Soil	Magnesian gleys, some brown magnesium soils. Rich rough grassland		
Land	Land suited to improved grassland and rough grazings. Serious trafficability and poaching difficulties. Land cannot support high stock densities without damage.		
v	Reedy grass dominant, clumps of shorter dry grass, mosses and small plants. Sphagnum at D.		
i	7.5YR 2.5/1 black	Peaty silt, humic	
ii	10YR 3/ 4 dark yellowish brown	2% orange mottles	
iii	10YR 3/1 very dark grey	Peaty silt with dark orange flecks c1mm 20-25% of roots binding it	
iv	10YR 5/4 yellowish brown gley1 8/1 light greenish grey 7.5yr 5/8 strong brown	Silty loam, small crumbs	
vi	7.5YR 2.5/3 very dark brown	Peaty silt with traces of sand, bound with up to 20% fine roots	
vii	7.5YR 2.5/3 very dark brown	As vi but including stones up to 2cm and rotten stone	
viii	7.5YR /2 dark brown	Crumbly, sandy peaty loam, up to 10% roots	moist
ix	10YR 5/4 yellowish brown 7.5YR 5/1 grey	Crumbly sandy peaty loam, mottled, includes a few stones up to 2cm	moist
x	10YR 3/2 very dark greyish brown	Slightly sandy, peaty loam. At top up to 40% roots, decreasing to c5% at base.	Very wet
xa	10YR 3/2 very dark greyish brown	Very sandy/gritty peaty loam, stones up to 2cm, max 2% root material	Very wet
xi	10YR 3/2 very dark greyish brown	Peaty clay, up to 20% roots, including grits and stone up to 0.5cm	Very wet
xia	10YR 3/2 very dark greyish brown	As xi but drier and more crumbly, up to 10% roots	Less wet
xii	10YR 4/3 brown	Crumbly peaty clay, includes stones up to 3cm	
xiii	7.5YR 3/4 dark brown	Sandy peaty loam, up to 5% roots	
xiv	10YR 5/6 yellowish brown 10YR 3/4 dark yellowish brown	Slightly sandy peaty loam, loose, crumby, a stone less than 1cm.	damp

Table 7.19 Watlie Auger Descriptions

Watlie is situated at approximately 35m AOD, just above the Loch of Watlee. The ground surface is damp to locally wet and the soils comprise peaty podzols. There is considerable variation in the colour of the soils across the site. The B horizon was observed in Column B and is gleyed.

DISCUSSION AND RECOMMENDATIONS FOR FURTHER WORK

Homestead Enclosures

Of the six Homestead Enclosures augured, Croag Lea, Hill of the Taing and Vassa are all severely affected by peat growth with little visible remnants of relict soils. These may, however, survive under dykes and structures and have the potential to be discovered by excavation.

The soils at Exnaboe appear to reflect the current land management situation rather than earlier use: the two auger columns from the unenclosed portion of the site appear similar to one another, but different from the three from the enclosed land which also returned similar results. It would be interesting to explore this further through soil micromorphology. Of all the "Homestead" sites, Exnaboe is the only one on soils which the Macaulay Institute classify as being land suitable for arable cultivation.

Both Houlland and Newing include one core within the enclosure which is distinctively different to the others. Newing is more peaty than Houlland and the principle interest at Newing lies in the A horizon which is unlikely to relate to antiquity. On the basis of the auger samples therefore, Houlland is the site which would appear to have the most potential for further examination. Since no previous micromorphology has been undertaken on Homestead Enclosures, Exnaboe will also be further investigated.

Multiple Field Systems

Of the Multiple Field Systems examined, Clevigarth and Pinhoulland would appear to be the most likely to repay further examination due to the greater variety of soils present. The shapes of the fields at Clevigarth are atypical of the more "pear shaped" fields in the other Multiple Field Systems and whilst they would repay further work, they may not be representative of the field type. Limited work has already been carried out in the area (Guttmann, 2008). The soils at Sumburgh Head appear to have been scalped which reduces their potential as a source of information. The other sites under consideration (Gallow Hill, Ness of Gruting, Pinhoulland and the Scord of Brouster) comprise peat and peaty podzols. Romans (1986) demonstrated that, although the Scord of Brouster still retained archaeological data, it was primarily found beneath features (lynchets, dykes, houses and clearance cairns) and is less attractive for further work, however it does provide comparative material. The soils at Pinhoulland are in better condition than those at the Scord of Brouster, being less podzolised and displaying greater variety. Pinhoulland is therefore selected for further work.

Iron Age Field Boundaries

The initial study revealed three places in Shetland where boundaries associated with brochs have been located. Underhoull was excluded from the period specific study as it is part of a multi-period landscape, to be examined later in the study. Sae Breck was identified late in the study, after the micromorphology samples had been taken. It is probable that broch-related field boundaries were common but that subsequent events, whether land use or the deposition of later material, has since obscured them. The soil profiles at Clevigarth demonstrated discernible differences on either side of the boundary and would therefore repay further investigation. The profiles at Tumblin, although deep (more than 0.4m) but were very peaty and suggested less potential for the recovery of information.

Viking/Norse Boundaries

All the Viking/Norse period sites are located on the scattald apart from Stove, and all the sites are peaty. All are relatively wet, Hamar being the driest. Hamar would have clearly been the most promising site for further investigation had it not been scalped. Even so, it is the primary A horizon which has been removed and which is now represented within the thin vegetation layer. Some of the underlying soils contain charcoal, movement of iron and manganese and, in one instance, iron coatings which would seem to predate the 17th century scalping. This means that it is highly probable that there are Norse soils surviving.

Gardie and Belmont are on the poorest soils, both being very wet. The current land management at Stove would appear to commend it but the apparent fertility of the site disguises underlying peaty soil.

Hamar and Belmont are currently being investigated archaeologically and excavation at Hamar is demonstrating significant local variations (e.g. patches of anaerobic material with the preservation of beetles). The augering results indicate that Hamar has the highest potential for the survival of Norse soils. Belmont has very different soil conditions to Hamar, and the fact that they are both associated with excavation in progress during this study further enhances their value as candidates for micromorphology.

Site Type	Preference	Site Selected
Homestead Enclosure	1	Houlland
	2	Exnaboe
Multiple Field System	1	Pinhoulland
Iron Age	1	Clevigarth
Norse/Viking	1	Hamar
	2	Belmont

Table 7.20 Summary of the sites selected for Micromorphology as the Result of the Field Soil Survey

Chapter 8: Results and Discussion 6 - Micromorphology

Introduction

The microscopic examination of features in soil thin sections can reveal information pertaining to a number of different processes; both environmental and anthropogenic. Processes are dynamic and may confound one another, in some circumstances destroying the legacy of one another (Courty, Goldberg, Macphail, 1989; Davidson and Carter, 1998), known as "regrouping" (Jongerius, 1970). (An example of this is bioturbation, the mixing of soils by soil fauna, which may destroy earlier pedofeatures) Jongerius identified three principal results of soil disturbance: pedoturbation, the mixing of soil components; compaction, the increase in the density of the soil as a result of pressure; and concentrations, the accumulation of soil components. As these features can be caused by either environmental or anthropogenic causes, interpretation needs to consider context. The discipline of soil micromorphology, therefore, is based on the identification of soil features, an interpretation of the processes which gave rise to them and the reconstruction of past landscapes and land management practice.

The literature relating to geoarchaeology in the North Atlantic has been reviewed in Chapter 2. This chapter will utilise this to outline the characteristic soil types likely to be encountered in the North Atlantic region. The soils may have altered significantly over time, for example, Neolithic brown soils may have become podzols by the Iron Age. This synthesis will facilitate the creation of a model of soil types and characteristics within Shetland, using both the Scottish Soil Survey for Shetland (Dry and Robertson, 1982) and applying the soil descriptions of Limbrey (1975). The chapter presents a table (Table 8.4) of the effects of environmental processes on these soils, including the pedofeatures which might be created allowing diagnostic or interpretive characteristics of possible anthropogenic processes in the Shetland soils to be tabulated. This enables a model for agricultural soils in the North Atlantic between the Neolithic/Bronze Age (at the earliest, c. 3000 BC) and the immediately post-Norse period (c.AD1500 onwards) based on the work of previous researchers, to be presented.

The present programme of micromorphology is then be addressed. Two new soil profiles are added to those already recorded from the multi-period Old Scatness site (Guttmann *et al.,* 2006; 2008; Turner *et al.,* 2010; Turner *et al.,* forthcoming). The two published profiles provide a timeline of soil management, unequalled in the North Atlantic area. Adding two more (one close to the periphery of the known worked area north of the site; the other to the south, from a previously unexamined area) tests whether adopting a more holistic, landscape approach and doubling the number of profiles, enhances or even alters the emerging chronological framework for soil management at a site and provides a control for this study. The chronological model for soil management in the North Atlantic will be developed by collating the results of relevant previous work.

Six field systems were selected for micromorphological investigation from those surveyed on the basis of the results of the field soil survey presented in Chapter 7. The investigation involves taking samples from both inside and outside enclosed areas, and at key locations selected on the basis of interpreting the field systems. The selected sites include two Homestead Enclosures from different parts of Shetland (Houlland and Exnaboe), the Multiple Field System at Pinhoulland, the broch boundary at Clevigarth and two

Viking/Norse field systems (Hamar and Belmont) which were both being excavated at the time of this study (Bond *et al.,* 2013).

The relative intensity of the amendment and use of the soils will be considered on the basis of the cultural indicators present, and the differing sites and periods, exploring whether there are identifiable trends over time. It will also help to ascertain whether there are distinctive, period specific, indicators of soil management which can be derived through soil micromorphology.

The chapter will conclude with an analysis of this work and observations arising from it. The integration of this work with other aspects of the research programme will appear in the following chapter.

METHODOLOGY

Undisturbed soil samples were taken from the profiles in Kubiena tins and these were subsequently prepared as slides for micromorphology at the University of Stirling using standard procedures (http://www.thin.stir.ac.uk/methods.htm). Thin section analysis is used to better understand how soils were used in the past by gathering information related to the environment in which they developed, identifying anthropogenic materials which may have been added to the soil, and 'reading' the cultural disturbances created in the soil by previous activity. This is reliant on observing or measuring soil characteristics including colour, texture, structure, porosity/voids and pedogenic concentrations, mottles, cutans and nodules. Thin sections were examined using polarising microscopes at a range of magnifications and three light sources: plane polarising light (PPL), cross polarising light (XPL) and oblique incident light (OIL). An initial examination was carried out, the thin sections then being described semi-quantitatively using standard texts (Stoops, 2003; Bullock *et al.,* 1985, Mackenzie and Adams, 2009). A second examination refined descriptions and interpretations in the context of the total landscape under consideration. A third inspection focused on interpretive features (such as coatings, clay accumulation and the presence of vivianite) and was carried out in conjunction with Prof. Ian Simpson who provided a valuable second opinion. The results are tabulated in data sheets in Appendix F. In the first instance, the data sheets and additional field and micromorphological observations were used in order to understand each profile individually. The results were then compared in order to determine points of similarity and difference between profiles and to explore this in the light of the results of the topographical survey. Previous work and the two new soil profiles to be examined from Old Scatness will be used to create a model by which to compare the results from the field systems.

In cases where single contexts were recorded in the field but were then shown to contain more than one context under the microscope, the letters A "above" or B "below" are added to the principal context number. The field descriptions of the sites appear as Appendix E.

THE NORTH ATLANTIC FIELD SYSTEM

The North Atlantic region is defined by the sea: both as the highway and as an influence on climate. Sea winds keep summer temperatures moderate and ameliorate the effects of latitude on winter temperatures. The salt (and sometimes sand) laden winds constrain plant growth and trees require shelter, protection from animals and usually human nurture to survive. The latitudes (for Shetland, 60 – 61° north) result in long summer days when plant growth can be rapid, and long winter nights which constrain the growing season. Rainfall is moderate, but the lack of tree cover (and resultant lack of transpiration) and the emphasis on sheep husbandry, mean that modern Shetland soils are often acidic and peaty. Upland soils are managed by muir burn or re-seeding, with lower parks being re-seeded or fertilised, when they are managed at all. Nevertheless, gardening and vegetable growing is increasing and a few people still grow bere, Shetland's traditional form of barley. However, ethnographic accounts (eg: Low 1779; Fenton 1978) and Shetland Museum's photographic collection demonstrate that arable agriculture was a feature of Shetland life into the mid 20th century.

The first soil micromorphology carried out in relation to Shetland archaeology was at the Scord of Brouster in the late 1970s (Romans, 1986). However, work in the North Atlantic developed in the early 1990s, with the work of Donald Davidson *et al.* in Papa Stour, Shetland (1994), and that of Ian Simpson in South Nesting, Shetland, and Tofts Ness and Marwick Bay, Orkney (1997;1998;1998a). The focus subsequently expanded to the Scandinavian homelands (Simpson, *et al.*1998); Iceland (Simpson, *et al.* 2002; 2004; Adderley *et al.,*2005); and Faroe (Adderley *et al.,* 2005; Simpson, in progress).

CHARACTERISTICS OF SOIL TYPES FOUND IN SHETLAND

The First Edition of the World Reference Base for Soils (1998) defined soil cover as a continuous natural body with three spatial and one temporal dimension. The three main features governing soil cover were defined as mineral and organic constituents; the constituents organised in structures as a result of its history, dynamics and properties; and its constant evolution. This has been developed to consider thickness and stability (IUSS Working Group WRB., 2006:8). It has been asserted that there is no such thing as a "natural" soil (Limbrey, 1978, *pers. comm;* MacKenzie, 2006:239): every soil is affected by the vegetation which it supports, land-use, and variations in parent material and relief (MacPhail *et al.*1998: 636). Whilst observable at the microscopic level, the Soil Survey of the Macaulay Institute describes the "natural" or "parent" soils at a more regional level for Shetland (Dry and Robertson, 1982) which allows for useful soil classifications at the macroscopic level. The Shetland soils fall into five broad types, the characteristics of which are described below.

Table 8.1 Characteristics of Soil Types found in Shetland (derived from Limbrey, 1995; IUSS Working Group WRB., 2006:23)

Soil Type	**Horizon**	**Soil Appearance**	**Pedofeatures/Characteristics**
Brown Soil/Brown Forest Soil	A	Dark brown clay loam	Worm mixed, strong, well developed crumb structure, porous.
	Bw	Yellowish brown hydrous iron oxides. Clay minerals formed in situ. Humic – decaying roots.	Root expansion and contraction due to water extraction breaks up parent material. Granular, irregular peds.
	B/C		Roots breaking up parent material.
	C		Parent material.
Ranker	A/C	Fine mineral deposits	Arthropods deposit faecal pellets among rock fragments which begins to create a soil.
Podzol	L *over* F	Organics	Litter *over* Recognisable plant residues.
	H	Black organic	mor humus.
	Ea	Bleached mineral soil. Lack of organics as nutrient poor.	Devoid of iron, aluminium, weatherable minerals.
	Bh	Dark reddish-brown or black humus	Humus accumulation.
	Bfe *or* Bs	Ochreous iron colours	Thin iron pan *or* Iron and aluminium oxides present.
	C		Parent material.
Gley	G	Mottled grey/orange (includes bright ocherous colours), often around a root channel as a pipe or fill.	Periodic water-logging causing changes to oxidation and distribution of iron (soluble in reduced state, when re-oxidised becomes immobilised as hydrous ferric oxide). Can affect lower part of soil due to groundwater or upper due to an obstruction eg: iron pan or a textural B horizon.
Peaty gley ("stagnopodzol")	L-F-H	Litter/recognisable plants/black organic	Thick peaty mor humus. Has high water retaining capacity.
	E	Saturated. High clay	Prismatic structure. Saturated, elluvial, gleyed

		content possible. Marbled or mottled appearance. Dark brown veining due to humus sol seeping from mor layer.	horizon. Water seeping through from above for prolonged periods, even when no rain. Removal of iron may release large amounts of clay which further impedes drainage.
	Bfe	Ochreous iron colours	Thin iron pan (or other impervious horizon)
	Bs *or* relict Bw	(see above)	Freely draining.
	C		Parent rock
Histosols	H	Saturated. Yellow, brown or black organic material, min 12-18% organic carbon content (dependent on clay content).	Surface or subsurface horizon at shallow depth consisting of poorly aerated organic soil material, minimum 10cm thick and saturated for 1 month minimum.

Characteristics of Environmental Processes on Soils

It has already been intimated that soils partially result from both parent material and relief (McPhail *et al.* 1998: 636). However, there are a number of additional processes which impact on them, creating changes, not all being the result of human intervention (Fig 7.2). These processes can be identified through micromorphology creating sets of diagnostic pedofeatures: "suites of observable characteristics" (French, 2003: 50). These processes have been variously described (eg: Courty *et. al.* 1989; French 2003) and are summarised below.

Table 8.2 Characteristics of Environmental Process affecting Shetland soils (derived from Courty *et al.* 1989; French 2003)

Action	Process	Micromorphological Pedofeatures/Characteristics
Colluviation	Upslope erosion resulting in a heterogeneous sediment, deposited lower down the slope.	Heterogeneous with minerals, of unsorted size. (May also be visible in the field)
Soil creep	Down-slope movement of soil due to gravity (0.025-2.5cm p.a.) Can be result of rain splash or frost.	Very localised and moves small amounts of material therefore has no significant influence on appearance of soil.
Solifluction	Movement of water-saturated material.	Can be massive, poorly sorted, angular stony fine-grained deposits, grains tend to be orientated down slope.
Waterlogging	Soil which is saturated for prolonged periods, causing iron depletion and accretion.	(see Gley, G horizon, and Podzol, E horizon, above)

Windblown (Aeolian) deposition	Includes traction (dragging along surface), saltation (jumping) and suspension, depending on the strength of the wind.	Presents either as sand grains which are rounded and fairly well sorted or as wind-blown silt, "loess", depending on the parent material. May include shell. (May also be visible in the field)
Eluviation	Leaching or groundwater percolation, removing fines (silt, clay, organic material).	Lack of fine fragments, including clay and silt. Soils likely to be poor.
Illuviation	Re-deposition of fines towards the base of a profile (usually a B horizon).	Accumulation of fine fragments, including clay and silt; generally found below an eluvial horizon.
Acidification of soils	Wet environment, movement of iron.	Nutrients concentrated in surface organics. Iron movement visible as areas of reduction (grey) and accumulation (bright orange). Black manganese movement. Iron coatings of minerals, voids or leaching out of organics. Bleached stone rim due to loss of iron from mineral. (Some or all of these may be visible in the field)
Periodic wetness	Seasonality, changes in water courses, etc.	Occurrence of diatoms (aquatic algae with siliceous cell walls, 5 - 400µm).
Peat	Gradual accumulation of vegetation in stagnant water.	Organic material, yellowy-orange to black, some organics might be recognisable, may include silt and clay (mineral detritus). (Identifiable in the field)
Pyroclastic deposits	Sediments which have settled out of the atmosphere following volcanic eruptions and can travel long distances (eg: Iceland to Shetland).	Light, spiky, glassy material. (May be visible in the field)

CHARACTERISTICS OF ANTHROPOGENIC PROCESSES ON SOILS

Considerable recent research has focused on micromorphology as a tool for identifying soil features to define aspects of human initiated land use, particularly in relation to relict agriculture (Carter and Davidson, 1998; 2000; MacPhail, 1998), and increasingly in the analysis of archaeological site formation (Kemp 1998:138; French 2003:47-48). There is also a growing body of experimental work which is improving understanding of potentially diagnostic pedofeatures (eg: Jongerius, 1970; 1983), materials (eg: Guttmann *et al.,* 2006) and also their limitations (Davidson and Carter, 1998). It is now possible to use this work and also more general texts (eg: Courty, Goldberg and McPhail, 1989; French, 2003) to define reference characteristics indicating processes within the relict soil. Interpreting features is complex: soils are dynamic and one event may completely obliterate the signature of previous use. Further to the environmental characteristics listed in Table 7.2, bioturbation (the mixing of soils by soil fauna) plays a significant role in altering soil structure. Earthworms ingest soil and redeposit it, either at the surface or within the soil structure, as well as creating channels surrounded by more compact soils (Canti, 2003). A highly biologically active soil can be completely reworked, resulting in densely packed aggregates separated by a network of channels (Courty *et al.* 1989: 142) removing previous pedofeatures and organic matter, and creating a homogenous mass within 40 years (Davidson and Carter, 1998; Davidson, 2002). An excremental reworked groundmass, particularly when associated with high levels of organic material and indicators of soil amendment (e.g. cultural material or phytoliths) may itself indicate cultivation (Simpson, *et. al.* 1998a). The degree to which structural signatures survive in the soil is linked to the speed of burial of the context: the construction of a monument will preserve the evidence better than the gradual accumulation of colluvium (Davidson, 2002).

Table 8.3. Characteristics of Environmental Process affecting Shetland soils (principle sources: Courty *et al.* 1989; French, 2003; also: Carter, 1998:100; Davidson & Carter, 1998; Guttmann *et al.* 2006:78; Jongerius, 1970; 1983; Romans & Robertson, 1983; Simpson and Barrett, 1996; Simpson, 1998; 2000; 2003; 2005)

Process	**Further details**	**Pedofeatures**
Clearance by burning	Affects the top few centimetres. Base-rich ashes initially promote biological activity. Soluble nutrients and salts leach – bio-activity decreases	Finely mixed charred organic fragments, remnants of charcoal/burnt wood and reddish brown aggregates. Topsoil is rubified, contains clay. Lower topsoil has clay coatings &.rich in fine charcoal – BUT hard to identify if soil not sealed rapidly. Numbers of phytoliths – at higher temperatures may melt and fuse to create glassy, vesicular slag.
Grazing	Soil horizon less developed than if wooded.	Fine roots and bio activity – deep stable crumb-structured mull horizons.
	Intensive grazing	Platy structure near soil surface – elongated and platy pores within dense fabric. (Freezing also produces platy structure).
	In wet, acidic, soils grazing may lead to water logging of peaty soils	Stocking areas and drove-ways can become puddled.
	Presence of grazing animals	Increase of organic matter and phosphates.

	Sheep and cattle:	Fine and coarse fungal bodies respectively. Fungal ring becoming increasingly birefringent with age (c 900 yrs).
Ploughing (ard/hoe/spade)	Eliminates upper soil horizons – especially in organic rich layers; may be ard marks at base of soil; possibly lynchets, terraces associated. Structural breakdown and slaking, soil water just below Ap horizon or in deep cracks. Direct rain on plough soils in winter, encouraging formation of agricutans.	Creates homogeneous Ap horizon with signature of surface humic layer and mineral material from underlying reworked A horizon, vughy porosity, abundant textural features: agricutans (fine grained sand and "punctuations" of organics) creating dusty clay coatings and impure (with silt) clay coatings and infills. Agricutans may have internal structure – laminated micro-layers of varying texture and/or composition due to successive episodes of disturbance of varying strength, layers of silt or sand-sized grains – if stronger disturbance. Only dusty clay may penetrate to any depth.
	Ploughing upslope	Rounded fragments of B horizon
Ploughing in acid soils	Chemical changes may be too weak to increase pH and alter the soil solution. Organic matter may be rapidly humified.	Textural features may be lacking. Only evidence may be mixing of microfabrics or anomalous heterogeneous microfabrics at variance with local soils
	Ploughed layers may be modified subsequently – pedofeatures may not survive. Partly depends on rapidity of burial.	Biological reworking, creating densely packed aggregates separated by a network of channels
Plough pan	Weight, vibration and cattle trampling	Horizontally bedded fabric/minerals
Puddling	Human or animal trampling of wet soil or naturally occurring after surface slaking. Pressure causes clay to slip and swell, distorting arrangement of intergranular spaces	Hard compacted soil structure or crust (poorly-permeable or non-permeable). Often destroyed by subsequent activity or roots.
Surface Slaking	Destruction of surface aggregates by raindrops	Formation of crust.
Internal Slaking	Structural collapse of cultivated layer due to water saturation, possibly due to plough pan below cultivated layer	
Puddling; Compaction	Saturated with water due to pressure on surface. Today's heavy machinery can impact 80-100cm below the surface.	Under crust: horizon with vesicular porosity, horizontally bedded fabric, commonly dusty clay coatings in pores, as result of fine material as water above drains.
Plaggen soils	Deliberate introduction of mineral and/or organic matter to increase nutrient supply and yields	High amounts of organic fragments, may be more brown than other humus.
	Addition of turf or peat, as byre bedding, fuel, recycling turf structures	Turf: Yellowy-brown, phytoliths, minerals Peat: reddish-brown, diatoms, limited minerals
	Manure	May be highly humified organic matter; Concentrations of fungal spores Fragmented lignified tissue Fragmented phytoliths (diatoms less

		common) indicate herbivores Calcitic spherules – herbivore dung in calcareous situations NB: no evidence seen at Papa Stour, but known to have been present.
	Herbivore waste	High porosity, contains undigested plant fragments and amorphous dark brown organic matter, large number of phytoliths, detrital mineral grains which had been ingested (horse and cattle contain coarse silica skeletons of plant stems; sheep and goat - more compact, highly disorganised phytoliths; omnivores – highly phosphatic, groundmass amorphous, colourless to dark brown, non to weakly birefringent, ingested materials including bone, plant, phytoliths, pollen grains, hair and mineral
	Faunal activity on manure	Dispersed areas of yellow, brown & reddish brown fine amorphous organic material; spongy microstructure
	Ash	Wood: pure white to white/grey, highly birefringent – species may be identified. Grass and leaf: less homogeneous, less grey, due to presence of brown charred grass and yellow unburnt organics, undifferentiated b-fabric, contains lot of phytoliths – become smoother at high temperatures, melt at very high temperatures to glassy, non-birefringent vesicular residue (1713°C pure silica) Peaty turf: 400°C brown to orange-red under OIL; 800°C bright orange-red to white
	Heated minerals	Rubified and highly reflective under OIL, crystallic b-fabrics indicates heated mineral in groundmass. Range of colours in OIL can indicate temperature: structural disruption of mineral material, segregation of iron oxides, reddish, rubified fine mineral = low temperature; yellow fine material = high temperature.
	Cultural Midden, Domestic	Debris including shell, bone, charcoal, ash, decayed vegetable including cereal, pottery fragments Vivianite: calcium-iron-phosphate, yellow anisotropic infills, radial crystallisation pattern – bone in decomposition
	Cultural Midden, Industrial	Iron slag: very dark grey, interwoven columnar form, minor vesicular porosity, high order red and green birefringence. Hammer scale: “rusty iron” frags, opaque to faintly translucent, very dark red at edges, black interior, fine laminae originating from the hammering

TOWARDS A DEFINITION OF INTENSITY

In order to assess relative intensities of agricultural practice and landuse, it is first necessary to define intensity. The Oxford English Dictionary defines intensity as "the measurable amount of a property, such as force, brightness, or a magnetic field". There are two components which contribute to understanding the intensity to which a field has been cultivated: the degree of amendment and the type and quantity of pedofeatures and cultural indicators which survive. Both these factors are difficult to measure precisely. Not all types of amendment are equally efficacious: the amount of midden material required to make a soil fertile may be greater than the quantity of manure required, but other variables include the components of the midden and the pre-amendment state of the soil. Further, quantities of material added to the soil may be the result of longevity rather than of a single period of use. Cultivation is measured by the types and quantity of surviving pedofeatures, but some are more durable than others, and bioturbation also influences this (Davidson and Carter, 1998).

A comparison of the results of Guttmann's work at Old Scatness (Guttmann, 2001) with the archaeobotanical evidence (Bond *et al.,* 2010; forthcoming) demonstrates a coincidence of evidence relating to the Early/Mid Iron Age, an absence of soils evidence relating to the Late Iron Age and a discrepancy of evidence relating to the Viking period (Bond *et al.,* 2010). This will be explored further within this chapter, but it demonstrates the complexities involved in defining intensity of soil cultivation, which ultimately results from assessing the quantity of materials added and the prevalence of pedofeatures.

CHARACTERISTICS OF AGRICULTURAL SOILS IN THE NORTH ATLANTIC

The literature review demonstrates that there is a body of evidence from which to create a hypothetical model of how a soil in the North Atlantic was managed at any given period. This model is presented below.

Period	Characteristics	Examples
Neolithic/ Bronze Age/ Early Iron Age	Clearance by burning Domestic midden added to soils Possible use of flattened middens later	Scord of Brouster, South Nesting, Old Scatness, Knap of Howar, Noltland, Skara Brae, Tofts Ness
Mid Iron Age	Ashy middens. Animal manures added (not in equal intensity)	Old Scatness, Jarlshof
Late Iron Age	(deepened soils?)	(seen at Teampull Mhoire, Pabbay – absent from other potential papar sites: Paible, Taransay; Papa Stour church)
Viking	Wet and dry turf composted with domestic waste, not animal manure	*Ӧrsnes, Lofoten; Akurey and Ketilstađir, N Iceland*
Norse	Domestic midden	Old Scatness
	Turf composted with animal manure and domestic midden	Marwick, Quoygrew *Hov, Sandoy, Leirvik (Faroe)*
Post-Norse (possible Norse roots)	Hill turf composted with domestic waste (peat, hearth ash)	Papa Stour

Table 8.4. Model for Agricultural Soils in the North Atlantic (sources: see Chapter 2). Names of sites outside Scotland appear in italics.

NEW WORK AT OLD SCATNESS

<u>Introduction and Aims</u>

Two additional soil profiles were examined at Old Scatness, applying a landscape approach in order to examine the site more holistically, testing the previous results (Guttmann *et al.*, 2006; 2008). This will contribute to the model of soil management in the North Atlantic which will be further tested by this study.

A complex multiperiod site was excavated at Old Scatness between 1995 and 2006, during a project managed by the author. The focus of the site was a broch, the earliest structure located (400-200 BC). The broch was surrounded by a series of large diameter, singleskinned, piered and aisled roundhouses, which post-dated the broch (200BC – 0BC/AD). In time, these were replaced by a village of later Iron Age buildings: wheelhouses and cellular buildings, dating to the Late Iron Age or "Pictish" period (c.AD 600-800). Both the Iron Age villages were constrained by the broch ditch. When some of the cellular buildings and wheelhouses went out of use, they were infilled with domestic debris which included Norse steatite artefacts. Although the top of the mound was destroyed by later activity, there were traces of Viking/Norse settlement both within the enclosed area, and immediately to the north. The earliest micromorphological work carried out on "Profile 2" showed four Norse/Post-Medieval horizons, the earliest of which was dated to AD 1197±61 (Guttmann, 2001; 2008:807). The horizon below this was dated to BC95±155 (*ibid.*). This left a significant gap in the soils record, although the site was known to be occupied at the time. This gap also coincides with the period for which current knowledge of relict agricultural soils in the North Atlantic is the weakest. Both in terms of this study and in terms of the excavation strategy, revisiting the soils at Old Scatness through the excavation of additional soil pits had the potential to elucidate the development of agriculture in the area, facilitating a more complete investigation of the soils around the site, rather relying on a single section. In terms of enhancing the model for relict soils in the North Atlantic, this strategy had the potential to make a significant contribution.

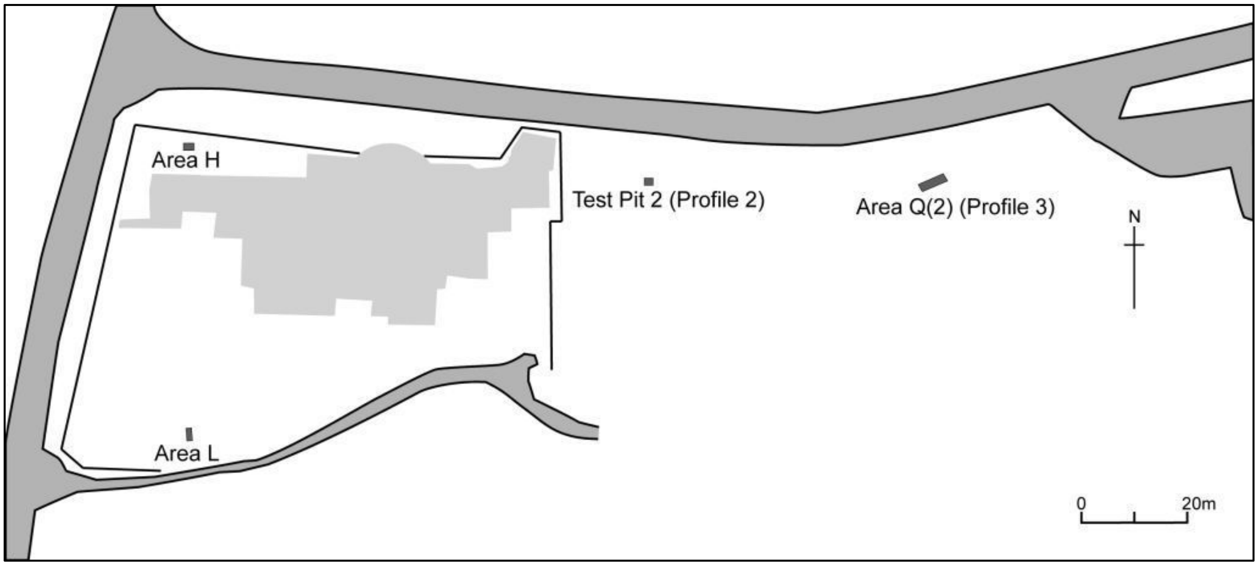


Fig 8.1 Location of Soil Profiles at Old Scatness (drawn by Dan Bashford)

Burbidge's "Profile 2" was located immediately north-east of the Broch boundary ditch (Guttmann, 2001). Area H, Burbidge's "Profile 1", to the north-west of the Broch Village was also sampled by Guttmann and Burbidge (Burbidge, 2003; Guttmann, *et. al.,* 2006; Turner, *et al.,* 2012; in press). The series of relict soils were already known to extend further east (Simpson, *et al.,* 1998b). Area Q2 was therefore located at the furthest point to the north-east as it was possible to go before being constrained by Sumburgh Airport's Control Tower development. Fortuitously, this led to the unplanned re-excavation of Burbidge's "Profile 3", which therefore provided a series of dates derived from his experimental optically stimulated luminescence (OSL) study (Burbidge, 2003). These dates apply to the last exposure of the quartz grains to light and so provide a *terminus post quem* for the use of the contexts. Area L was located to the south-west of the Broch Village and is the only soil profile from the south side. The later soils here were truncated by soil stripping which took place in the 1980s.

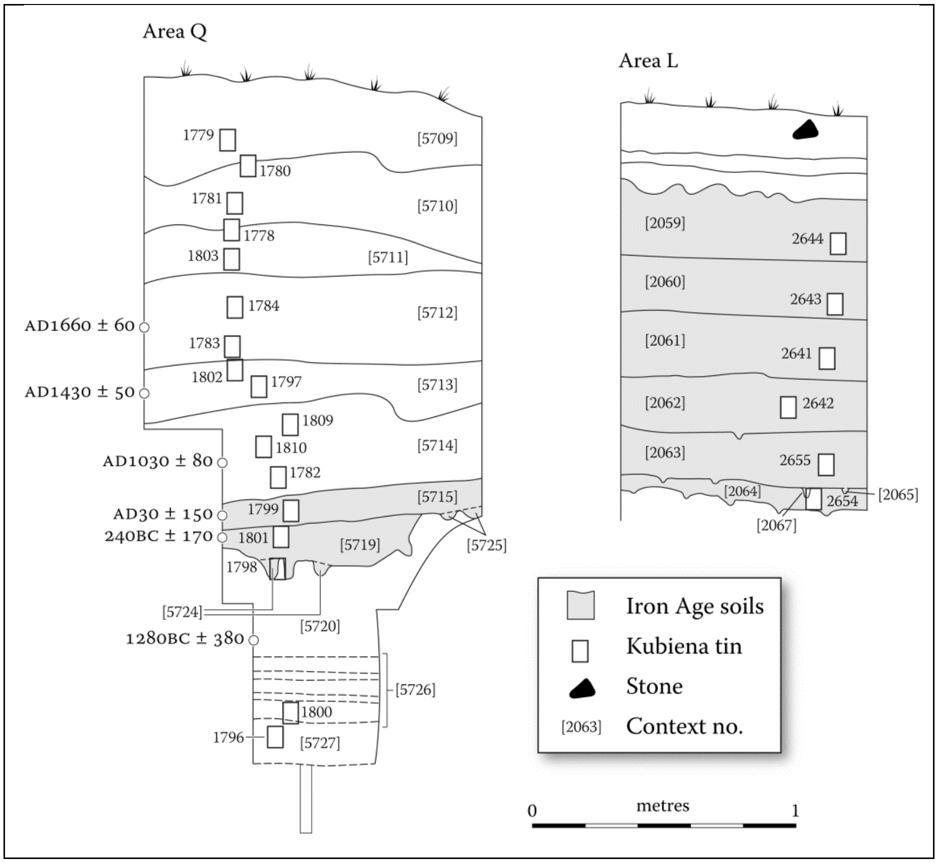


Fig 8.2 Sections: Areas Q and L, Old Scatness showing the Iron Age soils shaded (graphics: Bill Jamieson)

<u>Soils Environment: Old Scatness</u>

The Early/Middle Iron Age soils of Area Q2 had a coarse mineral component comprising sub-rounded to angular quartz, feldspar and calcium carbonate. In thin section the related distribution of the earlier soil is gefuric, whereas that above it is close porphyric and locally gefuric. The coarse fraction of both soils is moderately well sorted, with well sorted calcitic sand. This suggests that the base of this soil was a quartz sand to which windblown sand has accreted. Since the soils were freely draining the very rare iron accretion observed during micromorphology may be the result of iron pan being introduced along with the organic matter, probably turf, which was added to the soil

The soils to the south of the site were founded on a windblown quartz sand, however, by context [2062], temporally the third earliest context, the sand was changing in character, including more angular grains amongst the more rounded, sub-angular, grains. This suggests that either the source of the windblown sand had changed, perhaps with an alteration in predominant wind direction, or that some of the sand imported manually, whether intentionally or as a component of turf. The theory of importation is supported by the presence of compound quartz grains with a different mineralogy, which appear in low quantities from this period. That introduction of a calcareous component to the aeolian sand is also evident in Profile 2 and Area Q. The calcareous sand continued to be rare (≤2%) in the Viking soil and included some shell, but by the Norse period both the calcite and the occurrence of shell had become frequent (15-30% of the soil) with a monic and locally enaulic related distribution; this indicates a largely sandy soil with little fine fabric to add cohesion. The coarse fraction is well sorted, interpreted as windblown sand. This continued to increase in the post-Norse period, becoming the dominant windblown sand. The quantity of mobile iron and iron nodules in the sand also increases: probably imported, since iron is unlikely to be mobile in freely draining sands.

MICROMORPHOLOGY RESULTS

The detailed results are recorded in data sheets, Appendix F.

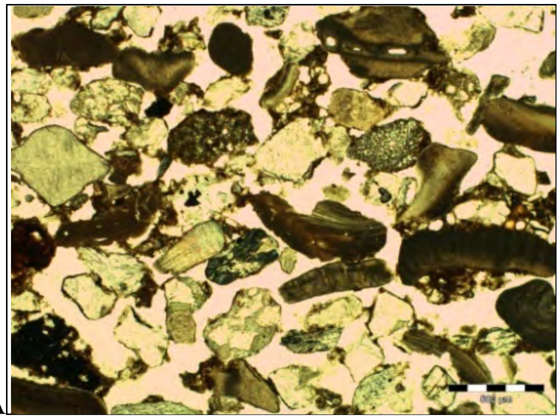
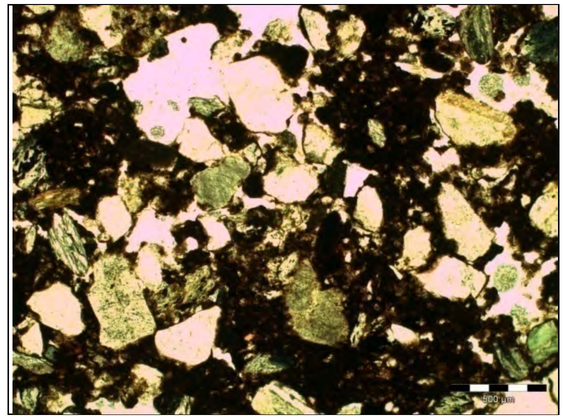
Old Scatness Iron Age

Area Q2

In excavating Area Q2 (Profile 3, Burbidge 2003; Turner *et al.,* in press) Burbidge dated two contexts [5718] and [5719] to the Iron Age. Context [5718] was dated AD30±150, and the context below it [5719] was dated BC240±170. These dates correspond to the Middle

Iron Age and Early/Middle Iron Age within Shetland. This stratigraphy is similar to that identified by Guttmann in Profile 2.

Following re-excavation, sampling and recording, the field description of context [5719], the earliest of the Early/Middle Iron Age contexts, was 7.5YR 4/2 brown, sandy silt. It contains rare mammal/bird bone, few phytoliths and very rare rubified material. The fine fraction is an orangey brown organo-mineral with speckled limpidity and a vughy microstructure. It is light orange under oblique incident light which suggests that peat ash has been added to the soil, although this component is not as great as that in the later, Middle Iron Age, context [5718]. Context [5719] also contains rare rubified material and very rare charcoal. There is very rare lignified material, the fine mineral component comprising few amorphous black and few amorphous brown with rare amorphous reddish black. Again, some of this material was mixed with mineral material indicating that turf had been added to the soil although there was no parenchymatic material present. There are few phytoliths, very rare excremental material, very rare organic silt and very rare iron accretion. The microstructure and the presence of excremental material indicate that the soil had been biologically active.

A  B 

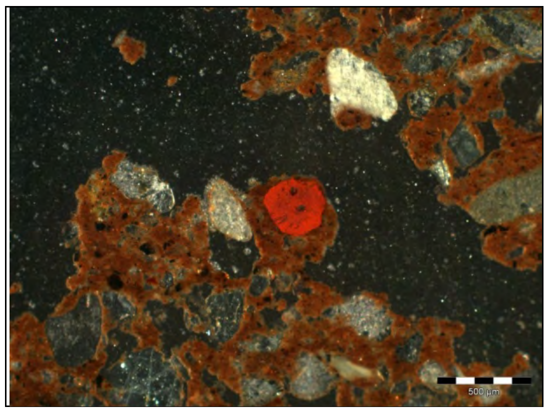
C 

Fig 8.3 a. Calcareous and quartz based windblown sands, OSB Q2 [5719]; b. Porphyric related distribution with dark brown organo-mineral fine material, OSB Q2 [5714]; c. Rubified material from heating, OSB Q2 [5714].

Context [5719] was created on the windblown sand, with the introduction of an organo-mineral content. It has few pedofeatures. It is clearly amended but the activity was less intense than it later became, and there is less ash in this earlier soil. Organic matter, probably turf, was added to the soil and may have originated from an area which was damp as there is very rare iron accretion probably originating as introduced iron pan, since the soil is well drained. There are what appeared in plan to be spade cuts rather than ard marks at the base of the earliest Iron Age context which cut into the top of the underlying context [5720].

The field description of context [5718], Middle Iron Age, Area Q2 is 7.5YR 3/1 very dark grey, sandy silt. It contains very rare fish bone and rare mammal/bird bone. In thin section the fine fraction is a brown organo-mineral with speckled limpidity and a spongy microstructure. It is more orange than context [5719] under oblique incident light, which suggests a higher peat ash component. This is consistent with the rare rubified material which is derived from burning. There is common lignified material, and frequent parenchymatic material. Some of this material was also mixed with mineral material indicating that turf had been added to the soil. In addition the fine organic component comprises common amorphous black, frequent amorphous brown and few amorphous reddish brown material. It also contains very few cell residue and very rare charcoals. There are rare phytoliths. There is very rare excremental material and rare iron accretion, which again appears to have been introduced with the turf given the well drained nature of the soil. The microstructure and the presence of excremental material indicate that the soil had been biologically active. Context [5718] overlies [5719] and also [5720]. Where it directly overlies context [5720] there are ard marks visible in the top of the earlier context. This appears to represent a different method of cultivation between the two Iron Age contexts, the later use of the ard being consistent with the increase in intensity of amendment of the soil.

Area L

Area L was excavated on the south side of the Iron Age Villages and ditch. It revealed a series of six soils created over a relatively short period of time, that were securely dated stratigraphically to the first half of the Middle Iron Age: approximately contemporary with the construction of the Broch and its use. In total, these six soils are over 1m deep. This offered the opportunity to examine the Iron Age land management in some detail, although soils relating to the Late Iron Age/Pictish phase remain absent.

The windblown quartz sand was amended with increasing intensity as the period progressed. That the earliest soil was cultivated was immediately apparent by the discovery of ard marks at its base. All the soils were orange under oblique incident light and included flecks of micro charcoal in the fine fabric, indicating that they contain ash derived from peat or turf. There was a high quantity of silicaceous material present, particularly in the earliest four contexts, gradually declining in the two later levels. This evidence, taken together with some intensively heated bone fragments in the earliest context, demonstrates that the ash, added to the soil, was from a source which reached temperatures in excess of 800°C (demonstrated by comparison with reference material: Simpson *et. al.*, 2003:1408). Whilst this might implicate an industrial process, there was no evidence of either metal working or pottery firing within either the micromorphological or hand sieved samples taken from contexts in Area L or in visually similar soils elsewhere on the site. It is therefore probable that the high temperatures derived from a domestic context. The presence of unburnt bone fragments and decaying plant material indicates that ash was not the only material added to the soils and suggests that ash was stored in a midden prior to being spread on the fields.

In context [2062], charcoal with mineral embedded and the fine mineral content suggest that the fuel was more likely to have been turf than peat. The amount of plant material added increased at this period. It has already been noted that the increased iron staining and iron nodules probably formed in a wet upland environment, being imported with turf material. The introduction of compound quartz grains suggests that these were also a component of the turf. There was a rare occurrence of vivianite, a phosphorous compound derived from bone and formed under wet, reducing, conditions. The soils themselves would have been free draining and so the alteration of the bone must have occurred pre, rather than post, deposition. A wet environment might also explain the very rare fungal spores in the earliest three contexts. This suggests that the middens, from which the material was derived, were wet for a period.

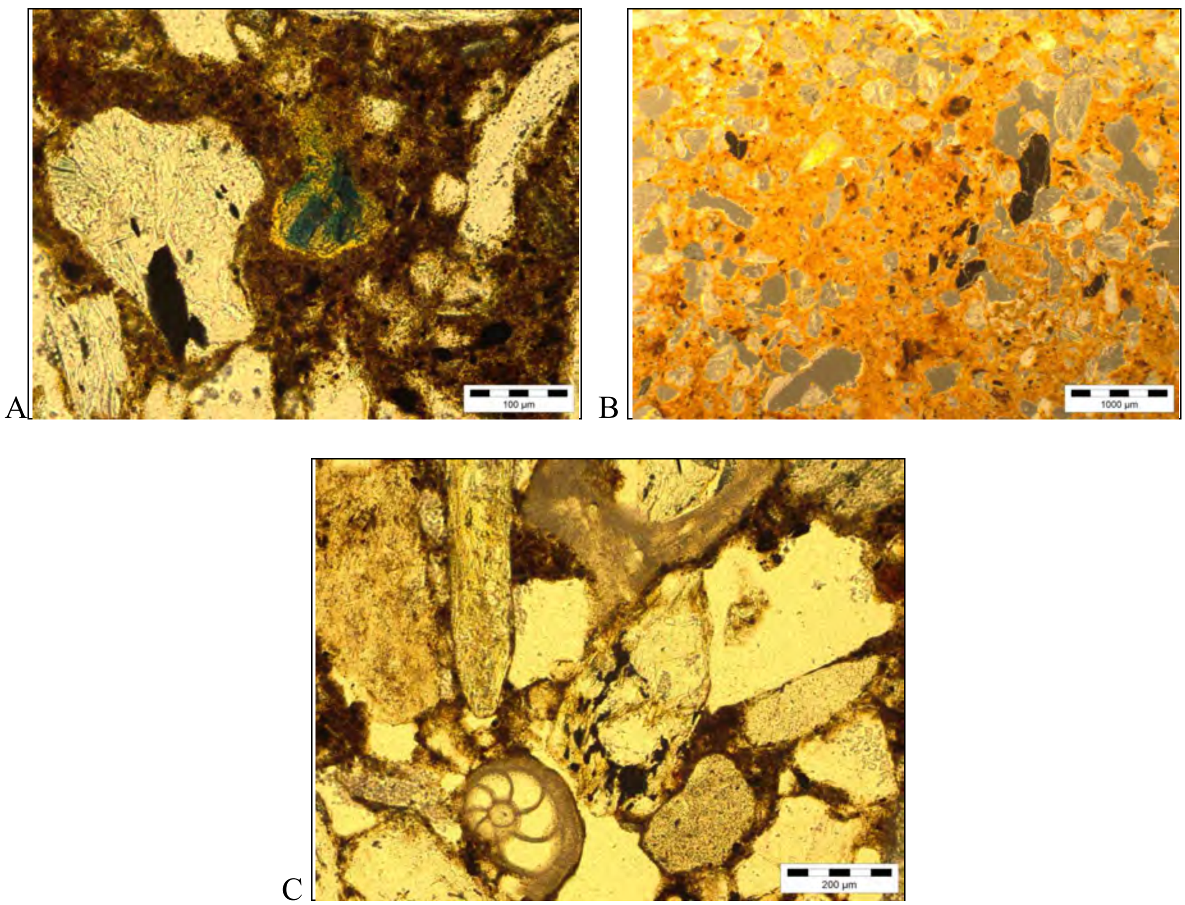


Fig 8.4 Old Scatness Broch, Area L, Context [2062] a. Vivianite (ferrous phosphate, blue colour in centre of image), attributed to bone decomposition derived from bone hydroxyapatite in reducing conditions; b. Ashy midden under OIL; c. Shell within quartz sand.

The later three contexts demonstrate a gradual decrease in the amount of bone present but a gradual rise in the presence of excremental material. The soil structure becomes increasing more open and reworked indicating increased biological activity. The proportion of fine material reduces and the compound quartz grains increase in size. The latest context also contains less bone and charcoal, suggesting a reduction in the intensity of soil amendment towards the end of the Middle Iron Age at this location.

Discussion: Old Scatness Iron Age

In Area Q the Early Iron Age soil was lighter orange under oblique incident light (OIL) than the Middle Iron Age soil. In Profile 2 the reverse had been true; the soils were bright orange under OIL, an indication that they include a large component of peat ash (Carter 1998, Guttmann *et al.,* 2001). There was no obvious bone material and the Middle Iron Age increase in Profile 2 was interpreted as result of adding more organic material, probably animal manures (Guttmann *et al.,* 2008). The addition of manure in the Middle Iron Age was encountered in Area Q, but the soils were shallower. As the results from Area Q appear to be the reverse of those derived from Profile 2, it indicates that, if Guttmann is correct about the Late Bronze Age/ Early Iron Age cultivation on top of flattened middens (Guttmann *et al.,* 2008), then this is a localised phenomenon. This might be explained by the location of Area Q, at a greater distance from the settlement, possibly close to the edge of the midden. The palynological evidence indicates that cultivation intensified in the Middle Iron Age (Bond *et al.,* in press). In the light of this, combining the evidence from the two profiles suggests that the Middle Iron Age soils at Profile 2 had sufficient inherited fertility, and that midden material could be dumped and cultivated, over a more extensive area. Area H, north-west of the site, included one Middle Iron Age context. This contained domestic waste in lower quantities (other than for the bone content) and, as with Area Q, these deposits could pass as soils rather than middens (Turner, *et al.,* in press).

The detail provided by the section from Area L shows amendment gradually increased and then decreased slightly, towards the end of the Middle Iron Age. It also demonstrates a somewhat surprising change in the source of fuel, with an increasing reliance on turf rather than peat. This raises questions as to whether the availability of peat was restricted: there is no peat in the immediate hinterland of the site and perhaps the supply was not directly controlled by the Broch inhabitants. However, it is clear from Profile 2 that some peat was still available for fuel and, subsequently, for soil amendment.

The initial increase in intensity and subsequent gradual decline of soil management, demonstrated in Area L, suggest that the soils do not result from the reuse of a midden. It is more probable that midden material, which varied slightly in content over time, was spread on the fields. The use of animal manure was confined to the north-west of the site. To the north-east, Area H included some unburnt peat suggesting a plaggen soil system (Davidson and Carter, 1998; Guttmann *et al*., 2003). The latest of the Area H Neolithic-Early Iron Age deposits included a finer sand than that from other profiles, suggesting that it was imported, whether for a specific purpose (possibly unconnected with agricultural activity) or was brought in with turf or possibly seaweed.

Combining the evidence from the two new soil sections at Old Scatness with pre-existing work provides a picture of differential land management in the Early/Mid Iron Age across a single site, with areas being cultivated differently, possibly serving different functions, or possibly reflecting the localised midden content, in specific areas of the site.

Results: Old Scatness Viking/Norse

One context in Area Q2 was dated by Burbidge (2003; Turner *et al.,* 2010) to the Viking period: context [5714] was dated to AD1030±80. Above this, context [5713] was dated to AD1430±50, that is, the end of the Norse period. The base of the context above this [5712] was dated to AD1660±60.

The field description for the Viking context [5714] was 5YR 3/2, dark reddish brown. The thin sections from this context have a predominantly gefuric to porphyric related distribution, with random un-accommodated vughs which vary locally from 5%–60% and which are coated with plant material and fine fabric (silts). The microstructure is complex, most frequently being intergrain microaggregate with dark brown fine organo-mineral material but locally including pellicular grain structure and bridged grain structure. There is rare fishbone and rare rubified material. There is a higher organo-mineral content in this context than in the context above it, and it is orange under oblique incident light; this indicates that the fine fraction has been subject to burning and may be composed of peat ash. The rare amorphous black material has no mineral component and this, together with the rare phytoliths which indicate decay of the plant material *in situ*, suggests that the material is peat. There are rare to few lignified tissues and rare charred charcoal in addition to parenchymatic material. There is some evidence of iron movement through the soil, in the form of iron accretions, which is likely to have been imported with the peat.

The field description of the Late Norse context [5713] is 10YR 8/3 very pale brown, mottled with 5YR 3/2 dark reddish brown. It contains very rare to rare fish bone, some of which was identifiable by eye in section, and locally rare mammal/bird bone. There is far less organo-mineral fine fraction; locally it is very rare to absent. There is very rare lignified material, and no parenchymatic material. The fine fraction is pale brown with strongly developed peds and is bright orange under oblique incident light, which suggests that it is predominantly made up of peat ash (Guttmann, 2001; Carter, 1998). The presence of ash, confirmed in thin section, is also suggested by the reddish colour of this context in the field. There is very rare excremental material and very rare iron accretion. This soil was lightly managed, with small amounts of peat being added to soil which was increasingly being swamped by windblown sand.

The Viking/Norse soils therefore show a number of indicators for the addition of fertilisers. The presence of the burnt material suggests an anthropogenic input, and the peat fragments are significant because peat does not occur naturally in this area. The rare excremental material and partial organo-mineral coatings are indicative of bioturbation. This evidence indicates that the soil has been significantly amended with domestic waste, predominantly from hearths, and may also have been cultivated.

The dates for Profile 2 were temporally much closer together than those for Area Q (Burbidge, 2003; Turner, *et al.*, 2010): contexts [C7] AD1200±60 and [C6] AD1360±50, both Norse. The overlying context [C5] was dated to AD1580±40.

Discussion: Old Scatness Viking/Norse

The thin section findings from Area Q indicate that, while anthrosols continued to be created during the Viking and Norse phases, limited manuring strategies to maintain soil fertility moved towards a greater reliance on domestic waste material, particularly ash-based material derived from hearths. The soils in Profile 2 were more cohesive and biologically active, although they too included hearth ash materials. Rare uncharred peat might also derive from hearth ash, although it could have been added as fertiliser (Guttmann *et al.,* 2006). Fungal sclerotia and very rare diatoms both suggest wet, peaty soils and are likely to have been imported. They may derive from unburnt fuel residues from peat combustion or from animal bedding (Turner, *et. al*., in press). Viking and Norse arable activity thus had a reliance on the earlier investment in soil fertility during the Iron Age period, when soils had been enriched and deepened by the addition of organic animal manures, turf and domestic wastes. This interpretation is supported by geochemical evidence from Profile 2, which indicated that phosphate levels in the Norse period diminished slightly compared to those of the Iron Age, although the Norse soils were nevertheless higher in phosphates than the overlying Post-Medieval soils (Guttmann *et al.,* 2008).

In 1998, Simpson *et al.* suggested that there was a continuum of manuring practice from the Iron Age to the Viking/Medieval period at Old Scatness, but the findings from this study suggest that the intensive practices of the Iron Age were discontinued in the Viking period. These findings, previously observed in Profile 2 and endorsed by Area Q, contrast with those from Viking and Norse anthrosols elsewhere in the Northern Atlantic, as were presented in the model in Table 8.4. A careful integration of animal and arable husbandry in the Norse period, suggestive of a well organised community who could therefore increase their production of barley and produce a trade crop, has hitherto been presented (Simpson, 1997; Simpson *et al.* 2005); at Old Scatness it appears that this integration was characteristic of the Iron Age settlement, but either became more restricted or broke down in the Viking/Norse period. The change in manuring strategy in the Viking and Norse phases may reflect a decreasing emphasis on keeping animals, and therefore a diminished availability of manure, at a time when fishing was becoming increasingly successful (Nicholson, in press; Barrett *et al.,* 1999). Alternatively a lower intensity manuring might be due to the increased growth of oats as fodder crops; oats are more hardy than barley and do not require such well managed soils. A third possibility is the relocation of the settlement focus. Viking habitation was less nucleated than in the Iron Age and might have resulted in different areas being taken into cultivation. Based on auguring at the margins of the identified cultivated area, Simpson *et al.* (1998) suggested a possible expansion of cultivation in the Viking period possibly relating to the appearance of flax, a demanding crop, at this time (Bond, in press). As soil management declined towards the end of the Norse period, so flax disappears from the record (Bond, in press).

These findings also offer an explanation for the lack of a visible Pictish soil in the sampled areas, although it is possible that they may have been lost either due to deflation or truncation. The soils dated to the end of the Viking period may have been in use for an extended period and therefore might represent continuity of use. Continuity was identified in earlier periods at Old Scatness and also at Toft Ness in the Neolithic/Bronze Age period (Guttmann 2004; Guttmann *et al.,* 2006, Turner, *et al.,* in press). It is also possible that, being close to the habitation, the area was an ash midden during the Pictish period which was subsequently flattened and cultivated in the Viking period (Turner, *et al.* in press).

The Viking and Later Norse soils were encroached on by windblown calcareous sand, which would have made fertility more difficult to maintain. The Viking soil was sufficiently well maintained to be fertile, but subsequently there may have been a serious decline in soil fertility as less effort was made to amend the soil. As the fertility of the land declined so would grain production, and thus one of the reasons for the wealth of the earlier broch village (Dockrill *et al.* 2005) may have been lost. Offshore fishing would have become increasingly essential to the economy of Old Scatness. Whether there was ever a temporary abandonment of the area was not ascertained from the excavations as the settlement mound was disturbed by later crofting activity. However, the discovery of the base of a corn drying kiln, dated by a Charles II penny, indicates that cultivating grain in the area, at least at subsistence levels, was not completely abandoned in spite of the evident deterioration in the condition of the land. In more recent times, this southern area of Shetland was held to be the best place in Shetland in which to grow bere, although not oats, due to the occurrence of the sandy soils (Elizabeth Johnston, Ian Smith, and other South Mainland crofters, pers. comm.).

Conclusions: Old Scatness

The new work at Old Scatness has achieved both its site-based and its wider aims and makes a significant contribution to understanding the management of agricultural soils of the North Atlantic. There is now an increased body of evidence, particularly for the Middle Iron Age and also for the Viking period, at a single site. In addition, reasons have emerged as to why the Late Iron Age/Pictish period soils are apparently missing from the Old Scatness sequence. The combined results from the four sections at Old Scatness demonstrate that the Iron Age cultivated soils were not being managed uniformly across the site. The use of the flattened middens, seen in Profile 2 and possibly in Area Q, may have been a pragmatic, and certainly localised, phenomenon. The addition of turf and manure to create "plaggen" soils was not universally practised across the site. The amendment of soils by the addition of domestic waste, with a lower ash component and a higher cultural material content, seen to the north-west and also to the south, may have been more typical of Iron Age practice.

A Viking dimension has been added to the sequence: the Norse soils at Old Scatness continue to appear differently managed to those elsewhere in the North Atlantic. Whilst arable land management continued, there appears to have been a reliance on the inherent fertility of the soils created during the Later Iron Age, supplemented with domestic waste. Fertility declined as the soils became subject to windblown sand encroachment in the Later Norse period, although the soil phosphate remained high suggesting that unsuccessful efforts to maintain soil fertility were still being made (Turner, *et al.,* 2010). However, land management practices altered significantly in the Viking/Early Norse period and were abandoned during the Later Norse period, coinciding with intensification of fishing, highlighting the impact of both environmental conditions and economic opportunity in shaping land use and management change in Viking and Norse Age Old Scatness. Nevertheless, it remains possible that the soils sampled were not at the heart of the Viking/Norse agricultural system. In contrast, the Neolithic/Bronze Age/Early Iron Age soils do conform to the pre-existing model of soil management.

<u>Summary of Agricultural Practice at Old Scatness</u>

1. Late Neolithic/Bronze Age. Domestic waste added.

2. Late Bronze Age/Early Iron Age. Increasing fuel ash included with the domestic waste. Possible cultivation of flattened middens.
3. Middle Iron Age. To the North-East: Cultivation of flattened middens suggested by high incidence of fuel ash; the area where the fuel ash was added was extended later in the period. The fuel included peat. Turf and manure was also added: it may have been a component of the middens.

To the North-West: Domestic midden, with higher proportions of unburnt bone and a lower fuel ash component, was added to the soil.

To the South-West: The level of amendment increased and then decreased over a series of six soils. There was a change in the fuel ash included, from peat to turf: some of the fuel having been burnt at high temperatures, probably in a domestic context. The context which was third temporally included greater amounts of plant material and iron nodules from a wet upland environment, and the occurrence of vivianite suggests that the domestic middens were also wet for a period. The later three contexts show an increase in manuring and also in compound quartz, but less domestic waste being added and a general overall reduction in the intensity of amendment.

4. Late Iron Age/Pictish period. Missing either due to deflation or truncation, or as the result of continuous use into the Viking/Norse period.
5. Viking. Intensity of use decreases, with a possible reliance on the inherent fertility of the soils created during the Later Iron Age. The deposition of aeolian sand increases. Domestic waste being added.
6. Norse. Increasing deposition of aeolian sand, to the point where there is little soil fabric: domestic waste still being added. Environmental conditions, an economic

change to fishing or a relocation of the agricultural focus of the site, or a combination of these factors, results in less intense use of the soils.

7. Post-Norse. Although subsistence farming continued, the soils sampled show an abandonment of previously cultivated land as the deposition of aeolian sand continued to increase.

Archaeologically, Old Scatness is a complex site which clearly housed large numbers of people including specialist craft workers, and possibly specialist agriculturalists who may have worked different areas for different purposes. Whilst many archaeological sites are not as complex as Old Scatness, nevertheless the results clearly demonstrate the value of a landscape approach to micromorphology to investigate agriculture. It also demonstrates the need to test the model further, looking at sites which appear to be single period, exploring the extent to which Shetland sites with good extant field systems fit the model.

SINGLE PERIOD SITES

It has already been observed that the "Single Period" sites within the study have been selected due to the completeness of the survival of their associated field systems. To some extent, their very survival indicates that the land either was, or has since become, less attractive for agriculture. In neighbouring Orkney for example, the physical boundaries of field systems do not survive in a comparable manner due to the higher continuity and intensity of modern agriculture on land which is generally lower lying and more easily cultivated. Since the soils on which the field systems survive have a tendency to be thin, often stripped, gleyed or podzolised acidic soils this work will also seek to establish whether such soils retain cultural information pertaining to relict fields. The majority of the informative soil samples from the Scord of Brouster were located under structures: either house sites or boundaries (Romans, 1986). The majority of soils examined in this study will be taken from the middle of the fields (with two exceptions from the edges of clearance cairns) adopting a landscape based approach rather than a structures based one. If there are cultural indicators in the soils, it will be possible to test whether these Single Period sites fit the emerging model for cultivation in the North Atlantic.

HOULLAND HOMESTEAD ENCLOSURE SOIL PROFILES

Two soil profiles were excavated at Houlland, Nesting, both within the Enclosure itself: Profile E north of the house and Profile D to the south. Two kubiena samples were taken from each profile.

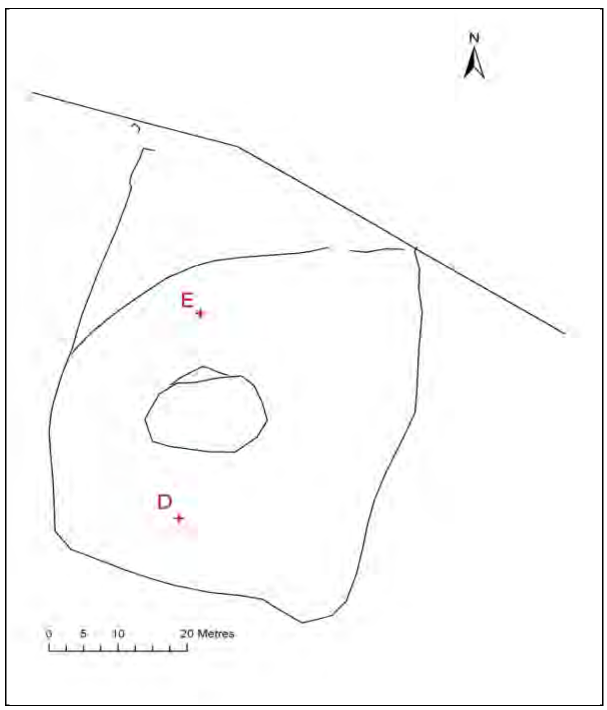


Fig 8.5a Location of Soil Profiles excavated at Houlland

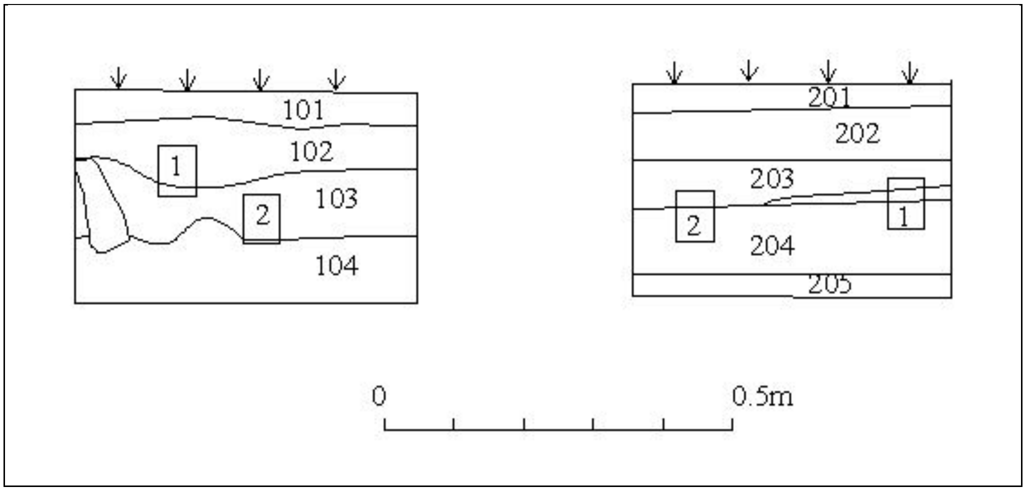


Fig 8.5b Profile sections excavated at Houlland (left D, right E).

Soils Environment

Houlland is situated on the Deecastle Association, comprising Dalridian Limestones and calc silicate rocks (Dry and Robertson, 1982: 35), some of the better agricultural soils in Shetland. The principal parent materials are crystalline limestone, calc-schist rocks and a brown drift containing schists. The soil series includes imperfectly drained brown forest soils with brown rankers, noncalcareous gleys and local peaty alluvial soils. Today, the soils can be cultivated or carry permanent pasture (*ibid.* 35).

The soil profiles revealed wet, acidic histosols rather than podzols. The soils were visibly wet in the field and methane was released from Profile E when the first sod was cut, indicative of peat. Micromorphology revealed unsorted minerals and compounds derived from the parent material (schist) were dominant (i.e. ≥50%) in both earlier contexts sampled, [103] and [204]. Iron movement is evident in Profile D, particularly in the upper context [102], in which the mobile iron appears to be leaching out of the organic material and is visible under OIL in the orange-brown and dark orange-brown groundmass.

Results and Discussion

Two contexts were identified in the field at Profile D, sampled in two slides. Each slide incorporated a lens or boundary area between the two contexts. The lower context [103] included the hint of a horizon comprising black organic accumulation and rare fungal spores. The groundmass was spongy, with channels and vughs concentrated towards the top of the context. The pedofeatures include dark brown areas with dense black organics, areas of dense mineral material and a more yellow-brown micromass. The majority of the boundaries between pedofeatures are very sharp; this and the inclusion of broken organics indicate that the context has been disturbed, suggesting a low level of cultivation. Above this, context [102] also incorporates a hint of cultivation: there is some clay accumulation (fig 7.6a), dusty silty infill, some fine silty clay coatings of minerals (fig 7.6b), some mixing of very organic material and areas very dense in minerals. There are areas which have a crumb structure, indicating that the groundmass was partially reworked by soil animals.

Two samples were taken from Profile E with a view to sampling contexts, [203] and [204] and the interface between them. The base of [204] was very peaty with some moderately sorted mineral accumulation and some clay accumulation. Above this lies a zone in which peat and mineral material are mixed. There is a horizontal peat layer suggesting that peat could be forming in situ. If so, this was short-lived, as the peat became disturbed again, both above and below the horizontal peat. There is some accumulation of clay, and the zone is probably cultivated. Some of the peat has been biologically reworked by soil animals, which is uncharacteristic of peat which forms in an anaerobic environment: this must have taken place after the ground disturbance.

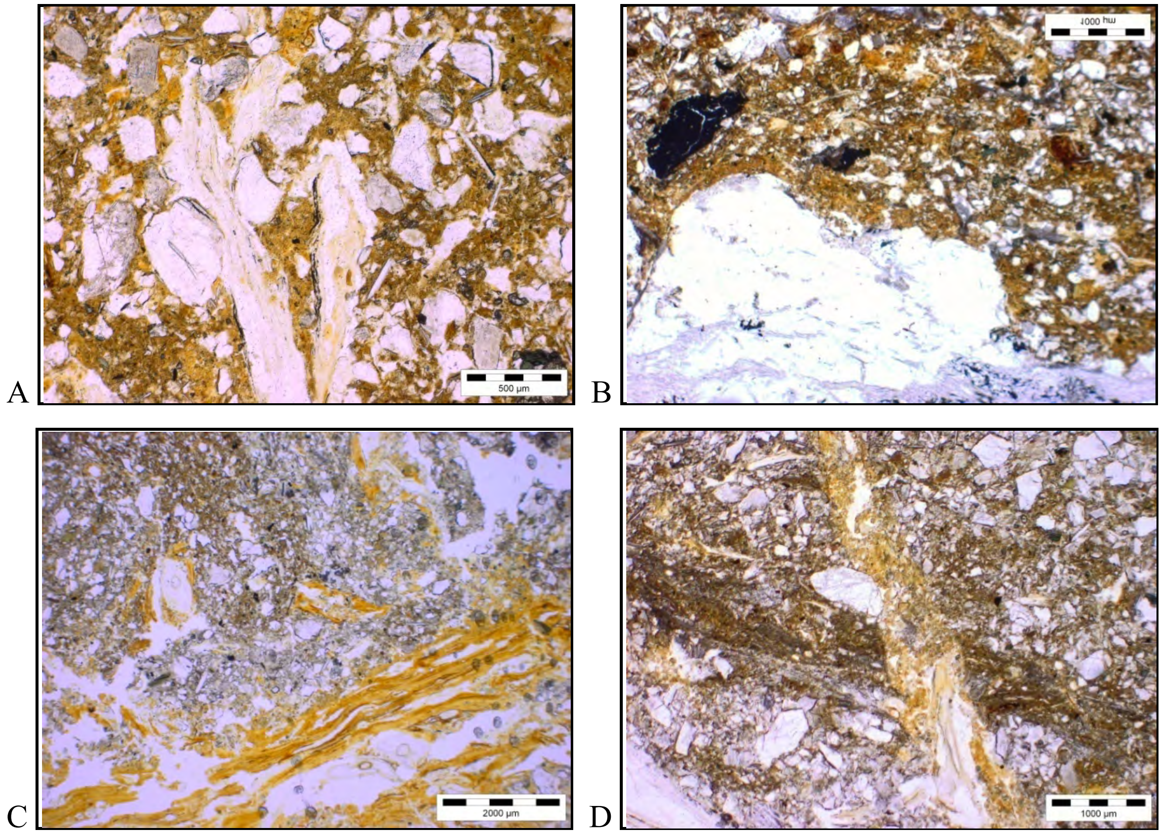


Fig 8.6 a HN08 D1 Dusty clay accumulation [102]; b. HN08 D2 fine silty clay coating of mineral [102]; c. HN08 E2 Soil [203] created on peat [204]; d. HN08 E2 Surface between [203] (above) and [204].

Above this, a dark brown undulating horizontal band denotes a second buried land surface (fig 7.6d). In contrast with the rest of the sampled section, although the horizon is mineral rich, there are no large mineral grains in this horizon, the maximum size being 640µm. There are small black flecks within the groundmass and there is a linearity to the phytoliths and to the less rounded minerals. The black flecks are probably charcoal. The lens recorded in slide E1 contains a cluster of charcoal fragments, which hints at a clearance horizon above the earlier cultivation.

The upper context [203] (fig 7.6c) becomes increasingly organic as it progresses up the profile; however it includes a mixture of peat and mineral material, black organic flecks, and also silt and clay accumulations, and therefore also appears to have been subject to cultivation.

The mineral content of the profile is intriguing. The preceding *Environment* section demonstrates that Houlland is located within an area which the Soil Survey of Scotland has attributed to the Deecastle Association, characterised by limestones and calc silicate rocks including calc-schists. The Deeside Association rocks comprise a band running approximately north-south through South Nesting. The rocks on either side of this band belong to the Arkaig Association (Dry and Robertson, 1982: 24), described as acid schists and gneisses. The evidence of limestone in the Profile, including glauconite, is rare-very few, i.e. ≥ 5%. There is some schist evident, however quartz and feldspar are present throughout the Profile and compounds of sandstone are frequent, being more abundant than the limestone and schist. The parent material of the adjacent Association, to the west the hill land, is described as deep blanket peat. This suggests that the sandstone mineral component is largely introduced, probably as an incidental inclusion with turf or peat, and from a considerable distance outside South Nesting. That the mineral material is imported is supported by the location of the site which is on relatively flat ground and therefore the accretion of large quantities of very mixed, poorly sorted, mineral material would need explanation.

Summary of Conclusions regarding land use at Houlland.

The several phases of use at the site may have taken place over a fairly short period of time, during the Neolithic/Bronze Age.

1. Peat development. It is most likely that this started before the Enclosure was built. This would be early, although not impossibly so, for the formation of peat (Neolithic/Bronze Age).
2. Enclosed area was managed in order to grow crops. The agricultural use of the area immediately around the house is in keeping with the land use seen within the Multiple Field System at the Scord of Brouster (Romans, 1986). Mineral material was imported in order to create the soil.
3. Cessation of cultivation, or a reduction in intensity of cultivation for a period, which enabled peat growth to become re-established. The peat layer is discontinuous, broken by vertical organics and so a low level of cultivation such as drilling individual seeds without disturbing the surface (suggested at Scord of Brouster, Romans, 1986) may have continued.
4. Increase in intensity of cultivation to similar levels as previously.
5. "Clearance" phase, during which the existing vegetation layer is burnt off.
6. Addition of further mineral material, and continuation of cultivation.
7. Abandonment of enclosure. Peat becomes re-established and area subsequently given over to grazing. The modern use of the field is grazing.

Exnaboe Homestead Enclosure Soil Profile

The Enclosure at Exnaboe is divided into three by modern fence boundaries: unimproved, unenclosed rough grazings (scattald) to the north, the other two areas are within small pasture fields which are grazed at differing intensities. Two soil profiles were excavated from the site: one on the scattald, the other within the southwest field within the Enclosure. Both profiles were very shallow, with three contexts above the parent rock which appeared identical in the field. Profile B was 0.25m deep and Profile C 0.2m deep, therefore only Profile B, on the unenclosed land and slightly above C, was sampled with one kubiena tin.

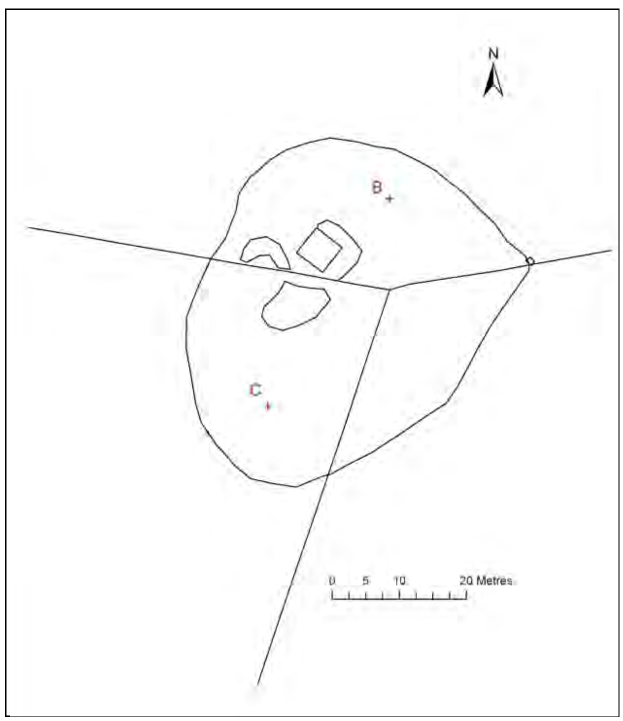


Fig 8.7a Location of Soil Profiles excavated at Exnaboe

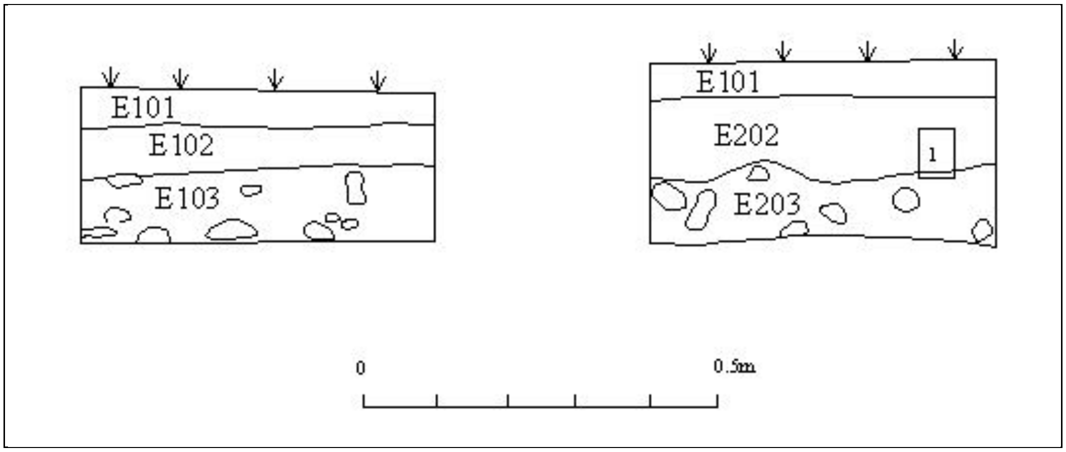


Fig 8.7b Profile sections excavated at Exnaboe (left: C, right:B).

Soils Environment

Exnaboe is located within the Skelberry Association, on drifts derived from sandstones, flagstones and conglomerates. The parent materials include patches of pyllitic schists (Dry and Robertson, 1982: 48). The soils are described by the Soil Survey of Scotland as peaty gleys and noncalcareous gleys with ranker soils and peaty podzols and local basin peat, peaty alluvium and saline gleys. The soils occur on thin stony drift and deeper heavier textured till. Today soil limitations, particularly shallowness and rockiness, mean that most of the land is used as rough grazings, but where soil and climatic conditions are more favourable cultivations have taken place with the establishment of pastures for grazing, conservation and arable crops (*ibid.:* 49).

The soils are podzolic (fig 7.8). The mineral material is poorly sorted and has accreted, the Enclosure being located on a gentle slope. There are two types of sandstone present and these are dominant in context [203]: the coarse grained is up to 600μm, the fine grained up to 200μm. There is a lot of iron staining within the compound minerals. Iron has also accreted within the two contexts sampled, [202] and [203]. In the upper context [202] iron is visible within some of the cell residue, there are nodules present and some of the minerals have iron coatings. Bleached stone rims are also present, where iron has leached out of the minerals. Context [203] is even more iron rich, the groundmass being bright orange under OIL.

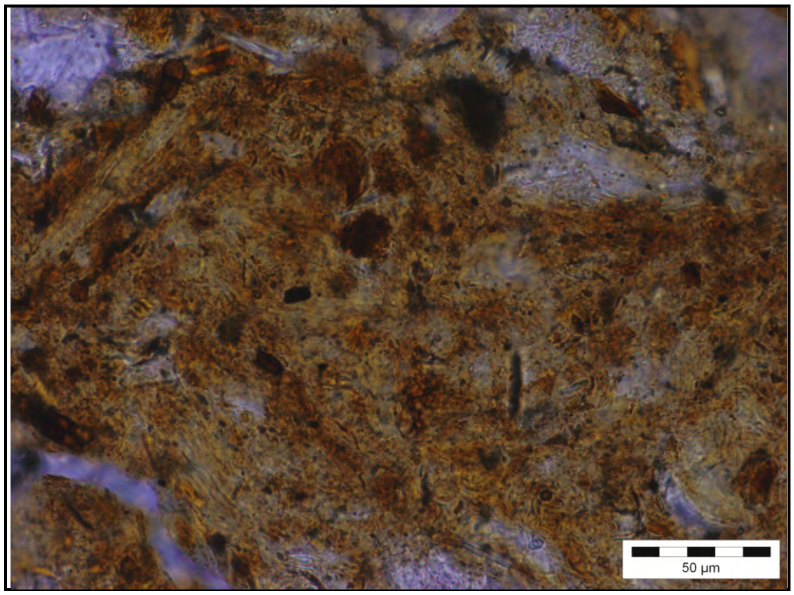


Fig 8.8 Exnaboe: Podzol showing iron mobile in soil, with phytoliths

Results and Discussion

Both contexts in Profile B have a crumb structure and contain groups of fungal spores which are few (5-15%) in context [202] falling to 2-5% in context [203]. All this is indicative of reworking by soil animals. Both contexts are very fibrous and contain rare phytoliths. The combination of these features would be typical of grazing. However the quantity of organic material is higher in [202] being rich in amorphous brown organics. Some of the organics appear to be partly shredded, suggesting that it may have been eaten, an indication of manuring; there are also very rare textural coatings. It is possible, therefore, that the upper context [202] has been worked during the period of the use of the Enclosure.

<u>Summary of Conclusions regarding land use at Exnaboe</u>

1. Grazing, which may have taken place before the construction of the Enclosure or have been contemporary with it.
2. Land within the Enclosure may have been amended and cultivated.
3. Reversion to grazing, ultimately divided between enclosed land and rough grazing.

PINHOULLAND MULTIPLE FIELDS SOIL PROFILES

Seven soil profiles were excavated at Pinhoulland. Profile C was located within the enclosure surrounding the most prominent house site, but this was only 0.15 - 0.18m deep with only one context below the turf and so was not sampled. Profile J2 was very stony and also was not sampled. Of the other profiles, three were from the open fields whilst one was under, and the fifth was adjacent to, the edges of clearance cairns.

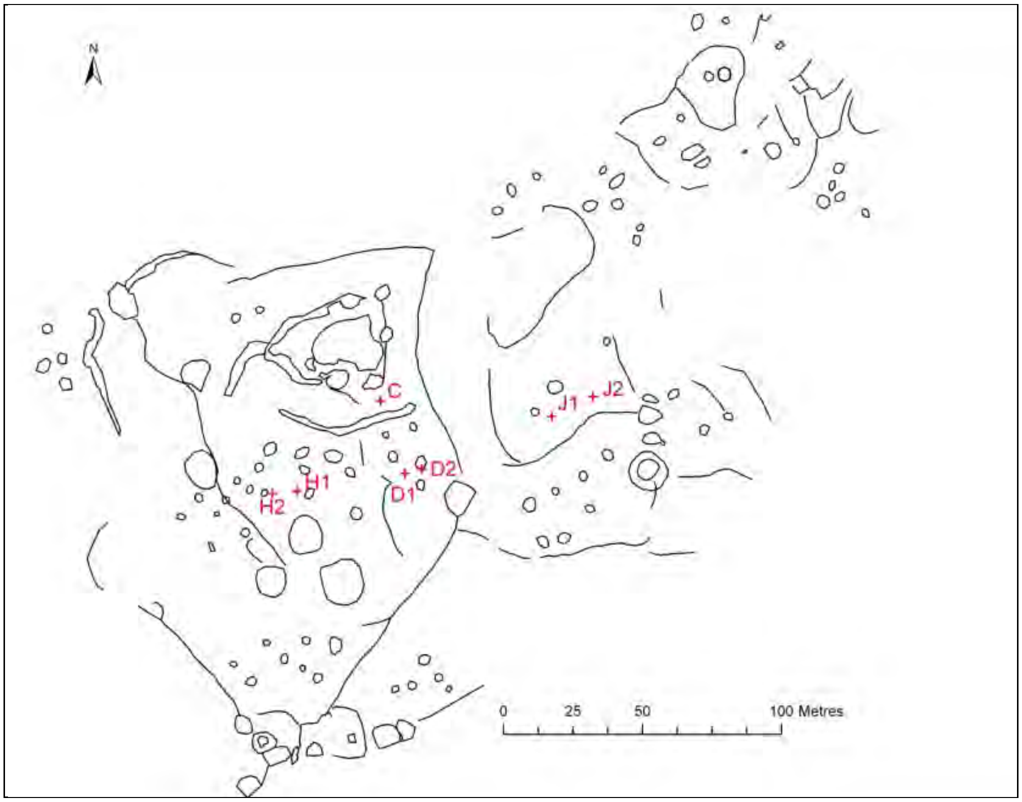


Fig 8.9a Location of Soil Profiles excavated at Pinhoulland

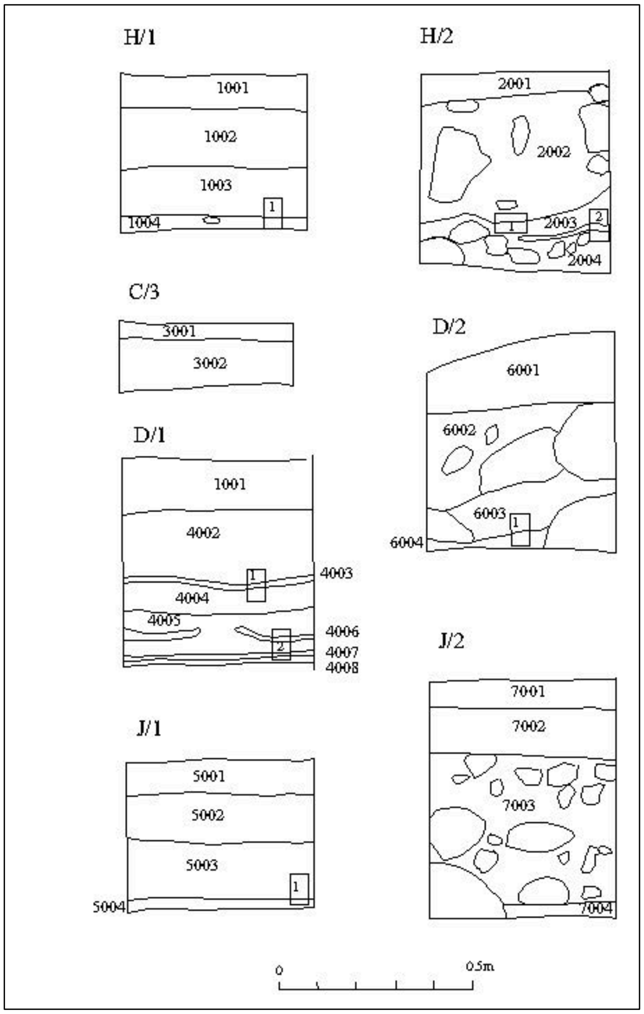


Fig 8.9b Profile sections excavated at Pinhoulland

<u>Soils Environment</u>

Pinhoulland is within the Walls Association, which comprises drifts derived from Middle Old Red Sandstone with acid schists and granites. The principal parent materials are all derived from sandstones: acid schists, felsites, granites and locally, rhyolites (Dry and Robertson, 1982: 57). The soils comprise peaty rankers, peaty podzols, peat, peaty alluvial soils and locally, brown rankers. Today it is mainly rough grazings (Dry and Robertson, 1982: 58).

All the soil profiles from the open areas are wet, acidic and peaty with iron being mobile in the groundmass. Iron is accumulating in many of the contexts sampled and iron nodules, iron coatings of minerals and iron staining within compound minerals are common occurrences, although there are differences within and between individual profiles. Bleached stone rim is also found on stones within the profiles. There are unsorted minerals accreting in many of the contexts, as the land is gently sloping. Profile J1, taken from the centre of a field, includes rare iron nodules but iron accretion is very rare and neither context is orange in OIL, indicating an atypical lack of iron in the groundmass. It is interpreted as a peaty ranker, with peaty turf overlying black humus stained rock rubble. Profile H1 has phytoliths in contexts throughout the profile, as is typical of a wet peaty environment. Profile D1, also from the middle of a field is the deepest profile from the open field (0.55m) and many of the contexts/bands within it comprise peat.

In contrast, there is no indication of any peat from Profile D2, taken from beneath a clearance cairn, reflecting the nature of the soil when the field system was in use. The earliest context [6004B] is founded on a brown soil, containing hints of an underlying dusty clay matrix. There are hints of a darker, more organic, peatier land surface above it [mid 6004] which, like the overlying context [6004A], contains dusty clay indicating a former brown soil and intermittent agriculture. Although Profile H2, which is at the edge of a clearance cairn, is acidic and iron rich, the peaty podzol is absent. In both profiles, the clearance cairn may have served to arrest the localised development of peat. Context [2003] in Profile H2, interpreted as intermittently wet, contains layers of iron accumulation whether due to the micro-climate or variations in the water table. The iron accumulation is less likely to result from podzolisation since it occurs above the base of the profile.

Results and Discussion

Profiles D1 and D2 will be discussed in some detail, with environmental information included where it is germane to the interpretation of the contexts. These two profiles, one in the open field, the other under a cairn, provide a benchmark for the other Multiple Field profiles. During fieldwork eight contexts were identified above the weathered bedrock in Profile D1. Some of these displayed more than one zone under the microscope. The earliest context [4008] contained two zones, the upper zone recorded as [4008A]. Both zones were mineral rich, the lower context probably representing a ranker horizon: minerals had dark humic material accreting on them. The groundmass was slightly darker in the lower horizon; this and the variations in colour were the result of the amount of iron content. Both contexts contained phytoliths and diatoms: in [4008A] these were concentrated in the lighter material. The predominantly channel microstructure and porphyric related distribution are symptomatic of the peaty nature of the soil, but the mixed nature of the groundmass and the differences in density of the mineral content suggest that the later horizon had been disturbed.

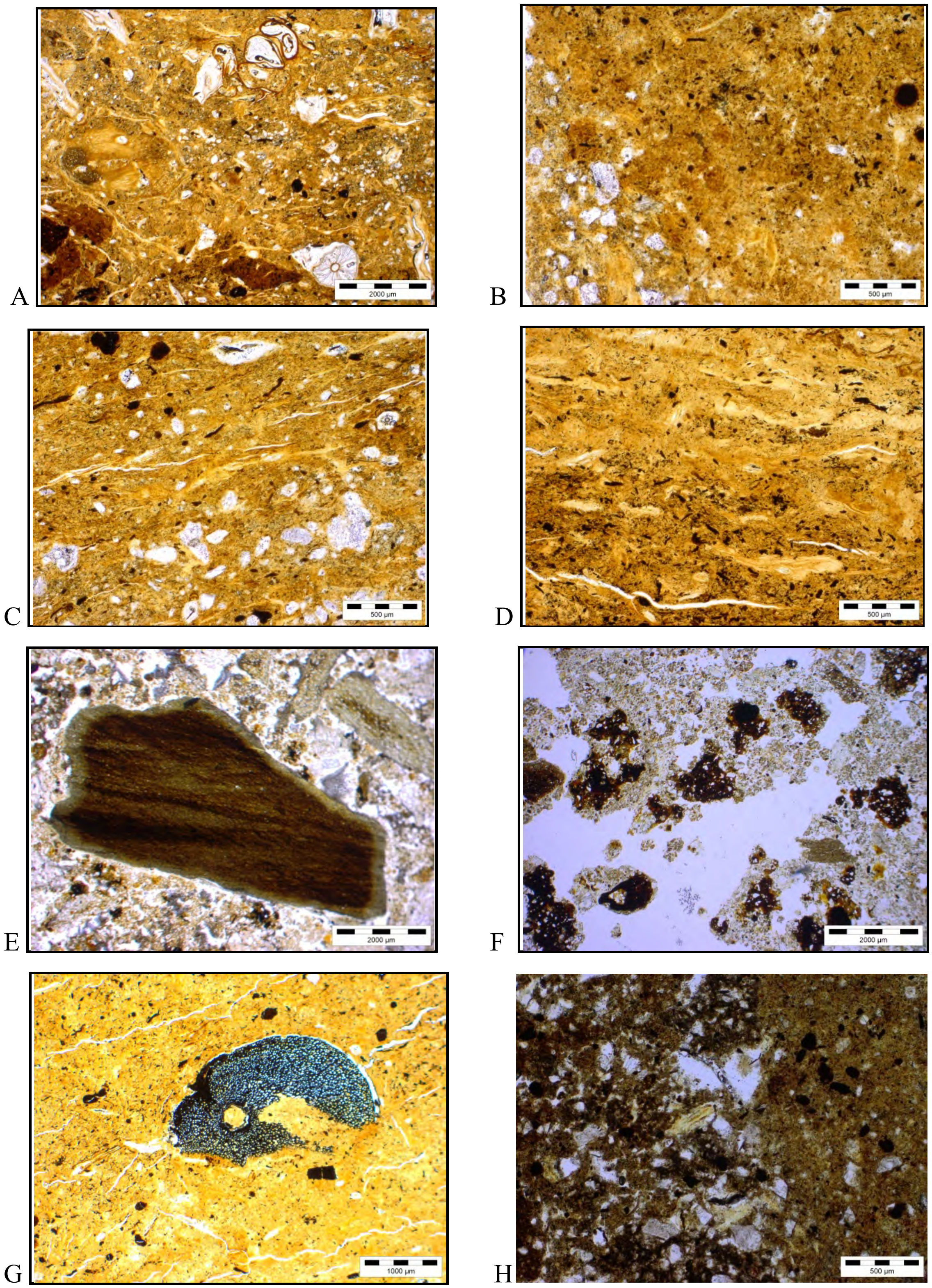


Fig 8.10 a.PHW08 D1/1 Peat containing minerals and parenchymatic organic material; b. D2 [6003] Peat coming down onto eroded surface; c. H1 peat with high mineral content; d. H1 peat with periodic phases of burning; e. H2/1 [2002] bleached stone rim; f. PHW08 H2/2 [2005] possible remnant podzol; g. J [5003] charcoal in peat; h . J5004, peat on eroded land surface.

The next context chronologically was [4007], which was also recorded as two zones under the microscope. Context [4007B] included very rare organic coatings and very rare textural coatings, a durable potential indicator of cultivation, although it can be caused by disturbance from other causes (Carter and Davidson, 1998; Usai, 2001). The groundmass included four distinct shades of brown and the size and density of the mineral content varied, indicating that the context was disturbed, possibly cultivated. The organo-mineral soil does not incorporate any peat: there are no phytoliths and only a single cluster of diatoms, in contrast to the contexts below. Fungal spores may indicate the inclusion of manure but the microstructure is channel and there is no indication of much biological reworking of the soil, perhaps due the rapidity of the next event. However, the lack of peat in this context suggests that it has either been created as the result of rapid accretion or intensively worked. The mineral content of context [4007B] was moderately well sorted and that of [4007A] was well sorted, indicating that there was disturbance, probably cultivation, taking place higher up the slope. The organic content of context [4007A] increased with the reappearance of peat, and with it phytoliths, but there was also a frequent amorphous black content, some of which was identifiable as charcoal. There was also charcoal in the micromass, which created a densely speckled b-fabric. There was less variation in the colour of the groundmass and the context appears to be the result of soil creep due to cultivation of the land above. The presence of charcoal suggests that midden material was being applied to the soil on the slopes above, possibly associated with the well-preserved house.

Following this, peat began to grow again, context [4005]. Discontinuous lenses of material within [4005], were recorded in the field as context [4006] which differed from context [4005] in that it contained frequent amounts of black organic material, some of which appeared to be shredded, possibly the dung of grazing animals, incorporated into the peat. This might indicate a change from sheep to cattle, or in the density of grazing animals. The interpretation of the organic material as dung would also explain the patchy nature of its occurrence. Context [4004], recorded as two zones, comprised peat. The lower context [4004B] is slightly lighter in shade and slightly less homogenous than the overlying context [4004], which also contains brown fungal spores and round amorphous brown organic material, possibly spores. The changes between contexts [4005] and [4004], and also within context [4004], may represent changes in the environmental conditions, but alternatively may indicate further changes in the grazing regime. The same could be true of context [4003B], another layer of peat.

Context [4003] represents a change to a more mineral based soil, although incorporating a few peds of peaty material. The organo mineral soil contains few occurrences of a black organic material, with mineral inclusions but is black under OIL, suggesting that the organic component is unburnt turf. It includes rare fragmentary diatoms as well as phytoliths. The micromass is flecked with black organic material, possibly charcoal and the groundmass varies in colour. The mineral content is moderately sorted, and some may have been imported with the turf or it may result from upslope activity. It is predominately feldspar with some quartz and is not as varied as the mineral content lower down the profile. The charcoal suggests that the turf was added as part of domestic midden waste, but there is no other cultural material to corroborate this. Context [4002] reverts to peat, although there is still rare charcoal within it. This charcoal could be residual from the previous context, or a half-hearted attempt to improve the soil without the inclusion of turf, or even a further episode of spreading midden material.

A single kubiena sample was taken from Profile H1, located in the adjacent field to the east of D1. Two contexts, [1003] and [1004], were recorded during fieldwork but six zones were recorded microscopically. The two lowest zones, context [1004], comprised peat. In the bottom zone there were very few minerals accreting, whilst the overlying zone lacked minerals altogether. The bottom of context [1003] included three distinct aggregate types: lighter brown with few black organic inclusions which also coat some of the channels; an orange organo mineral and an area which incorporated common black organic which was up to 40µm. The mineral material was well sorted, with a maximum size of 60µm. The micromass is bright orange under OIL. This zone represents a zone of burning, the black organic material being charcoal. The other three zones, contexts [1003 ii-iv], contained no mineral material: that in context [1003i] was probably the result of cultivation upslope. Context [1033ii] included some horizontal banding of colours in the organic material and also included black organic flecks and material up to 56µm. This was less bright under OIL but is interpreted as a layer of burning, possibly not in situ. The upper two zones of the context revert to peat.

Profile J1 was taken from a small, slightly separated, field to the east of Profile D1. One kubiena sample was extracted from the bottom of the profile, sampling two contexts. The earliest context [5004] is very peaty, possibly a peaty ranker, with black humus staining on the rock rubble: this may comprise the formation of peat over an eroded land surface.

There is little cultural component other than areas of amorphous black flecks within the groundmass (av. 52µm but rising to 440µm) but there are some lines of compression, signified by an increase in soil density and a strong linearity. Alternatively, this could be caused by the weight of the overlying peat. The overlying context [5003] is also very peaty, with several shades of organic material but with no evidence of any disturbance.

Profile D2 was taken from under a cairn. Two contexts were located in the field and were sampled in one kubiena tin. It was possible to identify three zones in the earliest context [6004] under the microscope. The earliest zone [6004B] was not heavily organic, being more characteristic of a brown earth. It included peds of three shades of brown, the darkest of which included a high mineral content whilst the lightest contained fine organics and either manganese or iron. The lighter peds were also very silicaceous, containing fractured phytoliths and diatoms and some amorphous silica. It is possible that these were once part of a turf content from which the organic content has disappeared. There were also charcoal flecks embedded in the brown earth. The mixing of the peds indicates that the soil was worked; the charcoal flecks suggest that domestic waste was added to the soil. Turf may have been a component of the midden material or it may have been in situ: there was some linearity within it, suggesting a relict land surface. The mid [6004] context comprises a darker linear phase having the appearance of a land surface. The soil is peatier and includes traces of a disrupted iron pan, hinting at a podzol disturbed by working. Above this, context [6004A] is similar in composition to [6004B] although the range of colours of the peds is slightly darker. It too contains a small amount of brown soil, representing a third episode of cultivation. Context [6003] was the matrix between the lowest stones of the cairn. It is spongy with areas of weakly separated crumb structure, indicating biological reworking of an organic content. The mineral content is coarser and there are areas which contain black organic flecks. The context is highly silicaceous, with cellular organic material clearly visible as articulated silica and phytoliths, the occurrence of phytoliths being frequent and not restricted to particular colours of peds. The boundaries between the peds are more subtle than in earlier contexts. This indicates a very high turf content, and suggests that turf is being dumped together with the cairn material. One explanation for this is that the cairn was part of a boundary which included turf in its construction. Alternatively, the cairns may have functioned as "skru steeds" where sheaves, or possibly turves, were collected together between cutting and use elsewhere.

Profile H2 was located at the edge of a clearance cairn, where two kubiena tins sampled four contexts. In the earliest context [2005] the organo mineral groundmass has a weakly separated crumb structure, containing fungal spores and minerals with clay coatings. Some iron pan was incorporated and there were areas of both depletion and accretion in the groundmass. There are hints of a remnant podzolic horizon. The soil does not have the characteristics of an A horizon, the organic content being relatively low, and it is possible that the turf was stripped from here. The structure of context [2004] has areas of weakly to highly separated crumb structure and contains fungal spores and organic silt coatings as well as some clay coatings of minerals and voids. These are suggestions of cultivation. The groundmass is paler than that of the contexts above and below, with little iron in the groundmass, the paler colour possibly being the result of a depleted environment, although there are small patches of iron accretion. Context [2003] includes turf with mineral inclusions, clay and organic silt coatings, and areas which have a crumb structure due to bioturbation. These are also hints of agriculture. Context [2002] incorporates turf with mineral inclusions, coatings and a crumb microstructure. Both contexts have been disturbed and may have been cultivated.

Summary and Conclusions

The use of the Pinhoulland field system is complex, based on the results of the excavated profiles. The results allow a model to be constructed the field system.

1. Prior to the ingress of humans, the area supports brown soils.
2. Sporadic episodes of cultivation, (at least three), mainly evidenced by the mixing of peds. Some turf (organic with mineral content) added to soils. Formation of peat and peaty podzols began during this period. Turf may have been stripped in some areas prior to cultivation.
3. Creation of clearance cairns, which may have functioned as *skru steeds* or comprised elements of boundaries.
4. Peat formation increases.
5. Episodic cultivation continues interspersed with grazing, suggested by fungal spores. Each field unit is not continuously cultivated, there being episodes of peat growth with minerals accreting when the focus of cultivation moved further upslope. A discontinuous layer of possible dung suggests that either the type of ruminant or the intensity of grazing changes. These changes may dictate the differences between peaty horizons, but this may be a product of environmental change. The cultivation episodes continue to be characterised by the addition of organo minerals, including unburnt turf and charcoal, possibly midden material. There is at least one episode of burning during this period of land use.

6. Today the land is used as rough grazings. There is a plantiecrub within the field system. These are post 18th century AD (Fenton, 1978) and were set in rough grazings, at a distance from the cultivated area. The foundations of a horizontal mill and an animal pund at the edge of the coast both have specialised functions and there is no indication for the land being used for anything other than light grazing once the Multiple Field System went out of use.

CLEVIGARTH BROCH BOUNDARY SOIL PROFILES

Previous work carried out at Clevigarth (Guttmann *et al.*, 2008) was restricted to the immediate vicinity of the Broch and identified soils which were dated to the Bronze Age. The purpose of this investigation is to examine soils on either side of the boundary, interpreted as belonging to the Broch, in order to identify any differences between them. Two soil profiles were recorded: Profile 2 inside the Broch boundary and Profile 3 on the opposite side.

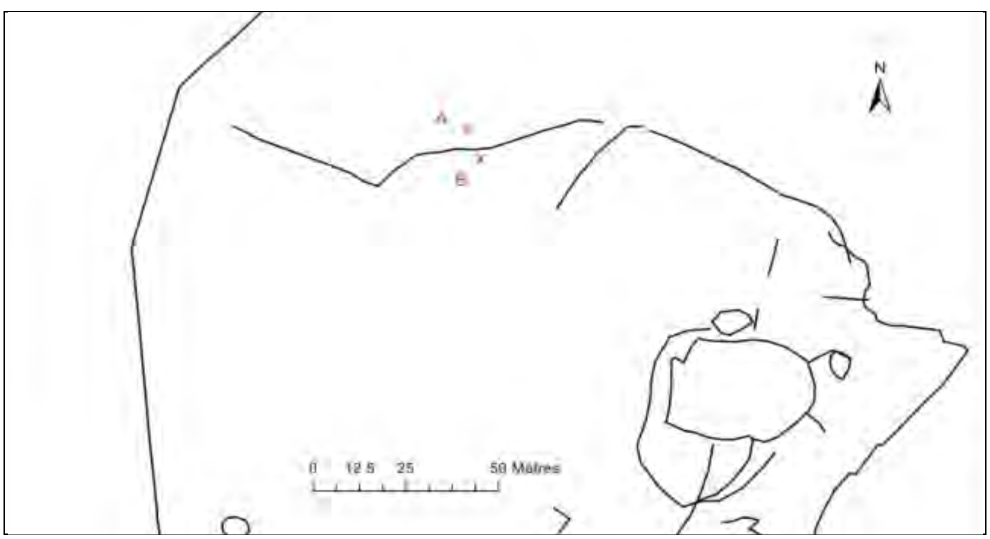


Fig 8.11a Location of Soil Profiles excavated at Clevigarth (A= Profile 3; B= Profile 2)

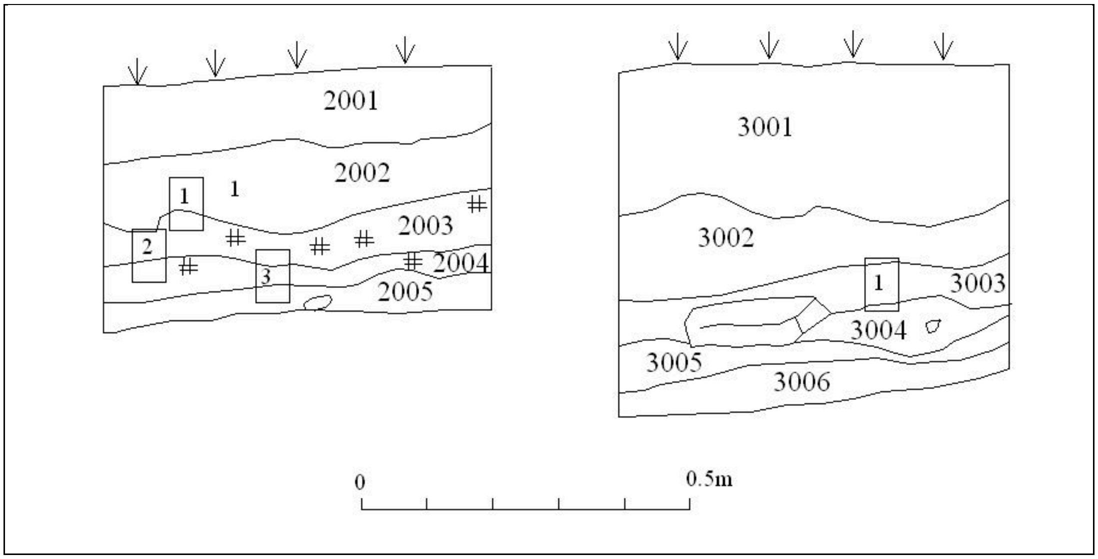


Fig 8.11b Profile sections excavated at Clevigarth

Soils Environment

Like Exnaboe, Clevigarth is also located within the Skelberry Association, comprising drifts derived from sandstones, flagstones and conglomerates. The parent materials include patches of pyllitic schists (Dry and Robertson, 1982: 48). The soils are described by the Soil Survey of Scotland as peaty gleys and noncalcareous gleys with ranker soils and peaty podzols and local basin peat, peaty alluvium and saline gleys. The soils occur on thin stony drift and deeper heavier textured till. Today soil limitations, particularly shallowness and rockiness, mean that most of the land is used as rough grazings, but where soil and climatic conditions are more favourable, land use includes pasture for grazing, conservation and arable crops (*ibid.:* 49).

The underlying soil at Clevigarth is peat, in which well sorted calcareous wind blown sand has accumulated. At Old Scatness the calcareous sand was later than the glacial sand, first appearing in the Early/Mid Iron Age. Although only a few miles apart, Old Scatness is on the west coast whilst Clevigarth is on the east, and so episodes of blown calcareous sand may not be contemporary. The presence of windblown sand in each context demonstrates that each was once at the top of the profile. There is a small amount of iron movement in the profile, which would be consistent with a wet peaty environment. The mineral component is different between the two sides of the boundary, there being more sandstone in the profile outside the broch boundary. The minerals comprise small angular fragments, the majority being sand. There was also less peat visible than in Profile 2.

Results and Discussion

Three kubiena tins were used to sample four contexts in Profile 2, inside the broch boundary. The earliest context [2005] demonstrates a small amount of clay movement, but is a fairly uniform dark brown with little sign of cultural activity. There is some peat accumulation within the calcareous windblown sand, which is missing from the overlying context [2004]. This has a greyer groundmass, pale under OIL, with inclusions of turf containing moderately dense areas of small minerals (up to 8µm). Some of the mineral content has coatings of both organic silt and clay. The groundmass varied in colour from grey-orange to mid brown and was mixed with the turf, demonstrating that the soil was amended for cultivation. The context above this [2003] is amended to a greater degree although not intensively. There is some charcoal, evident as rare black flecks in the micromass (up to 50µm) and dense patches of turf containing minerals. There are also some patches of dusty clay accumulation and some minerals have organic silt coatings. In the overlying context [2002] the amount of sand gradually increases and the evidence of activity becomes progressively less intense, although there is more bioturbation towards the top of the sample.

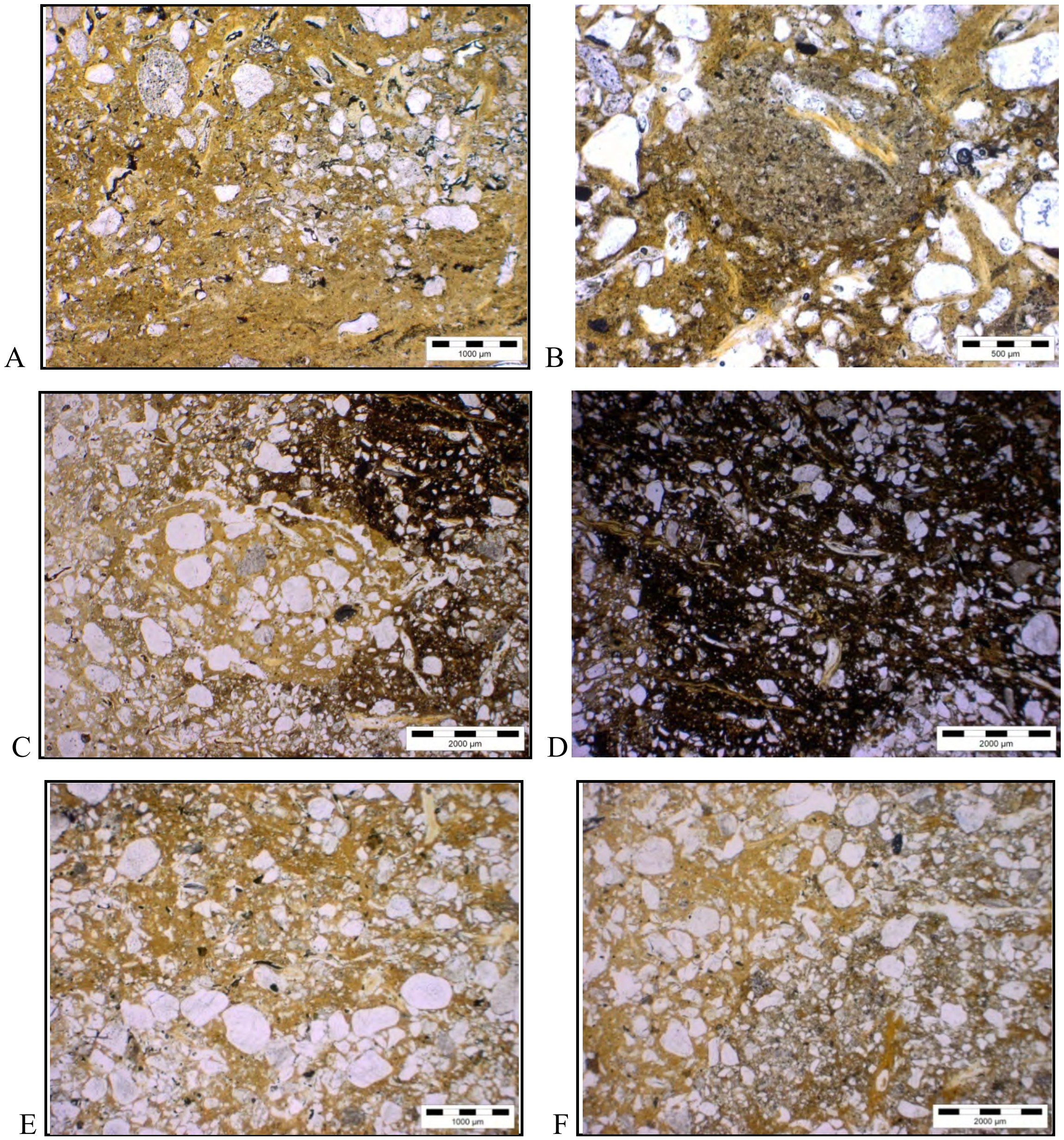


Fig 8.12 Clevigarth: a. Clev 2iii Sandy soil created over peat; b. Clev 3 Exogenous nodule, calcite; c. Clev 3 [3003] Mixing of sandy soil, peaty material and dark organic (turf impregnated with manure?); d. Clev 3 [3004] Turf with roots running sideways; e. Clev 3 Surface between [3002] and [3003]; f. Clev 3iii Surface between zones [3003] and [3004].

When Profile 3 was excavated, context [3003] was clearly quite different from any context within Profile 2 and was, therefore, sampled. Contexts [3002] and [3004] were also sampled. The earliest context [3004] includes patches of very organic mineral-free groundmass, possibly manure. The less organic peds include differing amounts of minerals to one another. There is also a fragment of turf which is horizontal, at right-angles to its naturally occurring orientation, within the profile (fig 3.12d). A brown ped which contains calcitic mineral is clearly different from the rest of the context and must have been imported. There is also clay accumulation within the context, which is a partially developed anthrosol, probably a former land-surface. There are rare organic coatings visible in all three contexts. In context [3003] the amount of black organic flecking in the micromass increases, and the colour of the peds is more varied. Primarily pale to mid brown, the context includes an area of dark brown which contains coarse amorphous black organic material. This may have originated as manure and the context is mixed although less well amended. Context [3002] also contains black flecking but this, together with the rare organic coatings, are the only signs of cultural amendment, indicating that the level of cultural activity reduced at this time.

Summary of Conclusions at Clevigarth

1. The earliest activity identified at Clevigarth comprised cultivation in one or two episodes. It was not intensive, the soil being amended with unburnt turf fragments which were mixed with charcoal, suggesting that this is domestic waste. The level of activity gradually diminished to nothing. These soils are therefore similar to those previously examined in the immediate vicinity of the broch, radiocarbon dated to the Neolithic/Bronze Age (Guttmann *et al.*, 2008) and probably also date to that period. Field observation suggests that this was also the case in the earliest levels of Profile 3. Interestingly, this area is some distance from the only recorded

Neolithic/Bronze Age house in the area and there are no boundaries here relating to early prehistoric activity. The remains of an early structure may underlie the broch or amongst the structural remains located around it.

2. The creation of the broch boundary, leading to differential use of the land on either side.
3. The land outside the broch boundary is cultivated, with manure and turf being added to the soil. Activity here diminishes over time. The most actively managed soil is only 0.05 – 0.1m deep, but this may be because it was at the edge of a more heavily managed area, or because it was only in use for a short period of time. Similar soils which have been observed in Greenland were in use for approximately 200 years (Adderley *et al.,* 2006). There is no cultural information contained in Profile 2 relating to how the land inside the field boundary was managed, and the hypothesis proposed is grazing. Further evidence supporting this interpretation can demonstrated by linking in the boundary evidence but brochs are usually situated on high, less cultivable, ground and it is therefore fitting that, in the majority of cases (Old Scatness being a notable exception) the land immediately around the broch would be grazed and cultivation would be carried out beyond the broch boundary.
4. Today the land is used as rough grazing.

HAMAR VIKING/NORSE SOIL PROFILES

Five soil profiles were excavated at Hamar, from which seven kubiena samples were taken. These were located at, or close to, the positions of previous augering sites. Profiles Y and H were located within the Upper and Lower yards, respectively. Profiles Q, AA and S were located to the south of Upper Hamar, with Q and AA to the west of Lower Hamar and S to the south of Lower Hamar. These three were situated amongst earthwork lynchets, aligned down the hill. During fieldwork the lynchets were interpreted as the result either of agriculture or the remains of turf stripping of the hill. Evidence of turf stripping was identified during the excavation around the Lower Hamar longhouse (Bond *et al.,* 2012). On excavation, soil profile AA (to the east of a lynchet) appeared to be identical to that on the west side of the lynchet at Q, and therefore AA was not sampled for micromorphology.

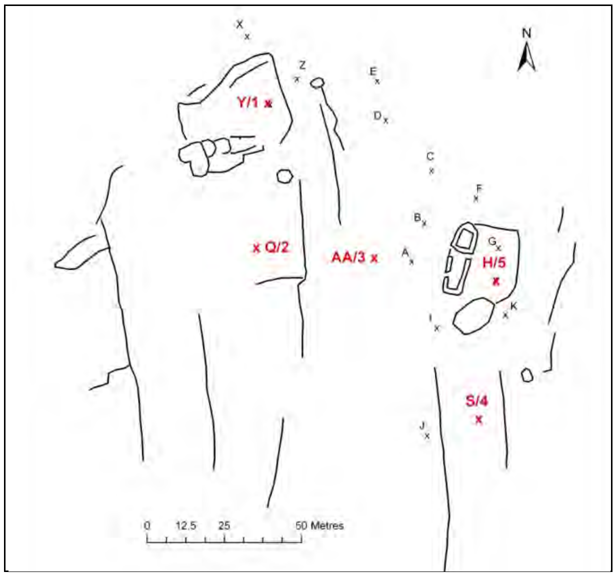


Fig 8.13 Location of soil profiles excavated at Hamar

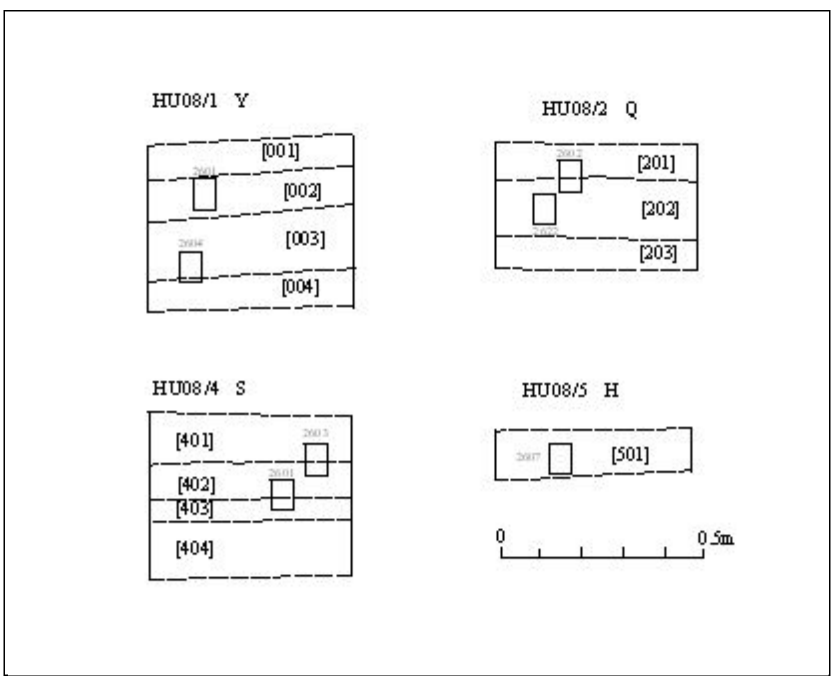


Fig 8.14 Profile sections excavated at Hamar

Soils Environment

The local bedrock at Hamar is part of the Leslie Association, comprising drifts derived from ultrabasic rocks (Dry and Robertson, 1982: 43-44). The Soil Survey of Scotland describes the parent material as rock rubble and rock "dominantly brown or yellowish brown medium- and moderately-fine- textured drift derived from serpentinite" 50-70cm below the surface. The soils comprise magnesian gleys with some brown magnesian soils, ranker soils and locally peaty alluvial soils. The soils developed on thin drift or rubble rock (*op. cit.:*46). Soils of the Leslie Association are described as including mineral horizons, which are "generally dark coloured with a high organic-matter content" rarely exceeding 15cm. The soils are base rich, with particularly high levels of iron and magnesium with "soluble phosphate becoming rapidly unavailable in combination with free iron and herbage may contain amounts of nickel ... which are toxic to grazing animals" (*op.cit*.: 44). Today the land is used as cattle grazings. Prior to excavation, archaeologists believed that the earthwork remains of the longhouse at Lower Hamar were so clear because occupation was short-lived in this unpromising agricultural location (Noel Fojut, *pers. comm.*)

The soil profiles demonstrate the accretion of mineral material due to colluvium (hillwash) over the period in which the hillside was in use, but the rate varied over time. Changing rates of accretion are likely to either result from differing intensities or practices on land higher up the slope. The mineral material in the profiles was generally angular, some contexts being moderately sorted, others being unsorted. This might indicate different causes of accretion, but is more likely that colluvium was a continuous process and that the differences observed were the result of the activity at the profile locations. The upper levels of the profiles are disturbed by rootlets (some remaining as parenchymatic material) and are also bioturbated. Phytoliths, some articulated, are present within the profiles, occurring in voids; evidence for the decay of plant material in situ. They indicate sporadic episodes of a water-sodden environment, an interpretation supported by the presence of mobile iron in the groundmass and iron nodules in some contexts, as well as the presence of stone rims: all indicating a wet, acidic, environment. In Profile Y, it is clear that the iron is leaching out of the organic material. The base of context [402] has a tendency towards peaty-ness, further evidence of a wet environment.

Results and Discussion

Profile Y was excavated within the yard associated with the longhouse at Upper Hamar. The profile was 0.4m deep, containing four contexts, three of which were sampled. Slide 2601 sampled the context below the top soil, [002] and 2064 sampled contexts [003] and [004] which lay stratigraphically below.

Of the four contexts sampled in Profile Y, the earliest, [004] is quite different from the later ones. The soil is coarse mineral based, the majority of which has organo-mineral coatings. All four contexts in Profile Y include peds of more than one type but the only context with sharp boundaries was [004]. The subtle changes to the textural pedofeatures below the mineral material indicates disturbance. Although Upper Hamar was located approximately 10m higher up slope than that at Lower Hamar, the land within the yard appears cultivated. The increase in well sorted mineral material [004a], and the subsequent cessation in activity, may indicate the construction of the Upper Hamar house and the creation of the yard. There are traces of an older land surface with approximately horizontal changes in the peds identifiable with fine material between the line of mineral material. Two bone fragments and pieces of charcoal are situated within this boundary horizon. Context [003] is more organic, containing weathered serpentinite flecks. The mineral content is well sorted. The variation in colour does not have sharp boundaries and there is no sign of either cultivation or compaction. The context above this [002], is very organic with little structure visible and is the only context from which charcoal is completely absent. Although it contains more mineral material than that below it, this is both abraded and angular.

In contrast with the Upper Hamar yard, the Lower Hamar yard profile was only 0.1m deep and only one context [501] was identified in the field at Profile H. The plant remains are inevitably fresh in such a shallow soil; the blocky structure, with continuous voids, and excrement, indicate that the soil is biologically active. The coarse:fine ratio increases significantly with depth (1:1 at the top; 19:1 at the bottom) probably due to the friable nature of the bedrock. At the top of the context the coarse material is organic: minerals are dominant at the base. Chambers arise primarily from the decay of plant material. There is no evidence that the soil has been cultivated or culturally amended. The shallow depth of the soil (11cm) together with the excavated evidence (Bond *et al.*, 2013) demonstrates that turf stripping took place here, probably in the 17th century.

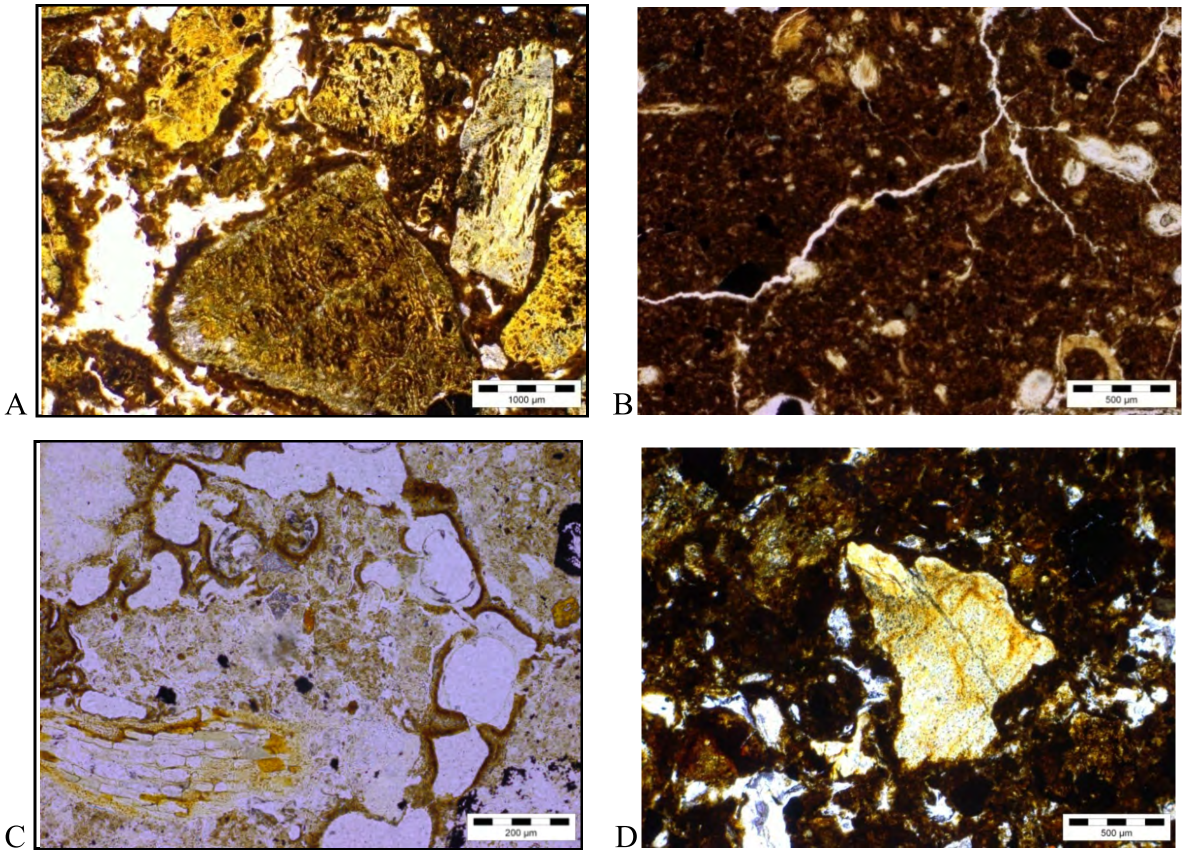


Fig 8.15 a. HU08 Very organic silt coatings around minerals; b. HU08 H[501] Channel structure; c. HU08 Q2/2 Silty coatings of voids and articulated phytoliths; d. HU08 S2 Bone

Profile Q was taken west of Lower Hamar longhouse, subsoil being contacted at 0.23m. Three contexts were identified in the field: slide 2602 sampled the boundary between contexts [201] and [202], whilst 2622 was taken from the middle of [202]. Context [202] looked sufficiently different in slide 2622 to its appearance on slide 2606 to suggest that there was an additional context present [202a] which was not observable in the field. The subsoil [203] was not sampled.

Profile Q indicates two major phases of activity. The earlier context [202a] is the most disturbed, evidenced by the juxtaposition of peds of at least four different shades of brown containing varying amounts of organic material and also by the accumulation of silt.

Clusters of fungal spores indicate manuring. Rare to very rare fine charcoal flecking throughout the profile, fragments of what appears to be pottery, either unfired or fired at a low temperature (red, but not increasing in intensity under OIL) and the presence of fish bone all suggest low intensity spreading of domestic waste. However, clusters of both bone and pottery, as well as the variations in colour under OIL, indicate that this was not well mixed. Context [202] includes less well developed peds and poorly sorted coarse material. This may indicate a period of less intensive use, possibly a change from arable agriculture to grazing.

The coarse organic component of Profile Q increases with depth. There is a further increase in coarse material, particularly serpentinite, in [201] possibly indicating hillwash, which could have made the land less cultivable. There may have been a short-lived attempt to use this land as arable, but any attempt to amend the soil with domestic waste or manure had ceased and the land was probably given over to grazing.

Profile S lies south of the Lower Hamar longhouse and is therefore the lowest profile from the sloping hillside. Four contexts were identified: 2603 sampled the topsoil [401] and the context below, [402]. Slide 2608 sampled contexts [402] and [403]. The subsoil [404] was not sampled.

Profile S includes three phases of activity. Context [403] is very disturbed and very open, with dominant organic silt coatings indicating cultivation. Burnt bone and charcoal suggest a degree of amendment of the soil. The bottom of context [402] includes fewer coarse grains and is more compact than [403]. However, the coarse:fine ratio of the context varied from 9:1 at the top, to 2:1 at the base, suggesting an increase in disturbance on the land higher up slope, whether due to an increased intensity of agricultural activity, turf stripping or the result of building the longhouse. The frequent organic silt coatings and the accommodated peds of differing shades, differing organic and differing mineral content, indicate that the context has also been cultivated. The variation between the peds indicates that the soil was a composite. The presence of fungal material suggests manuring, potentially accounting for the more organic peds. Apparently unfired pottery and charcoal also suggest cultural amendment. The top of the context is clearly demarcated by a line of mineral material. There is less iron mobilisation in the soil, so the soil is potentially more productive. Where the line of mineral material is discontinuous, the upper horizon is lighter than that below it. This might mark a time of increased colluvium accumulation increased (possibly due to a change in use of the land above, such as the 17th century turf stripping) which made the land unviable for cultivation. The context immediately below the turf line, context [401], is more organic, with a low mineral content and chambers forming due to the decay of plant material. Variations exist between ped colours, but none contain significant amounts of mineral material, although they vary in compactness. This suggests that some disturbance of the ground, whether deliberate manuring (some fungal spores were present) or turning over the top surface. There is no indication that this top soil has ever been cultivated, the final phase of activity being grazing.

<u>Summary of conclusions concerning the use of the hillside at Hamar</u>

1. Building the sunken floored building underlying the longhouse was the earliest construction event on the hillside and it is possible that the earliest use of the land below it (evident in the very disturbed and open context at the base of Profile S)

was contemporary with its occupation. The subsequent disturbance may then have been the result of the construction of the Lower Hamar longhouse. This suggestion has to be treated with caution as there are no dates for the soil profiles and information derived from Profile H suggests that the longhouse and its associated yard were created on previously unused land. This could be explained as a later use of the land at H, which is upslope from S, or by the truncation of the profile due to soil stripping in this area. It would take further work and dating evidence to resolve this.

2. If it had not taken place before the construction of the longhouse, the cultivation of the land below Lower Hamar, seen in Profile S, would have begun. (Stone rims show this soil eventually became acidic.)
3. Expansion and intensification of agriculture. Land to the west and also at least 10m to the north, above Lower Hamar, was taken into cultivation as evidenced at Profiles Q, AA (not sampled due to its similarity in the field to Profile Q) and Y. The pedofeatures contain varying amounts of organic and mineral material, demonstrating that the soil was a composite, perhaps augmented with turf from other parts of the hillslope. The more mineral rich, less organic, peds may be derived from colluvium washed down the hillslope. The field was also manured and there was a low intensity addition of domestic waste. The low lynchets, aligned approximately north-south down the slope of the hill, may relate to this period. The archaeological evidence indicates that the land supported a good crop of barley and that arable farming was practised in the area during the life of both longhouses (Bond *et al.,* 2013).

4. Construction of Upper Hamar house and yard. There was an increase in the ratio of mineral to organic material seen in Profile Y, possibly relating to this. The surface is identifiable and contains charcoal and bone.
5. The archaeological evidence indicates that cultivation continued as before on the remaining land.
6. i. An increase in colluvium, evidenced as an increase in mineral material. This may have been caused by, or the effect of, changing land use. It may have been associated with the turf stripping around the area of Lower Hamar in the 17th century seen in the archaeological evidence (Bond, 2013).

   ii. The yard at Upper Hamar was abandoned and possibly used as a garden plot. There is evidence of low intensity disturbance, in the form of silt coatings.
7. An increase in colluvium throughout the area, followed by a possible short lived attempt at cultivation. (Low level disturbance, with some coating and some difference in mineral and organic content and colour of peds, but no manure or cultural material added).
8. Grazings. The use of the hillslope as grazings continued until present. Today the land supports cattle.

BELMONT VIKING/NORSE SOIL PROFILES

Three soil profiles were excavated at Belmont. Profile 1 lay within the north yard, and Profile 3 was excavated within the smaller south yard. Profile 2 lay to the east, above the longhouse and yards, within the enclosed infield. One kubiena sample was taken from each profile, as all the profiles were shallow (between 20-28cm deep). The present ground surface is poached (primarily by Shetland ponies), wet and eroded and the profiles were located in areas where augering suggested that the soils were deepest. Three contexts were identified at each profile in the field, although at Profile 3, the south yard, this includes the friable bedrock. Profile 2 was the most complex of those excavated and a broken line of organic material located within context [B202] was recorded as a separate context [B203]. This context was interpreted in the field as the fragmentary remains of an early land surface. Although not observable in the field, microscopy demonstrated that the material below [B203] was different in character to that above and below it, and so the lower layer has been recorded as [B204a]. Microscopy also demonstrated that context [B202] comprised six linear zones, each of which has been recorded individually.

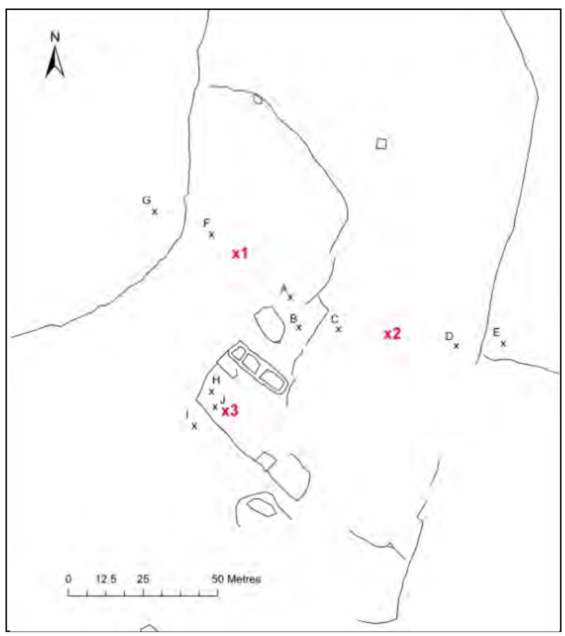


Fig 8.16 Location of soil profiles excavated at Belmont

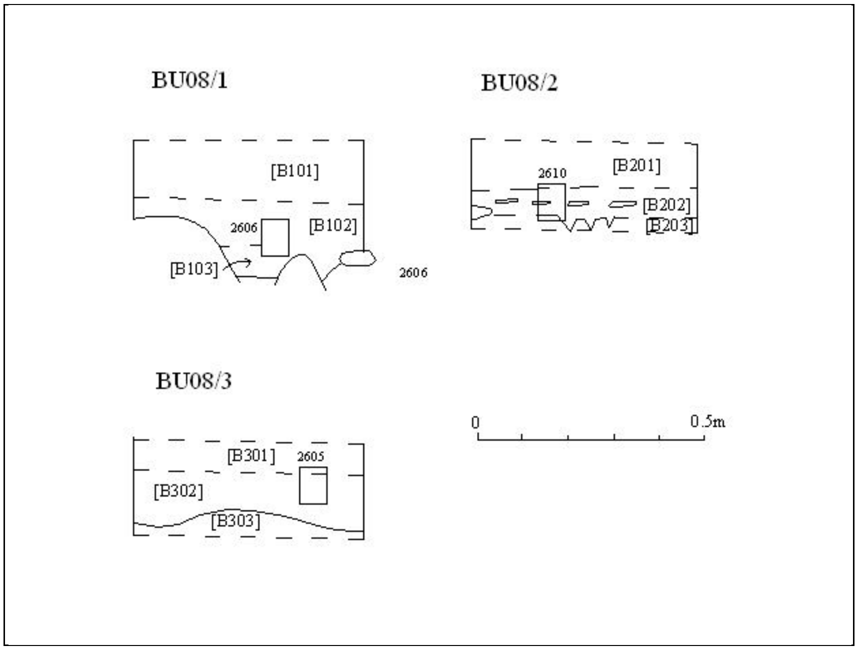


Fig 8.17 Profile sections excavated at Belmont

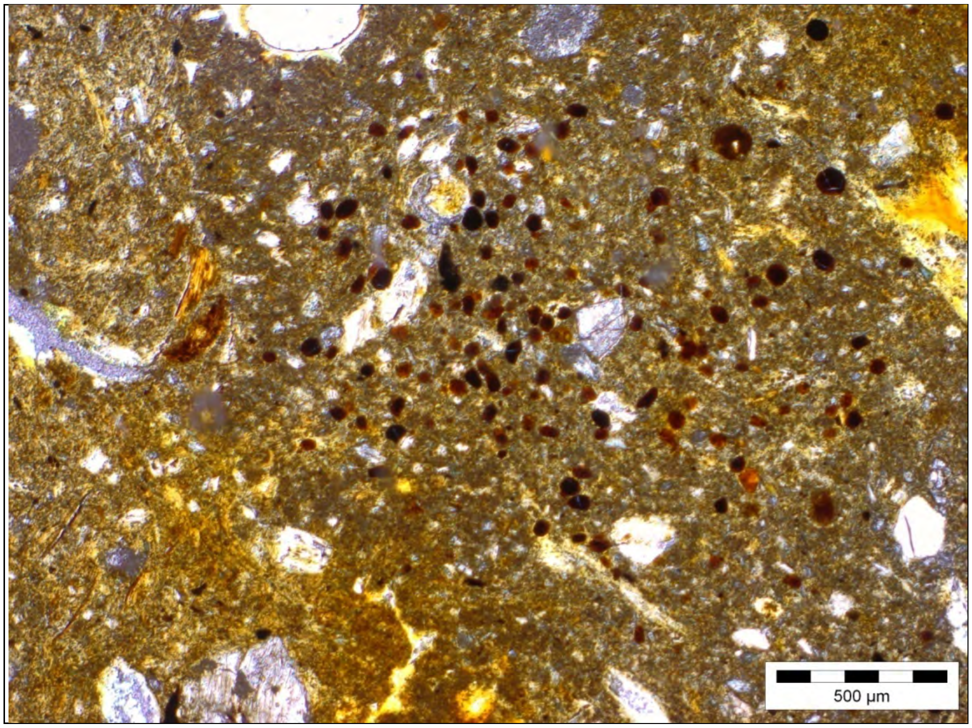
Soils Environment

As at Hamar, the local bedrock is part of the Leslie Association, comprising drifts derived from ultrabasic igneous rocks (Dry and Robertson, 1982: 43-44). The difference between the two areas, as described by the Soil Survey of Scotland, is the preponderance of strong and very steep slopes which are generally strewn with rocks and boulders. The soils comprise magnesian gleys and rankers which have developed on thin drift and on rock. It describes the parent material as rock rubble and rock, which have relatively high grazing values but which cannot be improved mechanically due to both slope and rockiness (*op. cit.* 46).

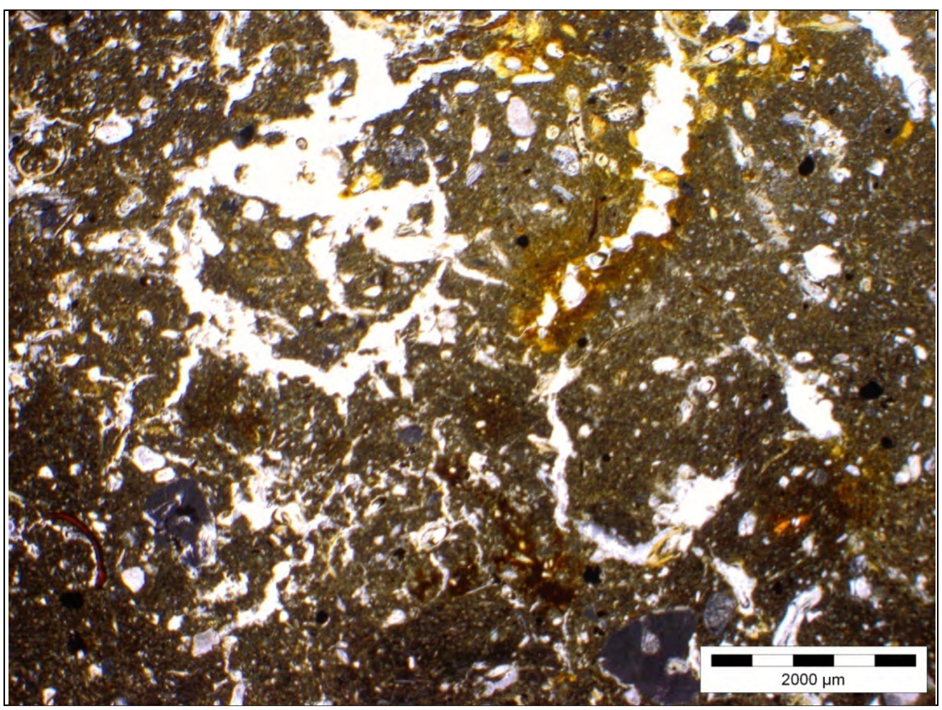
The soil profiles strongly reflect the Soil Survey description of the Association: Profiles 1 and 3, located in the two yards, comprised peaty gleys. Only Profile 2, located in the infield, contained contexts described in the field as silty. The mineral content of the profiles may be alluvial, since the mineral component of Profile 2 is moderately sorted at the top and moderately to well sorted through the mid zones. It is poorly sorted at the base, although the fragments are angular. There is banding in context [B202] (Profile 2) which does not respect the pedofeatures. The variation in the quantity of phytoliths present throughout this context indicates that the amounts of vegetation and/or water in the soil fluctuated. The bands themselves have micro-bands within them. They are parallel to one another, which also indicates that water is likely to be key to their formation. The presence of iron accretion in all but one context is likely to be the result of plant decay, although iron has leached out of one horizon. This banding is therefore interpreted as related to the formation of iron pan.

Today the hillside is wet, and seasonally extremely wet, and excavations of the longhouse have demonstrated that water running off the hillside was a problem which the longhouse residents managed with drainage (Larsen *et al.*, 2013). This suggests that the hillside was not consistently peat-covered at the time, as peat would impede mineral movement. An alternative cultural explanation for some of the mineral content is explored below. The upper levels of the profiles contain parenchymatic (fresh) material, which in Profile 3 is up to 50mm diameter, and there is rare excrement in context [301] demonstrating that these contexts are disturbed. The profiles are silicaceous, silica filling voids derived from decaying plant material in situ. There are dense concentrations of phytoliths in both Profiles 1 and 3, as well as very rare diatoms, resulting from the wet environment. The presence of a pollen spore in Profile 3 also indicates a wet environment. Iron is mobile in the groundmass and Profile 1 contains a pale yellow grey context which is iron depleted. The iron is clearly leaching from decaying organics and the variation in ped colour in

Profiles 1 and 3 reflects both differences in the decay of organic matter and the relative amounts of iron present.



A



B

Fig 8.18a. BU08 [102] Small nodules of iron accreting within a dense iron rich environment; b. BU08 [103] better drained, spongy, enaulic structure, iron mobile in soil

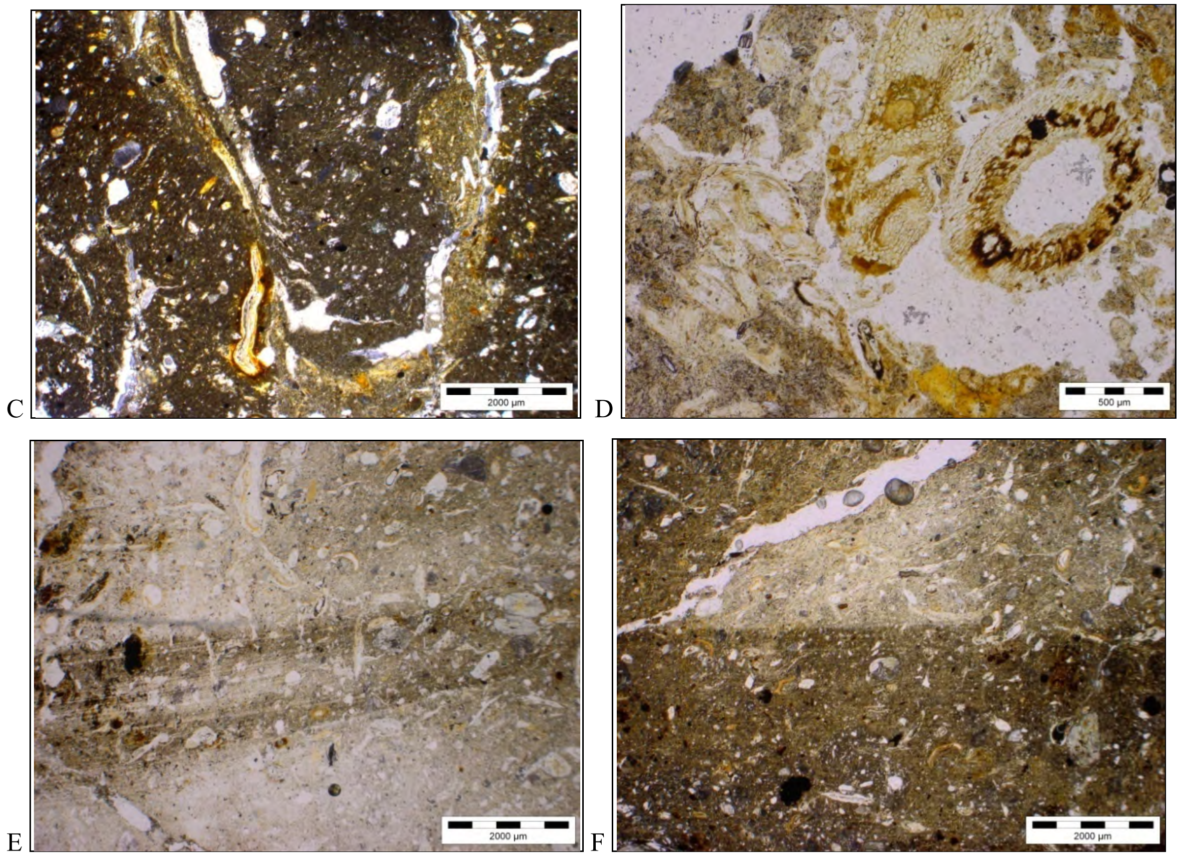


Fig 8.18 c. BU08 [103] silt accumulation within void; d. BU08 [301] organic rich cellular material; e. BU08 [202] banding within organic silt; f. BU08 [202] modified fossil soil

Results and Discussion

The soils of Profile 1 are very dense with no evidence of amendment. There are no coatings of the coarse mineral component of either context and the very rare occurrence of bone could result from natural processes. The concentrations of phytoliths and diatoms, the silicaceous/calcitic material in the voids and the movement of iron in the soil, all suggest that the soils were wet pasture. Only two fungal spores were identified and these were not in close proximity and so cannot be taken as a livestock indicator. The lack of livestock indicators suggests that the pasture was harvested rather than grazed. Although this area is interpreted as the North Yard, there is no visible sign of a yard surface or significant alteration in use. The profile is shallow (28cm at the deepest point) and while it may have been truncated there is no evidence for this.

The soils of Profile 3 are fairly dense, with no conclusive evidence of amendment or cultural material. Concentrations of phytoliths and diatoms, the silicaceous/calcitic material in voids and the movement of iron in the soil suggests that, as in Profile 1, these soils were wet pasture. Organic material is evident throughout the profile and the soil would have supported a productive pasture, attractive for spring grazing. As with the North yard, there was no clear indicator of a yard surface. They may have been sufficiently short lived to have little impact on the soil profile, but it is only 20cm deep and therefore possibly truncated with the removal of cultural layers.

The high mineral content at the base of Profile 2 shows that the infield area was reasonably well drained. Ard marks were identified in the field between contexts [B202] and [B204], consistent with the very angular division between contexts [B202] and [204a], evident from slide 2610 even without a microscope. At the macro level there appear to be two adjacent sub-rectangular peds, one on top of the other, each having a corner at the lowest point. Each is topped with the darker organic material, interpreted as a possible early land surface during fieldwork, potentially the organic component (grass) of ard-ploughed or spade turned turf.   Excavation did not reveal the plethora of ard points usually associated with an ard-worked soil (e.g. Scord of Brouster, Whittle, 1986) and the rocky land is not well suited to ard ploughing, making digging more likely. Below the ard, or spade, mark the soil is very homogenous; above it, context [B201] varies in colour and the darker areas include a higher density of mineral material, suggesting the addition of soil and/or turf to the soil.

Despite the disturbance there is a lack of coatings, cultural evidence or manure, and this may indicate that the digging/ploughing was carried out in order to improve the productivity of grassland in the infield rather than to facilitate arable cultivation. Apart from a single fungal spore in [B204a], fungal spores and excrement were both absent from the profile, suggesting that the field was not manured. The main function of the infield may have been to harvest the meadow, rather than graze it.

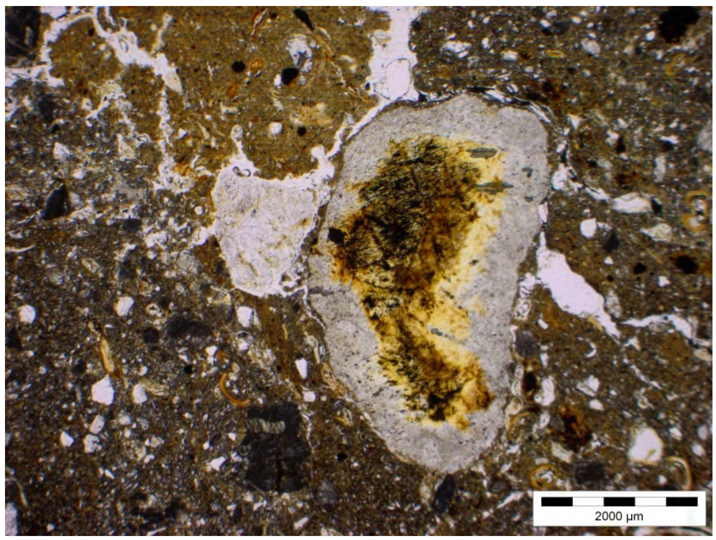


Fig 8.18g BU08 [202] mineral with bleached stone rim set in a mixed groundmass

The mineral component of the contexts tells an interesting story. In Profile 1 the lowest context sampled [B103] contained more subangular serpentinite (5-15%) than the contexts overlying it (0.5-2%), although the reverse was true of the quartz (15-30% in [B102] but 2-5% in [B103]) and olivine (2-5% in [B102] but <0.5% in [B103]). In Profile 3 both contexts contain subangular serpentinite, up to 1600µm and angular flecks of quartz averaging 20µm. The coarse mineral component of Profile 2 is moderately sorted at the top and moderately to well sorted through the mid zones, but poorly sorted at the base incorporating larger mineral material (on average 1600µm). Serpentinite and quartz are very rare to very few and there is very rare olivine at the top of the profile, although olivine only occurs in one of the zones within [B202]. The mineral content of [B204a] is far higher, with 15-30% serpentinite and 5-15% quartz. The greater serpentinite content of the lower context of Profile 1, the greater size of the serpentinite compared with the quartz in Profile 3 and the greater content of serpentinite in context [B204a] are hard to explain away as local variations in the mineral component of the drift. However, excavation has demonstrated that working the serpentinite (and there are worked outcrops higher up the hill), played an important role in the economy of the longhouse (Larsen *et al.*, 2012). It is therefore possible that the observable increase in size and quantity of angular serpentinite is the result of working these outcrops, whether this reached the infield as a direct result of quarrying, as colluvium/alluvium, or whether it comprised part of the domestic waste which was spread on the fields and which is virtually invisible in all other respects.

Summary and Conclusions

Profile 2 lies within the area of hillside interpreted as the infield at Belmont.

An undisturbed, or very lightly used, mineral soil was brought into use and improved by digging or ard ploughing and the addition of turf, although it lies at approximately 40m AOD, above the longhouse. The amendment of the soil may be Bronze Age, and spade dug as there is a lack of ard points in the archaeological record. There are two groups of rock-cut cup-marks in the vicinity, presumed to be Bronze Age, one demonstrably predating the construction of the Belmont longhouse (Larsen *et al.,* 2013). The land surface [B203] may be later, as there were no traces of cultivation in the yard areas.

The subsequent addition of turf to the soil may correspond to the Norse use of the infield. The Norse inhabitants at Old Scatness partially relied on the inherent fertility of the soils, although they added some domestic waste (Turner, *et. al.*, 2010). Since the infield was a large area to which to add waste, perhaps the lack of domestic material seen at Belmont is not surprising. There is no evidence that the land had a Norse arable use and it was probably silaged and seasonally grazed.

The North and South Yard areas (Profiles 1 and 3) show no evidence of their use as yards or of amendment at any period. They are both wet and would have supported a productive pasture suitable for spring grazing; a lack of livestock indicators suggests that the grass was harvested rather than grazed. It is possible that these profiles have been truncated by turf/peat stripping, but there is no direct evidence for this beyond the lack of cultural evidence associated with locations interpreted as yards, adjacent to domestic settlement.

Excavations at Belmont (Larsen *et al.,* 2013) suggest that whilst the Belmont longhouse did function as a farm, its location close to outcropping soapstone was significant to the economy of the settlement. There is clear evidence of large scale soapstone working within the longhouse.

Table 8.5 Summary of Results from Key Contexts Relating to Agricultural Practice

Context	Environment	Soil Type	Mineral Component	Amendment	Cultural Features	Biological Activity	Interpretation
HOULLAND HN D [103]	Wet, Acidic, Iron Rich Accreting (colluvial)	Peaty, colluvial	Limestone, Calc Schist Unsorted compounds ≥50%	Introduced material? (or mixing). Manure.	Sharp boundaries, variety of shades, mineral density & concentrations black organic. Horizon black organic & rare fungal spores Broken organics		Hints – cultivation. Grazing
HN D [102]					Clay accumulation Dusty silty infill Mixed organic & mineral peds	Areas of crumb structure	Low intensity cultivation
HN E [204]	Wet, Acidic Accreting (colluvial) Iron Rich	Peaty, colluvial	Mod. sorted, Predom. quartz	Accretion	None		Disturbance upslope
HN E [204a]			Quartzite, feldspar, sandstone	Mineral material imported (not local geology)	Clay accumulation Peat disturbance – mixed peds 2x dark horizontal bands, linearity to phytoliths & minerals		2 phases of cultivation
HN E [203]					Group of charcoal frags Black organic flecks		Clearance by burning
EXNABOE B [203]	Wet, Acidic, Iron movement	Podzolic	Sandstone, poorly sorted	Accretion. Incidental addition of dung due to animals present	Fibrous organics, phytoliths, fungal spores	Crumb structure	Grazing
B [202]				Manure	Organic material, some shredding Textural coatings		Cultivation

PINHOULLAND D1 [4008]	Wet, Acidic, Accreting	Peaty ranker/ peaty	Unsorted Quartz, feldspar, biotite	Accretion	Mixed groundmass Phytoliths, diatoms both in lighter peds		Lightly cultivated
D1 [4007b]	Well drained Accreting (colluvial)	Organo mineral Peat indicators absent	moderately well sorted	Created or intensively reworked soil Manure?	Organic coatings, Mixed groundmass, No phytoliths, diatoms, or peat. Fungal spores		Cultivation increasing
D1 [4007a]	Wet, Acidic	Peaty, Accretion (colluvial)	Well sorted	Accretion (Midden or burning upslope)	Charcoal flecks & amorphous black charcoal		Disturbance & midden? upslope,
D1 [4006]	Wet, Acidic	Peaty silt	V. rare quartz	Incidental addition of dung due to animals present	Black organic material, some shredded		Grazing
D1 [4003]	Well drained	More mineral based, peaty peds included	Feldspar and quartz – less varied than accreting mins – imported with turf?	Turf Charcoal flecks (domestic midden?)	Black organic with mineral inclusions, flecked micromass, frags of diatoms, phytoliths		Cultivation
D1 [4002]	Wet, Acidic	Peaty silt	none	Charcoal-accreting or cultural?	Charcoal (rare)		Light cultivation / edge of midden/ upslope disturbance
H1 [1003i]	Wet, Acidic	Peaty silt	Varied between peds Well sorted		3 aggregate types – differing min & b-fabric Bright orange OIL		Clearance - Burning in situ
H1 [1003ii]			None		Horizontal bands of colour of organo mineral. Black flecks (organic) Darker under OIL		Burning – not necessarily in situ
J [5004]	Wet, Acidic	Peaty ranker	Fairly well sorted		Amorphous black flecks Some linear compression		Hint of cultivation

					(denser & strong linearity)		
D2 [6004b]	Well drained	Brown earth	Unsorted Quartz, olivine, compound	Turf (organic content disappeared) – added or in situ? Domestic waste	3 aggregate types: darkest – highest min content; lightest – fine organics & manganese & silicaceous (fractured phytoliths & diatoms, charcoal flecks in brown earth		Relict land surface Cultivation (1)
D2 [6004]	Wet, acidic	More peaty, hint of podzol	Unsorted, quartz, olivine, feldspar, compound		Linear darker phase Disrupted iron pan		Land surface Cultivation (2)
D2 [6004a]					Small amount of brown earth		Cultivation (3)
D2 [6003]		Peaty silt	More coarse, quartz, olivine, feldspar, compound	Very high turf content	Subtle boundaries to peds, areas of black organic b-fabric Silicaceous, inc. cell material	Crumb structure	Turf being dumped – structural?
H2 [2005]	Wet, acidic	Remnant of podzol	Unsorted, quartz, feldspar Compound common	Turf stripping?	Fungal spores Clay coatings Organic content low	Weak crumb structure	Traces of cultivation but not an A horizon – turf stripping?
H2 [2004]	Wet, acidic, fe depleted. Small patches of fe accretion		Unsorted, quartz, feldspar Compound frequent		Fungal spores Organic coatings Clay coatings of minerals & voids	Weak-highly separated crumb structure	Cultivation
H2 [2003]				Turf	Black organic, mineral incs. Clay & organic silt coatings	Areas of crumb structure	Hints of cultivations x2
CLEVIGARTH P2 [2005]	Wet, acidic, Accreting (aeolian)	Peat with windblown sand	Calcareous sand (well sorted, small, angular frags)		Some clay movement Uniform dark brown, homogenous		No cultural activity
P2 [2004]	Less acidic, accreting (aeolian)			Turf	Black organic with dense areas of small minerals Organic silt & clay		Low intensity cultivation

					coatings, mixed shades in groundmass		
P2 [2003]	Accreting (aeolian)			Turf Midden (Charcoal)	Black flecked b-fabric Dense areas of black organics containing minerals Dusty clay accumulation Organic silt coatings		Moderate intensity cultivation
P2 [2002]	Sand increasing	Windblown sand, silty organo mineral	Calcareous sand	(Increase of windblown sand)	none	Weak crumb structure	No cultural activity
P3 [3004]	Accreting (aeolian)	(Less peaty than P2) Silty peat, Accreting (aeolian) Partially developed anthrosol	Calcareous sand Sandstone (absent from P2)	Manure	Patches v. organic groundmass Mixed aggregates, differing mineral densities Turf upside down in profile Calcitic brown ped Clay accumulation Horizontal surface at top Organic coatings		Moderate-high intensity cultivation
P3 [3003]	Accreting (aeolian)	Anthrosol. Less well developed	Calcareous sand Rare sandstone	Manure? Midden? Less well amended	Increased black organic flecks in b-fabric. Varied colour peds; dark brown contains coarse amorphous black organics		Moderately cultivated
P3 {3002]	Accreting (aeolian)	Sandy silt	Calcareous sand Sandstone frequent		Black flecking Rare organic coatings		Low level cultivation
HAMAR Y [004]	Accreting (colluvium) Periodically wet, acidic	Angular, coarse serpentinite	Mineral based		Sharp boundaries between peds		Disturbance upslope, some low level cultivation
Y {004a]					Horizontal changes in		Low intensity

				Domestic waste?	peds 2 bone fragments, charcoal Mixed: subtle boundaries		cultivation (land surface)
Y [003]		Increasingly organic	Well sorted, serpentinite frags		Mixed peds, subtle boundaries No compaction		None
Q [202a]	Accreting (colluvium)	Peaty. Organo mineral	Rare quartz (mod. sorted)	Low level of domestic waste inc some manure	4 shades of ped, varying amounts of organics. Silt accumulation Silty clay coatings dominant Clusters of fungal spores Fine charcoal flecks Pottery? & fish bone – group, not mixed		Low level cultivation (lack of mixing)
Q [202]	Accretion (colluvium)	Organo mineral	Serpentinite Poorly sorted	None	Peds less well developed		Grazing?
Q [201]	Increase in accretion (colluvium)		Increased serpentinite	None			Grazing (cultivation unviable due to accretion?)
S [403]	Accretion (colluvium)	Organo mineral	Coarse	Domestic waste	Mixed, open structure Organic silt coatings Burnt bone, Charcoal		Cultivation
S [402]	Accretion (colluvium)	Organo mineral	Less coarse, more dense at top than base. Serpentinite frequent	Domestic waste	More compact Organic silt coatings Peds of diff shades, organics & mineral content Fungal spores Pottery & charcoal Compact line of minerals at top		Disturbance upslope increasing, mixing reducing. Cultivation
S [401]	Accretion	Organo	Traces of	Manuring or	More organic, mixed	Roots	Grazing

	(colluvium)	mineral	serpentinite	turning over of top surface	colours, differing compactness Charcoal	(parenchymatic)	
BELMONT P2 [B203]	Reasonably drained, eroded	Peaty ranker	Moderately sorted, dense		Broken line of organics		Early surface, No cultural activity
P2 [B202]	Wet (fluctuating) Acidic Fe accretion	Peaty gley	Moderately sorted	Soil &/or turf	Peds varied colour, darker areas inc. higher density of mineral material		Possible cultivation
P2 [B204a]			Poorly sorted, large mins, dense content		Angular boundary, 2 sub-rect. Peds, one overlying the other, with dark org above each : ard marks		Ard /spade disturbance Meadow for harvesting
P3	Wet pasture, acidic, eroding	Peaty gley	Subangular serpentinite		Homogenous Concentrations of phytoliths, diatoms, silicaceous Organic		Pasture – spring grazing
OLD SCATNESS Q2 [5719] Early/Mid Iron Age	Well drained. Edge of settlement Accretion (aeolian)	Windblown, calcitic sand, well sorted Anthrosol	Subangular, calcitic sand, some shell	Midden Peat ash	Mammal bird bone, few phytoliths, rubified material Bright orange – OIL Mixed mineral Organic Spade marks		Intense Cultivation
Q2 [5718] Mid Iron Age				Peat ash increases. Turf	Rubified material Charcoal Organic Mammal/bird bone Brighter orange – OIL Mixed mineral in organics Rare phytoliths Ard marks	Excrement of soil animals	Very Intense Cultivation
L [2064] & [2063]	Well drained Accretion	Windblown, Angular	Quartz sand	Turf Turf/peat ash –	Ard marks at base Charcoal in b-fabric		Intense cultivation x2

	(aeolian)	quartz sand Compound quartz Anthrosol		in excess 800°C. Midden	High silica content Unburnt bone& organic		
L [2062]	Well drained Accretion (aeolian)		Quartz sand	Fuel ash – turf Wet midden	Charcoal & minerals embedded in organic Higher organic content Iron (not in situ) Vivianite, fungal spores		High intensity cultivation
L [2061] [2060] [2059]	Well drained Accretion (aeolian)		Compound quartz increases in size		Decrease in bone Rise in excrement Less fine material Less bone & charcoal	Increased activity – open, reworked	Cultivation reducing in intensity x3
Q2 [5714] Viking	Freely draining, accreting (aeolian)	Windblown, calcitic sand. Poorly developed anthrosol	Calcareous sand, shell	Peat ash Peat Midden	Fishbone, rubified material Orange OIL Black organic without minerals Phytoliths Charcoal Iron (imported)		Cultivation, moderate intensity
Q2 [5713] Norse	Freely draining, accreting (aeolian)		Calcareous sand, shell	Peat ash Domestic waste		Excrement of soil fauna	Low intensity cultivation

Summary of Conclusions Derived from Micromorphological Analysis

1. The model of cultivation practices and intensity demonstrates an increased intensity of cultivation, and general trends in the nature of amendment, but not universally so.
   A. Neolithic/Bronze Age cultivation was consistently low intensity, but this can only be considered a cultural indicator in cases where there is additional supporting evidence.
   B. The intensity of amendment increases from the Early/Mid Iron Age, but the picture is one of considerable variation in agricultural practice and intensity.
   C. High intensity amendment was over provision and probably the result of the availability of, and a desire to dispose of, waste materials.
2. The most commonly added material in the early prehistoric agricultural period was midden.
3. The inclusion of turf in the midden material began in the early prehistoric period.
4. Low level manuring in early prehistoric agricultural period may result from seasonal grazing, rather than the collection and dumping of manure.
5. Amending thin acid soils can significantly alter their character and prolongs their lives as cultivable soils.
6. The accretion of mineral material and its impact on soil structure can make a significant contribution to soil fertility.
7. Thin acidic soils can retain information relating to agricultural practice in a comparable manner to that found in sandy soils, and this is not restricted to soils which are sealed by structures. Taking a landscape approach to soils analysis is therefore a valid approach to investigating past agricultural practices.

8. The emerging evidence points towards the inheritance of previously cultivated land as a positive factor in the reuse of particular sites.

Chapter 9: Testing the Approach in a Multi-period Landscape

Introduction

The purpose of this chapter is to test the validity of a landscape approach by examining the multi-period landscape at Underhoull, Unst (HP 574, 044). This will test the extent to which place analysis, topographical survey and a soils field survey approach and micromorphology can be used to understand landuse at a site which has in use for at least 2,000 years and which has traces of field systems which potentially date from the Iron Age to the present but for which there is no solid dating evidence.

PLACE ANALYSIS

Shetland SMR: 129; 130; 131 (Lower Underhoull longhouse; Underhoull Broch; Upper Underhoull longhouse, respectively)

Height AOD:18-54m

Solid geology: Amphiboles, laminated horneblende schists, steatite, serpentinite, gneiss

Drift geology: Glacial deposits (mostly till, formerly covered by peat)

Local aspect: Southwest

The multi-period landscape at Underhoull is extensive, approximately 300m², and today falls within four modern fields. The broch is situated at the highest point, and the land falls away steeply to the south-west beneath it. The prominent broch remains are grass-covered and are encircled for three quarters of its diameter by a series of impressive banks and ditches, surviving over 1m high (the open side is located above the steep slope). There is a subrectangular structure built into the broch defences, possibly Norse due to its size and location (R Lamb, pers. comm.) A Viking/Norse longhouse (Upper Underhoull), between 50-60m east of the broch, has recently been excavated (Bond *et al.*, 2012). There is a further longhouse (Lower Underhoull) below the broch, close to the sea, which was excavated in 1960 (Small, 1966).

The east half of the broch is surrounded by an irregular earthwork, 70m from the centre of the broch at its closest point. Its spatial relationship with the broch is a strong indicator that the two were connected, and that it constitutes a non-defensive broch boundary. The circuit is interrupted by a relatively modern sheep shelter. The land below the broch is crossed by numerous boundaries, primarily banks and lynchets. The survey reveals at least three episodes of land use before the present field boundaries were created. The earliest field boundaries were aligned along the slope. This has some resonances with the type of land use evident at Sumburgh Head Multiple Field System, where terraces of cultivable land were used wherever they were available. Although there may be a pre Iron Age structure underneath the broch, as postulated for Old Scatness (Dockrill, forthcoming) and elsewhere (Hingley, 1996; Ballin Smith, 2005) the regularity of the boundaries suggests they are not Multiple Field System boundaries: they may however be part of an Iron Age field system. The northern half of this field system has been overlain by boundaries aligned downslope. This is characteristic of post-medieval/crofting period rigs but these boundaries, reminiscent of those at Hamar, may have earlier origins, possibly being associated with the Viking/Norse longhouses. Subsequently some of these downslope earthworks were realigned, eventually falling out of use whilst the lowest land was still under cultivation (Mackenzie, 2006: 161). Today the fields comprise much bigger units, all of which are lightly grazed by sheep, although in 2010 a small portion at the top (west) of the southernmost field was turned over mechanically for grassland improvement.

Boundary analysis was aborted at the point where it became clear that this would not contribute to dating evidence. Shape Analysis was not applied because the visible/ excavated archaeological remains were Iron Age and Norse, periods for which this had not produced a coherent set of results.

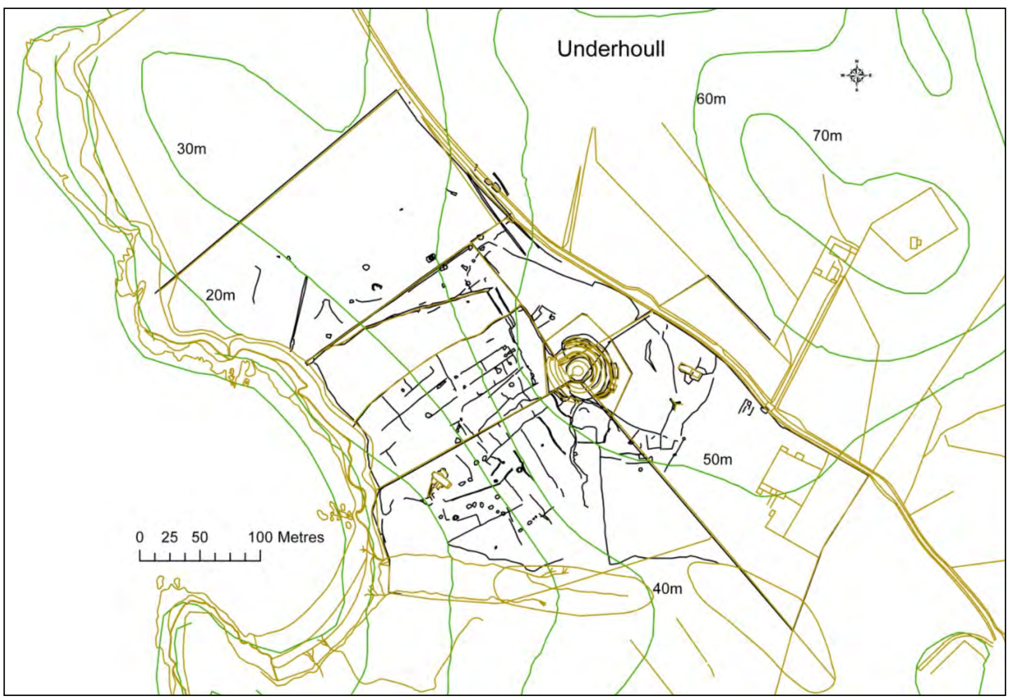


Fig 9.1 Underhoull survey on Ordnance Survey Map. (© Crown Copyright/EDINA right 2010. An EDINA supplied service)

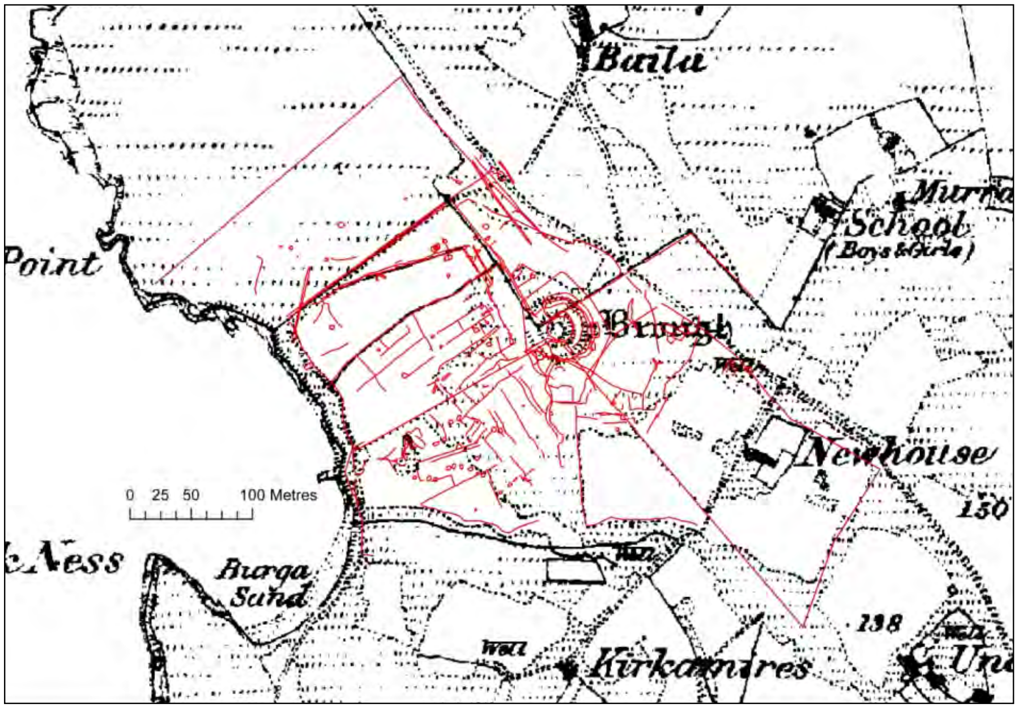


Fig 9.2 Underhoull, First Edition (1878) Ordnance Survey map.

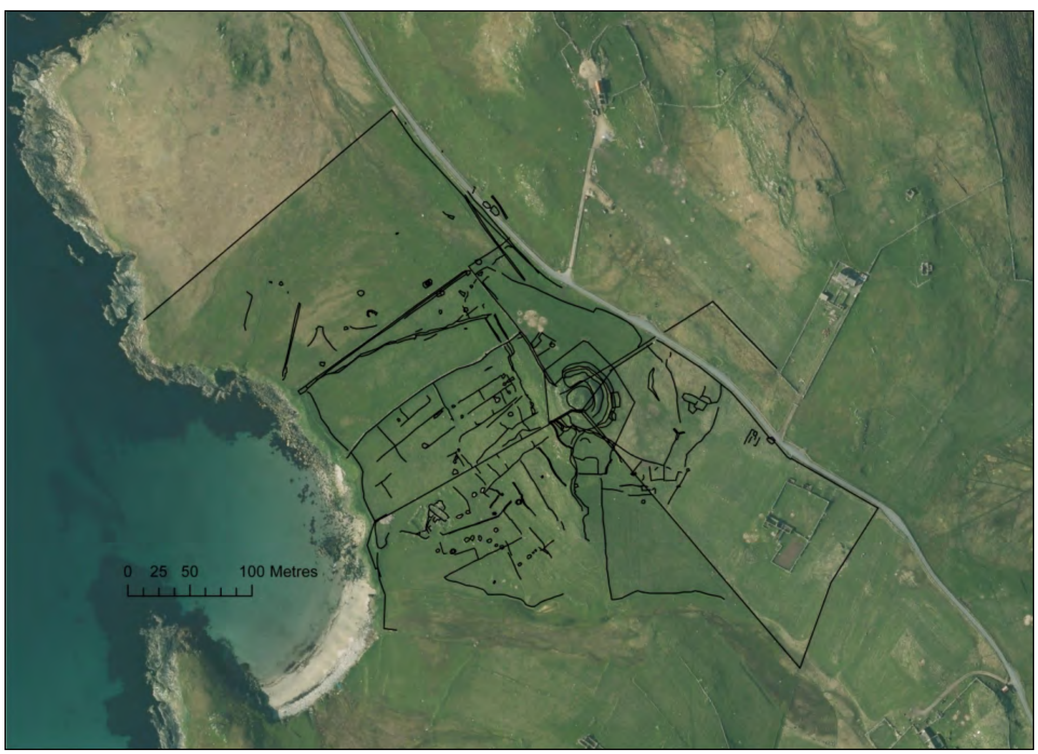


Fig 9.3 Underhoull survey on aerial photography (Licensed to Historic Scotland for PGA, through Next Perspectives TM).

SOIL PROFILES

The landscape at Underhoull is more complex than that at either Hamar or Belmont, being a palimpsest of successive uses. One of the aims of looking at this landscape was to better understand this. Ten soil profiles were excavated (Fig 8.2). The profiles were selected at points throughout the earthwork boundary remains to representative the relict field systems. A total of 16 kubiena samples were collected with the intention of sampling the stratigraphic sequence of each profile (Fig 8.3). This was not always possible due to the increasing stoniness of the contexts closest to the bedrock in some cases. The subsoil was not sampled.

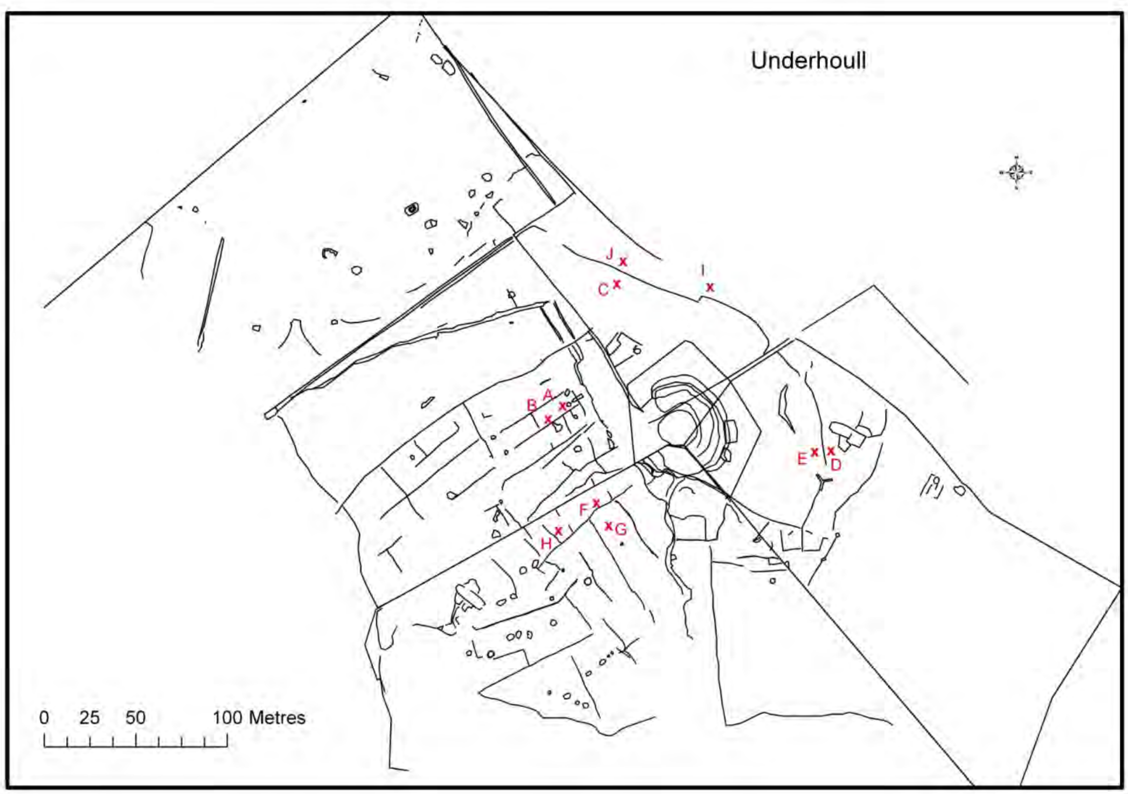


Fig 9.4 Location of soil profiles excavated at Underhoull.

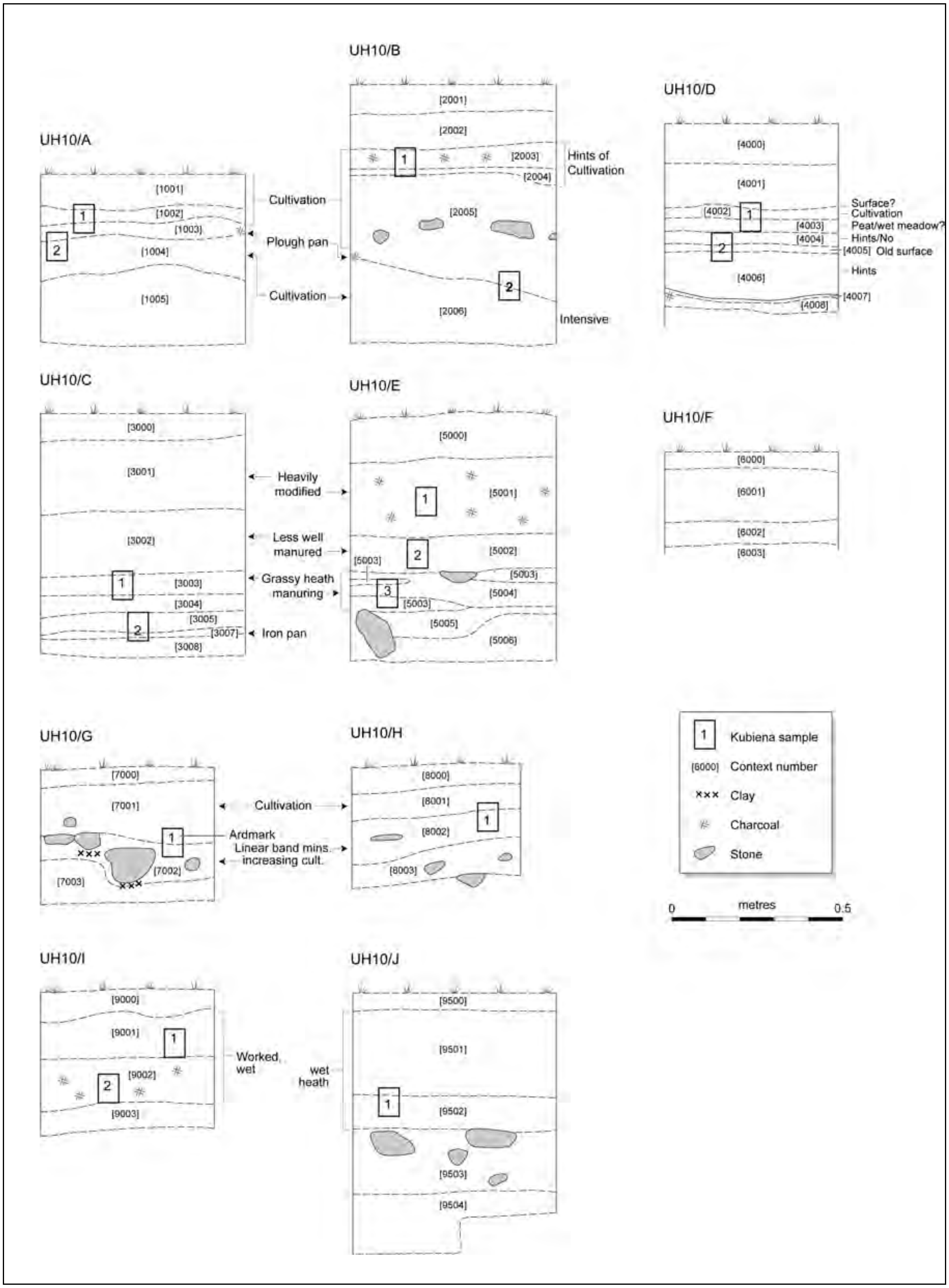


Fig 9.5 Profile sections excavated at Underhoull (graphics: Bill Jamieson)

Environment

The background environment at Underhoull is different to that of Hamar and Belmont, situated on the Arkaig Soil Association which comprises drifts derived from schists, gneisses, granulites and quartzites (Dry and Robertson, 1982: 24). It is described by the Soil Survey as a brown coarse- and moderately coarse-textured drift derived from acid schists and gneisses with colluvium and rock debris being minor parent materials. The drift is described as thin and patchy, located within an ice scoured landscape (*op.cit.* 24). The area comprises peaty gleys, peaty podzols, peaty rankers and local brown forest soils on a thin drift with peat and peaty alluvial soils being a minor part of the complex. It is described as rough grazings with some arable cropping where soil, slope soil pattern and climate permit (*op.cit.* 26).

The background environment evidenced in all the profiles sampled was one of accretion. This was unsurprising for the profiles below the broch as the relative steepness of the slope would make soil creep inevitable. This would be exacerbated by cultural activity, particularly cultivation. However, accretion was also evident in the profiles to the north and east of the broch, where the land in the immediate vicinity was relatively flat. Most contexts contain unsorted angular minerals, an indication of colluvium accumulating contemporaneously (alluvium or windblown mineral material would be better sorted). The coarse mineral component is primarily metamorphic, serpentinite and feldspar being the most common, but with quartz, garnet, biotite and muscovite present. Although sedimentation is active throughout the profiles, some areas have a lower mineral content than others, and areas where the groundmass is denser, demonstrating that these are soils not sediments. The majority of contexts contain silicaceous material (phytoliths and diatoms), indicators of an intermittently wet environment, although the land sloped significantly below the broch. These are less common and even absent from the better drained top of profiles. Iron accretion is evident in most contexts, further evidence of a wet environment; fewer contexts displayed grey areas signifying iron depletion. Three of the profiles, C, D and G, include iron pan forming in situ. Fragments of iron pan appear to be introduced elsewhere. A few contexts (eg: [1002], [7001]) include bleached stone rims, an indicator of an acidic environment. The boundary between [7001] and [7002] includes more voids than the contexts above and below and there is an in-situ iron pan forming along it. The majority of contexts display evidence of bioturbation (soil animal activity), indicating disturbance, whether recent or fossil. Some reworking of the upper contexts would be inevitable as the soils have been grazings for a considerable period. The upper contexts of most of the profiles are biologically active, including parenchymatic material, frequently identifiable as rootlets. This disturbance usually decreases with depth. There is no local memory of the Underhoull fields having been cultivated or fertilised (Peter Peterson, pers. comm.) although after that conversation, he mechanically turned over a small area of ground to a depth of about 0.15m.

A B

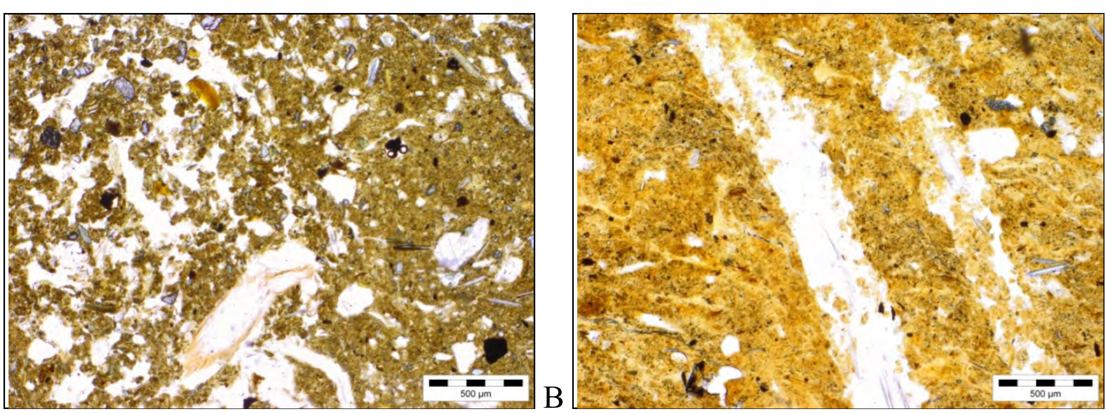
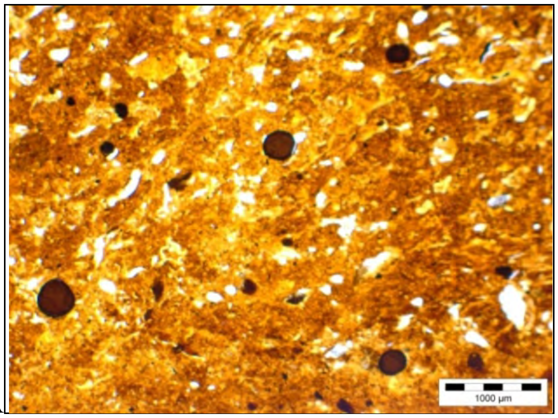
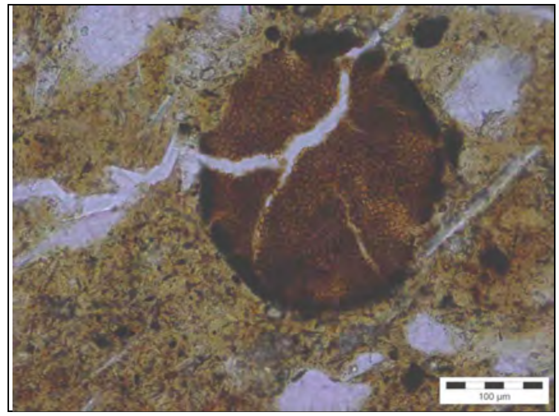


Fig 9.6 a. Bioturbated (right) and non-bioturbated (left) groundmass in Profile H [8001]; b. Faunal activity in voids within peat in Profile J.

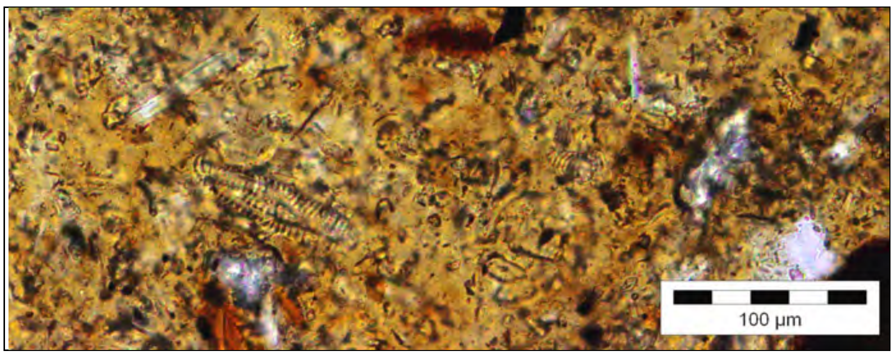


A

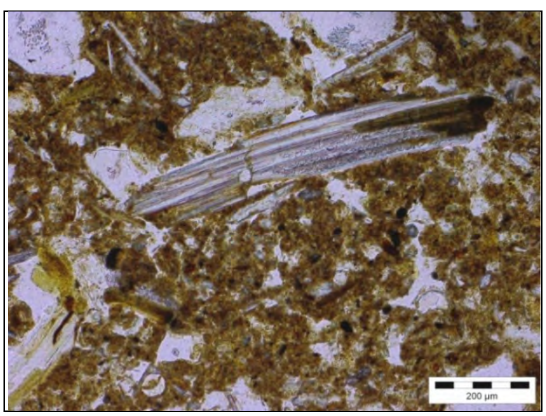


B

Fig 9.7a. Group of fungal sclerotia in peaty groundmass D1 [4003] indicative of manuring; b. Fungal sclerotia in E3 [5004].



A



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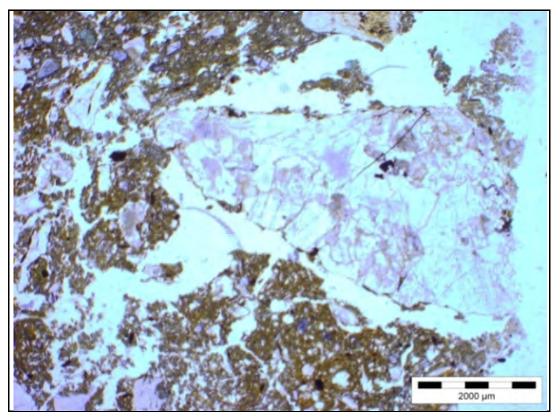


C

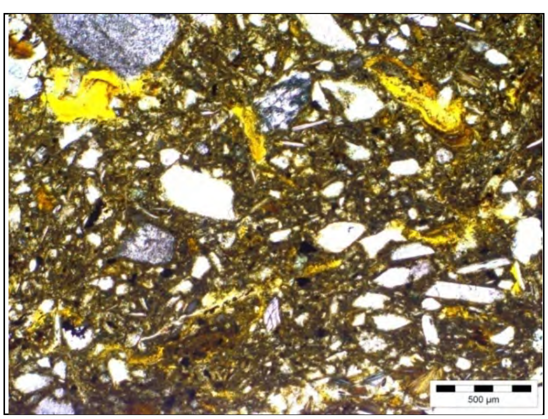
Fig 9.8 a. Diatoms in silicaceous environment, Profile E [5004]; b. Broken organics (indicating digestion and therefore manure) in Profile I [9001]; c. Quartz flake, apparently worked, with coatings beginning to accrete, from Profile A [1004].

The Fields West of the Broch

Profiles A, B, F, H and G are all located on the west side of the broch, below the ramparts, on slopes which are relatively steep and which extend to the sea.

Profiles A and B were excavated within the same unit, defined by down-slope and across slope boundaries: Profile A at the upper end, Profile B towards the lower end. Subsoil was contacted at 0.3m deep in Profile A and at 0.75m in Profile B. The earliest context in Profile B is [2006] and includes very fine charcoal in the micromass, evidence of the addition of some cultural material, and fungal spores which are often associated with the addition of manure. However, there is a lack of significant amendment visible. Nevertheless, silt accumulation in the context is indicative of intensive cultivation and the lines of dusty silt suggest that this was periodic rather than a single phase. The boundary between [2006] and the overlying context [2005] displays a discontinuous linearity and a zone of compaction of dark material and clay. This is interpreted as plough pan, an area of compaction resulting from cultivation of the material directly above it. The dusty clays and silts present are usually associated with cultivation disturbance (Jongerius, 1983; Adderley *et al.* 2010). Context [2005] is similar to [2006], with dusty clay accumulation and phased textural pedofeatures, however, it is more spongy and open than [2006] which is more dense and massive. The groundmass is mottled due to the accumulation and depletion of iron, and the angular minerals demonstrate that sedimentation took place contemporarily with the soil being worked. Context [1004] in Profile A is similar to context [2006], [1004] containing finer minerals, broken up as a result of disturbance. Both contexts were overlain by a plough pan, characterised by a linear organisation of the minerals and a degree of compaction along the boundary with [1003]. Whereas context [2005] is 0.25-

0.3m deep, context [1003] is 0.06-0.08m deep, however it has a more open structure and areas of dense organo-mineral material, probably turf, as well as fungal spores. This context was, therefore, clearly amended and cultivated. Material may have been lost from [1003] and deposited at [2005] the result of erosion and deposition consistent with the location of the profile. The overlying contexts in both profiles contain hints of agriculture: fungal spores, organo-clay coatings of minerals, (rare in context [1001], dominant in [1002] with a maximum thickness of 80µm, and in [1003] with a maximum thickness of 60µm), areas of groundmass of different colours, dark organo-mineral material which could be turf and some charcoal evident in [1003]. Context [1004] contained larger minerals, indicating that the land above Profile A was being disturbed. In both profiles, these contexts are shallow and the three contexts above the plough pan are probably the result of a single episode of cultivation, no surface being evident between them. The episode of less intense agriculture [1004], below the plough pan, is part of a separate event. Profile B includes a further two contexts, [2001] and [2002], relating to a more recent phase of land use which were not sampled. These are entirely absent from Profile A whether due to erosion or turf stripping (although there is no clear evidence of the latter).

A 

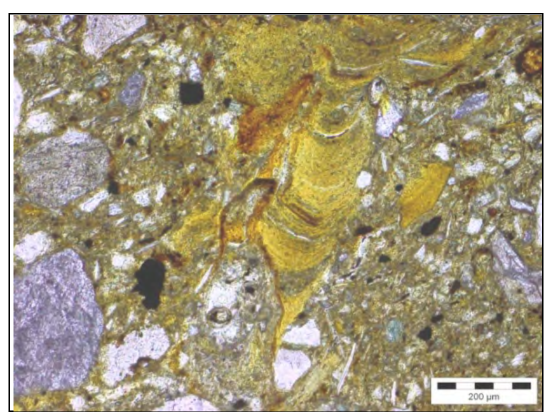
B 

Fig 9.9 Clay pedofeatures in Profile B2 [2006]: a. Clay features b. Dusty clay infilling (within an area of depletion)

Profiles F and H appeared sufficiently similar during fieldwork that only the deeper of the two, H, was sampled. Profile H was located within a small unit below the broch ramparts with horizontal and vertical boundaries creating a small sub-rectangular field. The down-slope boundaries are more meandering than those to the north and the modern field boundary superimposes a third or fourth field system over the earlier ones. It has been subjected to far greater sedimentation than A or B, containing larger angular mineral fragments, possibly because it is lower down the slope. The soils are peaty and silicaceous, with 5-15% phytoliths, but [8001] has a highly separated crumb structure, and is biologically active. The structure is weakly separated in the lower horizons [8002a] and [8002]. Minerals have organic silt coatings and broken fragments of iron pan, particularly in [8002a] may be introduced together with coarse black organo-mineral, possibly peat or turf, fungal spores and broken organic material both indicating manuring, and subtle changes in colour within the groundmass. There is also a clay pedofeature in [8002]. There are therefore hints of agriculture present in all three contexts. The base of the sample displays subtle linear bands of denser material. Whilst compaction along the edge of a sample may be produced during sampling, there are silty clay features within this, supporting the hypothesis that the tendency towards linearity is part of the soil structure.

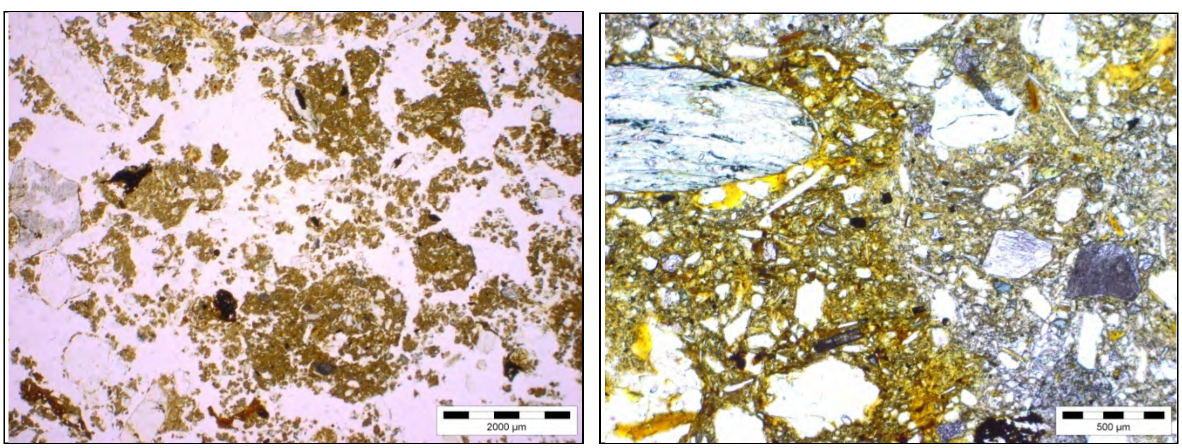


Fig 9.10 Soil Structure: Profile A1 [1002] open structure (including bioturbation); b. Profile B2 [2005] showing areas of iron accumulation and depletion (and angular minerals accreting);

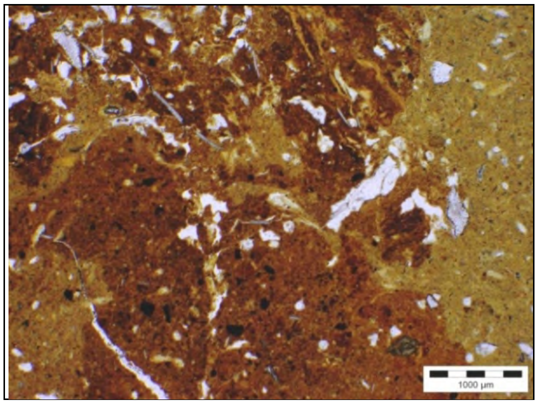
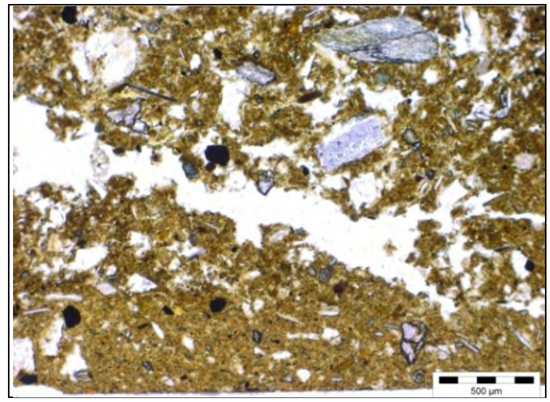
A  B 

Fig 9.11a. Profile D1 [4002] mixed colours in the groundmass which includes both peaty and fine material; b. Profile H [8002] showing compaction at the base.

Profile G is also very organic, with a similar tendency towards peat as Profile H, and with unsorted minerals accreting from the hill slope. It is located within the same modern field, slightly higher up the slope, within a field aligned across the slope, with no obvious down-slope divisions. The topographical evidence might suggest that Profile G could contain contexts equivalent to the earlier contexts seen in Profiles A, B and H. The mineral content of Profile G was more fractured with depth, indicating disturbance. Iron movement is very evident, accreting round channels, voids and minerals in context [7001]. Context [7001] was 0.15-0.18m deep and had been worked, demonstrated by the presence of fungal spores, clay pedofeatures and silt accumulation. It included areas of separated crumb microstructure. The fragments of iron pan and black and brown fragments of peat/turf without minerals mixed into a fairly homogeneous groundmass including fine black organics in the micromass, all indicate disturbance. The most remarkable feature of [7001] is that it was cut by [7001B]. The fill of this intrusive context was similar to that of [7001], but is defined by a dark cut line and a displacement of the iron pan which becomes vertical, and which therefore post-dates the iron accretion. The intrusion is shaped between a U and a V and would appear to be an ard furrow, indicating that context [7001] was ploughed.

The earlier context [7002] includes patches of broken organics, indicating manuring, and a zone where the minerals have a linear organisation, interpreted as a probable plough pan.

The signature of agriculture is much clearer in the deeper soil of Profile G than it is in Profile H. The topographical survey would suggest at least two phases of agriculture in Profile H and one fewer in Profile G. If the linearity in [8002] does represent a plough pan then it is possible that there may have been evidence of agriculture below this which the density of minerals made it impossible to sample. Alternatively, erosion may have caused a pre-plough pan soil to be re-worked: this is consistent with the thin soils. Profile G has stronger resonances than differences with Profile H. If the plough pans are comparable with those of Profiles A and B, it would appear that Profile B is the only profile not truncated by either later activity or erosion.

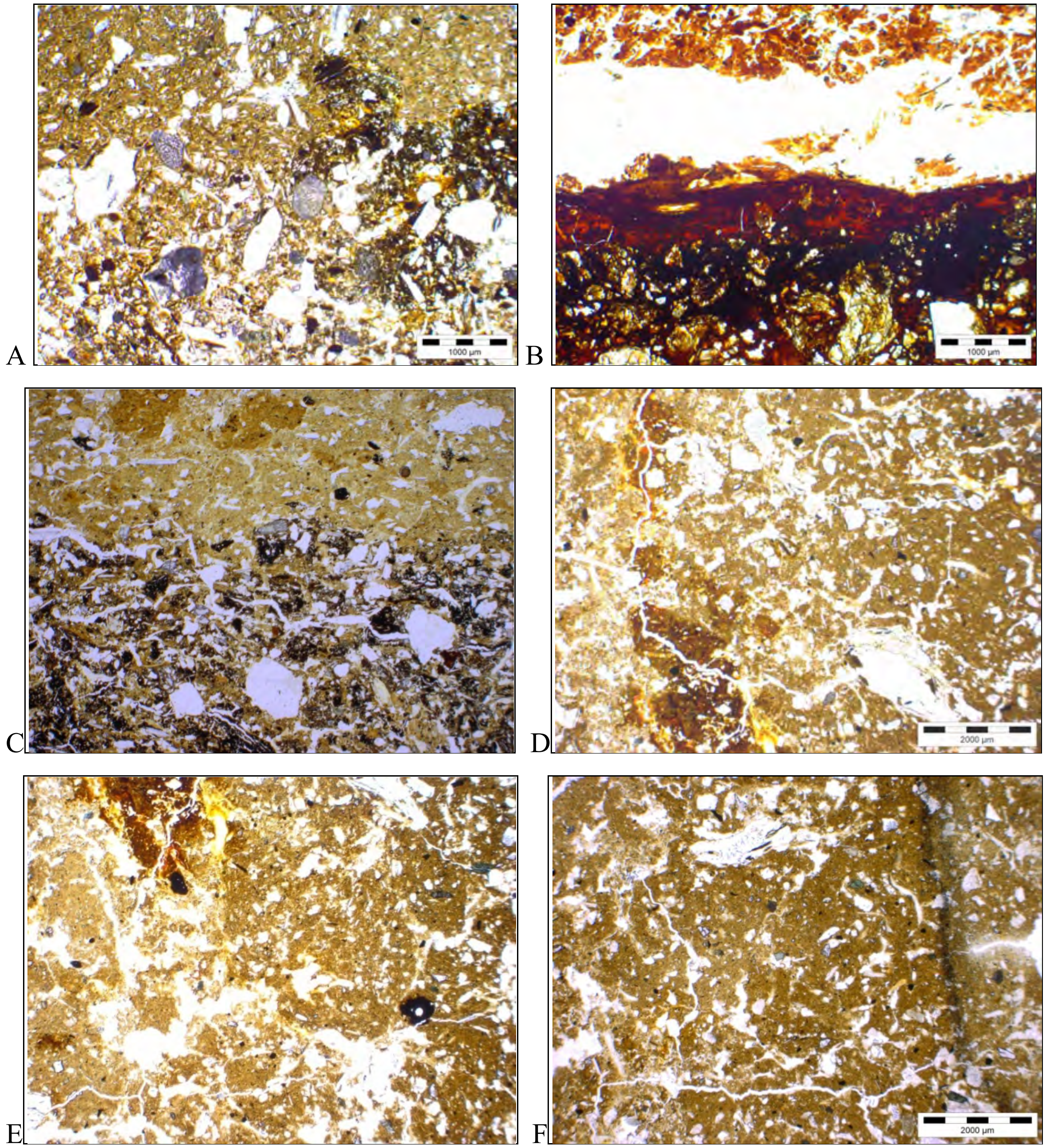


Fig 9.12 Boundaries and Surfaces at Underhoull: a. Plough pan in Profile A2; b. Iron pan forming in C2 context [3007]; c. Buried surface [4005] overlain by manured context [4004], D2; Ard mark in profile G: d. Showing displacement of iron to vertical; e. the base of the ard mark; f. The left edge of the ard mark clearly defined.

A study into deep topsoils created during and subsequent to the post-medieval period, revealed that the soils immediately below the Lower Underhoull longhouse were manured with byre contents: a mixture of cattle dung, "earth" (soft peat, in Shetland known as “mold”) and straw (Mackenzie, 2006, p162). MacKenzie’s programme of augering demonstrated that this was limited to the lowest land and did not extend much further west than the Lower Underhoull longhouse (*op. cit.* 161). The First (Old) Statistical Account of Scotland (Sinclair, 1791-99, V: 193) demonstrates that this practice was current at the end of the 18th century. Mackenzie discovered that traditional practice was to deposit the manure at the top of a slope and leave it to migrate down-slope through digging and by colluvium. Mackenzie’s work implies that the slopes above Lower Underhoull were not cultivated from the 18th century onwards.

Inside the Broch Boundary

Profiles C and E are both located inside the curving boundary, between the broch and the earthwork, which topographical survey suggests is associated with the broch. The samples were taken from opposite ends of the earthwork, about 150m apart, located today within different fields. It was anticipated that Profile E might have been impacted by the proximity of the Norse settlement on the opposite side of the boundary. Three kubiena samples were taken from Profile E. Two were taken from the bottom of Profile C in the expectation that the earlier contexts would contain more evidence of fossil land use. A comparison of the results from the two profiles displays a strong correlation between them.

Profile E has been subject to heavy disturbance which is clear from the presence of fractured minerals throughout the profile. Context [5001] at the top of Profile E is up to 0.25m deep and includes turf containing mineral material and silicaceous broken fragments of plant, as well as the presence of fungal spores, all indicating manuring. The groundmass is mixed in colour containing varying quantities of organic material, minerals are coated in organic silt and charcoal is present in sufficiently large pieces to be identifiable during fieldwork. Sieving has revealed fragments of potentially Late Norse pottery. The underlying context [5002] shows similar evidence of working although there are fewer obviously broken plant fragments, suggesting that it was less well manured. Context [5003] occurs as lenses within [5004]. There is dark material in the groundmass in both contexts together with groups of fungal spores, indicating manuring, however the amount of silicaceous material increased significantly, with diatoms being common in the upper lens of [5003A]. The mixing evident in these contexts, and the two identifiable intermixed contexts, decreases with depth. Vertical aggregates of lighter material in [5003B] are interpreted as relict vegetation. Profile E is therefore interpreted as heavily modified plaggen soils, created over a grassy heath, now surviving as a fossil horizon. Grassy heath would have been very valuable as fodder, prior to the establishment of agriculture. Profile C is very similar to Profile E, some contexts including larger minerals, which in [3003b] are as long as 7.88mm. There is also more iron accretion; context [3007] comprises iron pan containing three zones: an orange brown pan which is forming and is very organic, a horizontal channel and then a solid red-brown zone. The layer of organic material contains fine minerals from upslope erosion, overlying the iron pan. Below the iron pan, context [3008] is mixed with dense mineral material associated with brown and black organic material, indicating previous cultural activity.

<u>Outside the Broch Boundary</u>

Profiles J, I and D are all located outside the broch boundary. These are the wettest of the profiles studied, all displaying very organic profiles. Profile J was excavated on the opposite side of the boundary to Profile C, however there is a water course immediately to the north of Profile J which may have caused erosion, and therefore Profile I was also excavated. Unexpectedly, Profile I was the more truncated and the driest of the two. The upper context of Profile J, [9501], was consistent with wet heath: silicaceous and very organic with a spongy structure. There is some banding accumulation of minerals due to accretion, but also areas containing finer and coarser minerals and different colours of groundmass, some with sharp boundaries, indicating a degree of mixing. The dark coloured b-fabric is interpreted as arising from the breakdown of organo-mineral. The underlying context, [9502] is similar, although more biologically active, with the mineral component being more sorted. The dominant horizontal orientation of plant remains indicates an increased peatyness. In contrast, although wet, context [9001] in Profile I includes a high mineral content, probably caused by disturbance above it. In addition to the silicaceous content and the iron mobile in the soil, there are several different colours within the groundmass which has a moderately separated crumb structure, minerals have coatings of both organic silt and limpid clay with very rare clay pedofeatures and there are fungal spores indicating manuring. Two zones were identified in context [9002]. The upper zone shows signs of working and amendment, having a moderately separated crumb structure, turf fragments and two pieces of iron pan mixed into it, whereas the lower zone [9002B] includes groups of phytoliths with the same orientation, suggesting that they formed in situ, as well as a denser, spongy, structure.

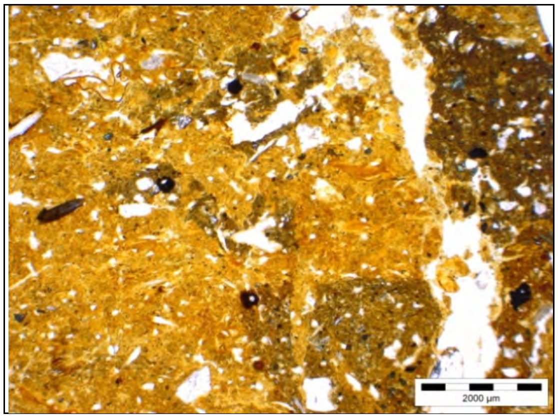
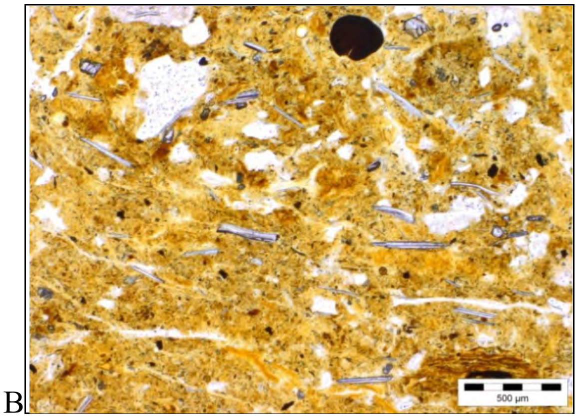
A  B 

Fig 9.13 Profile J: a. Mixing within predominantly peaty context [9501]; b. Linear banding within the peat, consistent with wet heath (silicaceous and very organic with a spongy structure)

Comparison between Profile I with C and E suggests that it is the earlier contexts which are missing from Profile I. Prior to excavation, the location of Profile I was decided on the basis of augering which demonstrated that it was deeper than much of the immediately surrounding area. The ground surface is uneven. The most likely explanation for this is the localised stripping of the earlier turf/soil (whether for construction, field amendment or fuel) prior to the time when the soil was itself amended and brought into cultivation.

Profile D is the most complex of those sampled due to the proximity of the longhouse. The lowest context sampled [4006] overlies iron pan [4007]. Within context [4006] there are hints of linear accumulation in the black organic and mineral deposition together with a trace of charcoal. There are no strong indicators of cultivation. Unburnt lignified material, which has little mineral content and, therefore, is probably peat rather than turf, is common in context [4005]. Again there is little evidence of cultural activity, and the context is probably an old ground surface. There is some indication of cultural activity in context [4004] in the form of fine charcoal and rare fungal spores associated with black organic material, indicators of manuring. However, the soil structure (channel and spongy) and the lack of coatings or pedofeatures suggest that surface activity was absent. In contrast, the overlying context [4003] is very dense and very organic. It includes lighter material which contains minerals and which may have been introduced as manure. (There are groups of fungal spores but not much fractured plant material.) Context [4002] is more disturbed, with mixed colours in the groundmass and a mixture of both peaty and fine material. There are also fractured phytoliths, manure and fungal spores present, all of which indicate manuring. This context has clearly been cultivated. There is a horizontal linearity to the channels and to the amorphous organic material which suggests that this is a second former ground surface. Above this, context [4001] includes mixed colours in the groundmass, some with sharp edges and a spongy structure, fungal spores and amorphous organic material, as well as patches of phytoliths and diatoms, all of which suggests disturbance, amendment and manuring.

SUMMARY AND CONCLUSIONS CONCERNING LAND USE AT UNDERHOULL

There have been three major structural events in the area:

1. Approximately 400-200 BC: The construction of the broch and ramparts (and an Iron Age souterrain and possibly other associated remains further down-slope). A later rectangular building post-dates the ramparts, and may be Norse, but is of unknown date.
2. Construction of Lower Underhoull longhouse (Small A., 1966): date uncertain but likely to be earlier than the construction of Upper Underhoull due to the more favourable location.
3. c.11th century AD: Construction of Upper Underhoull longhouse (Bond *et al.,* 2012).

Boundary construction events identified:

1. Construction of the boundary which respects the broch, located east of the broch.
2. Boundaries to the west of the broch aligned along the slope.
3. Boundaries overlying these, aligned down-slope.
4. Realignment of some of the down-slope boundaries which resulted in more linear boundaries
5. Present system of field boundaries, relating to light grazing

Episodes of soil use identified:

A. East of the broch:
    1. Grassy heath, valuable as fodder, particularly clear in profile E inside the broch boundary.
    2. The land outside the broch boundary apparently stripped of vegetation, whether for fuel, construction, animal bedding or soil amendment. This is demonstrated in the shallower soils outside the broch boundary, sampled at one of the deepest points, in Profile I. The lowest context hints at a previous in situ wet accreting environment.
    3. Heavily modified arable soils created on both sides of the broch boundary, evident in profiles E and C, inside the boundary, and I which is outside. (Since Profile J lies between the broch boundary and the water course, it is not consistent with the other soil profiles in the area.)

Profile D:

This area is very close to the Upper Underhoull longhouse. The profile is peaty, consistent with the other profiles east of the broch.

1. An area which had been cultivated associated with a buried surface with hints of plough pan in the context below.
2. A second phase of cultivation.
3. A second buried surface.

These three areas of worked soil are not reflected in the other profiles on this side of the broch. Either these are phases of working relating to activity associated with the longhouse or they represent a more sporadic arable use, which is possibly contemporary with contexts [5001] and/or [5002] in Profile E, adjacent. It might be possible to establish the relationship between the two profiles either by extending the trenches across the bank to obtain the stratigraphic relationships or if dating evidence becomes available from samples taken.

B. West of the broch:

1. Intensively worked land immediately above the C horizon.
2. A second phase of modification and worked soils, separated from the earlier phase by the formation of a plough pan, most clearly visible in Profiles A and B, and more tentatively identified in Profiles G and H. This phase of agriculture is very obvious in Profiles B and G. Further evidence of ploughing can be seen in Profile G which captures an ard mark.
3. A possible third phase of agriculture is visible in Profiles B, C and H where there is less amendment visible in the soils. It is also possible that this phase is

part of the previous system of land use which has been subject to reworking by soil fauna. However, reworking seems unlikely to be the cause in the case of Profile B, where there are another two, unsampled, contexts which overlie the two lightly worked contexts.

4. Localised cultivation involving the deepening of the soils at the foot of the slope, around the Lower Underhoull longhouse, documented as being practised in Unst in the 17th century and continuing until the 19th-20th century (Mackenzie, 2006).
5. The use of the hillslope as grazings which continues to present. Today the land supports sheep.

LANDSCAPE APPROACH: CONCLUSIONS

The adoption of the landscape approach at a multi-period field system clearly has much to commend it. Dating evidence would enable the results to be further tested but topographical survey is a primary tool in understanding a landscape, as RCAHMS survey teams have demonstrated in the past. Adding the soils dimension vastly increases the appreciation of how the landscape was being managed over time.

The site-based approach has been favoured in the past, in part because work has tended to focus on structures and since rapidly buried soils will retain their former character to a greater extent than those which were covered more slowly. The site-based approach has disadvantages however: the removal of the overlying structure is both destructive and potentially expensive; the soils sampled will pre-date the structure and therefore reflect the soil environment rather than contemporary land management; the soil profile may be atypical of the area as structures are often built on the most impoverished land, such as outcropping rock. A landscape approach addresses these issues and, as demonstrated at both Underhoull and the new profiles from Old Scatness, may provide considerable amounts of new evidence. The results from open areas have been shown to retain considerable cultural information, although this is not universally so, as was demonstrated in some of the Pinhoulland profiles. While it is necessary to be cautious without absolute dating evidence, the topographical survey has provided corroborative evidence for the micromorphology. The dangers inherent in relying on micromorphology alone as a dating tool are illustrated by the results of this study which demonstrates that soil management in the North Atlantic was less uniform than hitherto imagined.

Chapter 10: Synthesis

Introduction

The purpose of this study was to examine Shetland's well-preserved but largely over-looked, field systems spanning a period of approximately 4,000 years, in order to better understand past agricultural practises and lifestyles. The principal tools used to undertake this were: Place Analysis, Topographical Earthwork Survey, Shape Analysis, Boundary Analysis and Soil Survey (Augering and Micromorphology). The key purpose was to produce a new integration of field form and function and to provide a more comprehensive understanding of continuity (inheritance and sustainability) and change in the field systems of Northern Europe through time. Table 10.1 (below) summarises the results in relation to their potential to contribute to these primary elements which then be will be discussed.

Table 10.1 Summary of the potential of the results from the analyses undertaken to contributing towards the discussion about Field Form, Field Function and Inheritance.

		FORM	FUNCTION	INHERITANCE
Place Analysis	Geology: Fertility	X	Yes - moderately	potentially
	Geology: Building	Iron Age	Iron Age	Reuse of material
	Geology: Tools	X	MFS & Norse (some)	X
	Altitude	X	X	X
	Alignment	X	MFS	X
	Aspect	X	H Encs; MFS 50%	Limited influence
	Viewshed	X	H Encs; IA	X
Shape Analysis	Area	yes	Some potential	Some potential
	Perimeter	yes	Some potential	Some potential
	Shape factor	yes	yes	yes
	Convexity	yes	yes	X
	Feret ratio	X	yes	X
	Area: Min Rect Area	X	yes	X
	Area: Convex	Yes	Yes	X

	Area			
	Sinuousity	X	X	X
Boundary Analysis	Feature Type	No but Single event indicator	Yes	MFS – single event indications
	Dimensions	Hints	some	X
	Int & Ext height	X	yes	X
	Angle of Slope	X	unclear	X
	Direction of Face	X	Encs – int; MFS & IA downslope	X
	Stone size	0.3-0.4m common to all	yes	X
	Density	H Encs & MFS - discont	some	X
Soil Analysis	Intensity	X	yes	Increases possibility
	Specific Modifiers (turf/midden/manure)	X	Linked but not definitive	Some influence
	Thin acidic soils	X	Cultural indicators survive and retain information re function	Reduces possibility
	Accretion	X	Influences use	Increases possibilty
LANDSCAPE APPROACH	Field Systems	yes	yes	yes
	Soils	yes	yes	yes

FIELD FORM: FACTORS INFLUENCING FIELD MORPHOLOGY

Feature type

The Homestead Enclosures were each dominated by a single feature type, although different types at each site. The Multiple Field Systems do not have a dominant feature type but individual field boundaries do display a consistency. This suggests that the Enclosures of the individual elements of the Multiple Fields were created as single construction events and supports the proposition that the Multiple Fields accreted over time.

Each of the Iron Age boundaries is dominated by a single feature type. As Tumblin 1 (lynchet) is coincident with the later township dyke, the boundary may have been substantially modified in the post-medieval/early modern period, including regular breaching and repair. Here the relatively steep hillslope would favour the repair forming a lynchet rather than a bank.

Each Norse yard is relatively small and three are dominated by a single feature type, whether lynchets (Belmont South and Upper Hamar) or dyke (Stove). At Watlie, therefore, the topology has a significant effect on feature type. The yards at Hamar South and Belmont North are more evenly divided between two feature types. Neither is complete and both have been impacted by later land use which may have influenced survival but, in contrast with other sites, the yard lynchet at Belmont North is aligned down the slope rather than across it. Bigelow's excavations at Sandwick South revealed that the Late Norse longhouse had two yards associated with it, of which the northern yard was the earlier. The excavated wall "combined big othostats and rubble" (Bigelow, in prep). Excavated sections across the west yard boundary at Underhoull revealed earthen banks (Bond, *et al.,* 2013). There are unexcavated traces of an eastern yard at Upper Underhoull but, like the upper wall of the longhouse, it appears to be constructed of turf.

Shape Factor and Field Form

The Homestead Enclosures returned the most coherent set of results (particularly Area, Perimeter, Shape Factor, Convexity, and Area: Convex Area). That being the case, Shape Analysis can be used successfully to identify a distinctive form for the Homestead Enclosures. One of the Norse Yards, Stove, also fell within the Homestead Enclosure Shape Factor range, however the yard was smaller in terms of Area and Perimeter. The Iron Age field boundaries were insufficiently complete to apply Shape Analysis. Iron Age boundaries and the Norse infield boundaries appear similar in construction: the key factor in identifying them is their relationship to either brochs or longhouses.

Repair

Two Norse boundaries (Belmont and Watlie) and the broch boundary at Tumblin, incorporate lengths reused in later township boundaries. All three primarily survive as a single feature type and yet ethnographic evidence records that the township boundaries were breached annually following harvest, in order to allow animals entry from the outfield to graze and manure the land during the winter (Fenton, 1978:89). This damage was then repaired each spring before sowing the new crop. It is probable that only short lengths of boundary were broken down in any given winter: possibly those which were already in need of repair, sufficient to allow the ingress and egress of livestock. It would be beneficial to change locations annually, as poaching and erosion would result from regular use. These areas of repair are not clearly identifiable as changes in feature type. Short lengths of discontinuous dyke within the Sae Breck broch boundary may represent areas of repair, although other factors e.g. the availability of materials and differential survival, could also explain this.

It is possible that length and areas where no stone was observed represent repairs: it might be easier to use earth/turf and/or small stones to patch the breach. Lynchets also include small stone as a product of their formation. Where areas of small stones, or larger stones concealed by vegetation, correspond with a discontinuous dyke, the boundary may once have been substantial or been the footings of a fence or hedge. All the Broch and Norse infield boundaries incorporate sections of both small and no stone.

<u>The relationship of Stone Density, Stone Size and Geology to Morphology</u>

The significance of the visible stone (recorded as "density") is to some extent related to feature type. A bank constructed primarily of turf may incorporate small stone by chance; a discontinuous dyke would contain a less stone than a coursed dyke. Conversely, a coursed stone dyke could become vegetation covered and so resemble a bank. The significance of stone size and stone may also relate to function: if the primary purpose of a boundary was to define an area the feature need not be continuous. A bank recorded as incorporating discontinuous stone was a continuous feature with stone protruding at intervals. Stone within a lynchet or a bank may not have been integral to its construction: but as a component of earth or turf, the result of clearance, rebuilding, or modification, whether during use or more recently.

Three dry stone dykes, constructed as three separate events since 1995 and situated within a single small croft and garden ground at Whiteness, Shetland, were examined in order to compare their stone sizes with those found in the field systems. Each dyke stands to approximately 1.3m high including coping stones. There was some commonality regarding the dykers who undertook the work, all of whom have the ability to build to different styles for different purposes. The results suggest that all three dykes were, to some degree, the product of both available stone and function. The west dyke was agricultural and did not aim for the same aesthetic finish. Of the three, Easthouse North is the least well built, with far more tiny stones used in infill spaces. Here, larger stones lying within a metre of the dyke were not incorporated and the largest stone (0.4m) was reserved for the coping stones. The construction of Easthouse South was more regular being constructed from more angular stone. The large stone used in Easthouse West lay within 5m from the dyke and was incorporated at the closest convenient point, being moved into place by two people.

Fig 10.1 Dykes at Easthouse, South Whiteness: a South; b North; c West

	Source of Stone	Size	Geology	Characteristics	Dykers
Easthouse South	Modern quarry (Ratchie)	0.1-0.5m	Sandstone	Blocky, easily worked	K & M
Easthouse North	Mixed: local stone and modern quarried	0.1-0.4m	Limestone and Sandstone	Local stone is rounded and irregular	K (& S for a short period)
Easthouse West	Local stone and stone from ground breaking for building foundations	0.1-0.8m	Limestone	Rounded and irregular	S

Table 10.2 Drystone Dykes constructed At Easthouse, South Whiteness.

All the Easthouse dykes use small stone for pinnings and hearting as the prehistoric/Norse dykes must have done, although these crumble to dust under years of pressure. Large stone was more difficult to handle and was not consistently used. The balance varied between dykers, and each dyke is a product of both the material available and the personality of the craftsman as well as function.

The density of stone within an earthwork could result from one or more of several factors: the method of construction; the material available (e.g. turf/ outcropping rock/ beach stone); and/or the size of available stone. Stones which are >1.5m may be used *in situ*, and are frequently part of the live rock; stones between 1-1.5m, if not *in situ*, would have required more effort. The only Homestead Enclosure to contain any stone ≥ 1m was Croag Lea, one of two Enclosure sites situated on gneiss. Croag Lea also includes two large stones inside the Enclosure, the two large stones in the boundary being adjacent to them. The boundary is slightly irregular, but its alignment does not appear to change course at the point where the large stones occur, suggesting that they were either moved into place or that the boundary was designed to incorporate them. The other Enclosure on gneiss, Vassa, contained no stone >0.6m, possibly due to disturbance by peat cutting.

All the Multiple Field systems occur on Old Red Sandstone: two include stone ≥1.5m and five of six include stone of 1-1.5m. At Sumburgh Head the largest stones occur at ends of boundaries and are earthfast, suggesting that they pre-existed. At Clevigarth all the large stone (1-1.6m) is located close to the prehistoric house. At two sites (Gallow Hill and the Scord of Brouster) the large stone is concentrated within a single irregular field boundary; at another (Pinhoulland) the large stone is confined to the possibly territorial dyke, projecting southwest from the field system. There, two nearby freestanding orthostats are not included in the field system.

Sae Breck Broch is located on sandstone; with large stone in both the broch field and post-broch boundaries. Tumblin Broch is located on gneiss/serpentinite and is far more meandering than these. Tumblin may have been designed to incorporate large stone, including a huge erratic or freestanding rock outcrop, 3.4m long by 1.3m high.

All the Norse sites are on serpentine, but only one (Belmont) includes a stone/outcrop of 1.5m within the infield/township boundary. Other outcrops in the locality were excluded, although some occurred close to the line. One of these faces has Bronze Age cupmarks carved into it; there are also cupmarks in the bedrock immediately adjacent to the longhouse wall (Larsen *et al.,* 2013) therefore the cupmarks themselves are unlikely to be the reason for exclusion. The Gardie infield contains a high percentage of large stone: here bedrock is very prominent today, the land having been scalped, the shallow cover being extremely waterlogged. To the east it is hard to distinguish between ridges of outcropping bedrock and constructed boundary. Large building stone is therefore readily available and its use may have assisted field clearance, but its incorporation does not appear to have influenced the smoothly curving line of the infield boundary. The characteristics of the Norse yards varied considerably: excavation of the yard bank at Upper Underhoull revealed that the few small stones within it were not structural (Bond *et al.,* 2013); at Stove the yard includes a coursed dry-stone dyke, with a range of stone 0.2-1m.

The drift geology is described as "bedrock at or near the surface" for twelve of the nineteen sites within the study. This includes more than one example of each field system and had no direct relationship with solid geology. There is no clear relationship between solid geology and stone size: stone ≥ 1.5m was found at two Multiple Field Systems on Old Red Sandstone, a Norse site on serpentine and (the largest) within a Broch field boundary on gneiss/serpentine. The lack of stone ≥1m at the Homestead Enclosures, other than Croag Lea, is the most consistent result, and appears to be related to field form rather than geology: the Homestead Enclosures are also the most consistent group in terms of size and shape.

As might be expected from the comparison with the Easthouse dykes, small stone (≤0.2m) is commonly found at most sites. Where they occurred with larger stones, small stones probably had a constructional role: hearting within a dry-stone dyke (pinnings are unlikely to have survived) or packing at the base of orthostats. They may also have been incidental components of earthworks.

<u>The Effect of Terrain on Morphology</u>

Of the various feature types found within boundaries, there is a strong correlation between lynchets (with one side higher than the other) and hillslope evident at sites of all periods.

They commonly occur on slopes, as they always define a drop in the ground level. They may be created deliberately, linked with terraces (either cut into a slope, or artificially built up at the lower edge) in the latter case, revetting or a barrier would probably be required. Lynchets may also form at the lower edges of fields as the result of down-slope soil movement: this may be natural but is exacerbated where a slope is cultivated (when the soil is turned, it drops fractionally down-slope, a process known as "soil creep" (French, 2003:20, 22)). This could be managed by periodically excavating the lower end of the field and moving it to the top of the slope and manuring was sometimes carried out in this manner (Mackenzie, 2006:164).

The Sumburgh Head field system is dominated by a pronounced hill slope and lynchets define the lower edges of terraces set into the hill, sitting proud of the surrounding land. Most upper edges are created at the foot of a break of slope, the ground rising steeply above it. This phenomenon is pronounced at both the top and bottom of the South Newing Enclosure. Lynchets may contain large stone, either naturally or due to clearance. Excavations at South Nesting Hall (Dockrill, et al 1998) revealed a line of large stone below the break of slope, bounding a level cultivated terrace. Field clearance stones were mixed with larger stones. Ard points and broad bladed stone tools were also found indicating that was developing during cultivation. Some lynchets may have originated as either banks or dykes, which developed through use. Lynchets are therefore frequently indicators of cultivated land and workable soils.

Terrain has an effect on the height of earthworks: the greatest feature heights identified at Sumburgh Head include the lower edge of a terrace above a steep slope; the lower boundary at South Newing and the lynchet between fields F1 and F2 at Pinhoulland are enhanced by the natural fall in ground height. At Pinhoulland the larger stone was not reused (and was an obstacle to stripping) which might explain why field F6 is now so prominent compared to the overall site. The longhouse at Lower Hamar was also prominent prior to excavation due to turf stripping (Bond, *et al.,* 2013).

Lynchets also occur naturally, for example as the result of wind blow. There are examples along the east coasts of both Unst and Yell where blown sand has caught against post and wire fences. Although the fences are not solid obstacles, the accumulation may be significant. Lynchets can also arise with the addition of material on one side of a boundary for reasons not necessarily connected with agriculture. Soil micromorphology has the potential to provide information about the processes giving rise to individual lynchets.

<u>Invisible Elements of Field Boundaries</u>

The highest part of the Enclosure at Croag Lea corresponds with the edges of a break in the boundary, immediately adjacent to a knoll. The knoll may have supplied a degree of protection at this point which rendered a boundary unnecessary. Alternatively it may have been closed with a less durable barrier, e.g. a fence or hedge.

In discussing field systems in the Yorkshire uplands, Fleming (1971) suggested that the primary purpose of the walls was to get rid of unwanted field stone. This could be true if the boundaries consisted solely of stone dykes and lynchets, however the presence of banks containing no visible stone, and the largely continuous boundaries enclosing areas, indicates rather that the boundaries were intended to serve as physical divisions. The field survey demonstrates that clearance mounds were incorporated along some boundaries (e.g. the west boundary of Pinhoulland F4; the boundary between Scord of Brouster F7 and F5; the east side of the Hill of the Taing Enclosure). These expand the widths of the boundaries on both sides and so must predate the boundaries. The incorporation of clearance cairns within boundaries was also noted at the Scord of Brouster (Whittle, 1986).

Discontinuous field boundaries may be fragments of once continuous lines, (e.g. north of field F5, Ness of Gruting). Gaps in the observable boundary might arise in a number of ways, including the reuse for plantiecrubs, later dykes or other structures. Turf or earth may also be reused: for wall construction, for deepening and improving soils elsewhere, to enhance soils inside plantiecrubs, or for use as fuel. Boundaries may also disappear where they become submerged in peat, misleadingly named “sub peat dykes” by Whittington (1998) and Lamb (e.g. 1984).

In some cases, e.g. within field F2 at Gallow Hill, fragmentary lengths of boundary occur on an alignment at variance with that of the surviving field. Some may be the by-products of other land use e.g. spade or ard cultivation or clearance, but some may be part of an earlier phase of the field system, superseded within the prehistoric use of the site. Therefore deliberate clearance, stone robbing or subsequent land use might all be explanations for the fragmentary remains. Earthworks are particularly vulnerable to trampling and/or erosion, and as all the sites have been grazed post-boundary use, may have become slight or even disappeared from view.

Today the Enclosure at Exnaboe falls within three land units: two enclosed fields and an area of scattald, all of which are currently grazed at different intensities. The widest and highest length of the boundary crosses the fence line dividing the field of lowest grazing intensity and the more heavily grazed scattald. Current grazing pressures are therefore not significantly affecting the monument. Sheep tracks might create localised damage to earthworks: the land would have to be overgrazed and the vegetation cover damaged for this to have a major impact. Cattle are much more destructive: particularly in winter, when poaching can cause significant damage: cows are also less discriminating in what they eat so have a greater impact.

Another possible explanation for fragmentary boundaries may be the use of organic materials: whether dead wood in the form of fence posts or palings, or living shrubs and bushes, which might once have created an effective barrier with no surviving above-ground evidence. It is clear from ethnographic sources (e.g. a photograph of the hill dyke at Benigert, North Roe, Jack Petersen, 1949 reproduced in Smith, 2000: 38) that wooden stakes, "sometimes linked together by rope or wire" (Fenton,1978: 89), were used in the top of the post-medieval township dykes to provide extra height. This could have occurred in earlier times; alternatively boundaries may have incorporated growing plants, whether bushes or living hazel fences. Hedges are not features of post-medieval boundaries in the Northern Isles, but in a recently cleared, lightly wooded, Neolithic/Bronze Age landscape, incorporating trees and bushes may have been both practical and efficient. Such remains cannot be identified by topographical survey and even targeted excavation may struggle to locate evidence, although stake holes and the root systems may be preserved within buried soils. The lack of tree cover in Shetland today, and the wealth of still visible, stone built, prehistoric sites, makes it easy to overlook the fact that Shetland was lightly wooded in prehistoric times and that trees were not only cleared but, in some cases, regenerated (Keith-Lucas, 1986). Prehistoric trees are visible in the pollen record (e.g. Edwards, 1998), and today wood is frequently reported during peat cutting. With careful management Shetland can, even today, produce hazel and willow which can be productively pollarded every three years (Paul Goddard, Shetland Amenity Trust Woodlands Project Team Supervisor, pers. comm.).

Dimensions (Feature Height and Width)

The dimensions of boundaries may be influenced by a number of factors. These include original construction, which might be influenced by the materials used or the function of the boundary. They are also influenced by factors of survival and destruction (e.g. stone robbing or later land use).

Of the Enclosures, only South Newing has a feature height greater than 0.6m and only Exnaboe has a boundary width greater than 2m. The combination suggests that this class was never particularly massive. At South Newing, the additional height appears to be the result of the terrain (a steep slope with feature heights between 1-1.5m located at the lower edge, where the ground falls away below the Enclosure adding to its height). The excessive width west of the Exnaboe Enclosure is harder to explain: the site is almost devoid of visible stone, but incorporates a stone built plantiecrub beside the earthwork remains of a prehistoric house. The widest area coincides with the greatest feature height, suggesting a high turf content. The width could be the result of collapse, robbing either turf or stone, or of later agricultural practices flattening and spreading the boundary. A section excavated across a narrow section of the northwest bank indicated a higher stone content that appearances suggest. Therefore the lack of visible stone, together with the lack of clear definition in the house-earthwork, and the presence of the plantiecrub, all suggest post-medieval/early modern period disturbance.

The locations of the highest or widest points of the Multiple Field Systems are scattered throughout the field system. The Multiple Field Systems meandered in order to incorporate clearance heaps or other pre-existing features. This is not evident at any other period, other than possibly at the Hill of the Taing Enclosure, although heaps of stone thrown to the edges of rigs were a feature of post medieval and early modern agriculture. This could imply that other fields were not used for intensive arable cultivation, but it could also indicate that the fields were sufficiently well amended that stone was not an obstacle to cultivation.

Slope might influence the dimensions of some boundaries but there are also significant slopes at the Ness of Gruting, Sumburgh Head and South Newing, where the boundaries are less substantial. An alternative explanation for the differences between boundary forms may be temporal: the Enclosures and Multiple Field Systems are up to twice as old as the more substantial broch boundaries of which one (Tumblin) appears to have been reused more recently.

Four Norse yards included short stretches of boundary over 1m high and there is considerable variability between widths at different points, particularly noticeable at Belmont and Hamar where the surrounding land has been subject to stripping. Lower

Hamar incorporates a bedrock mound at one corner; Upper Hamar is ill-defined and overgrown by vegetation along the northern boundary. Small-scale excavations over the yard boundaries at Belmont (Larsen *et al.,* 2013) and Underhoull (Bond *et al.,* 2013) have demonstrated quite different methods of construction: at Belmont the boundary adjacent to the longhouse wall, was visible as upright stones; at Underhoull excavation revealed an earthen bank. The longhouses themselves displayed similar contrasts: at Belmont the foundations comprised a course of massive stones, whereas the seaward facing wall of the longhouse at Underhoull comprised smaller stonework and the inland facing wall was turf built. This may have reflected a difference in the availability of materials or of status. Against the latter is the high quality of the soapstone artefacts found as well as the sprung wooden floor (Bond *et al.,* 2013). The yard at Stove survives as a ruinous coursed stone dyke, possibly a later rebuilding but no longer part of the current pattern of land use and crossed by the modern fence.

Watlie has the lowest surviving boundaries among the infields and lies inside the township, on the land which is locally the flattest. It was part of the post medieval/early modern period, by the crofting settlement a short distance to the north. The boundary may have been eroded by crofting activity.

Both Belmont and Watlie include lengths of infield boundary reused within the later township dyke. These boundaries had relatively consistent widths, with a greater variability between their heights. The township boundary at the Broch of Tumblin shared a similar range. At Belmont, the township boundary width is slightly smaller than the infield dyke which was not reused: the reuse may result in it surviving in a better, less collapsed, condition, being maintained more recently with less time for deterioration. At Watlie the reverse was true and the reused township boundary was slightly wider than the remaining infield boundaries and a similar range to the reused Tumblin boundaries.

Angle of Slope

The angle at which a slope is stable will vary according to its construction material and how rapidly vegetation becomes established. Limbrey (1975: 316) noted that "a newly built earthwork suffers erosion at the surface and settling within it, and these two processes combine to reduce the height and slope until a stable cover of vegetation is achieved." This has been tested in the experimental earthwork project at Overton Down (Bell *et al.*, 1996). Even when the earthwork is covered in vegetation, the angle of slope can continue to reduce. The natural processes of soil creep, settling and soil washing would be exacerbated by factors such as the trampling of animals or disturbance of vegetation cover, whether by overgrazing, agriculture, the decay of posts or the removal of stones. Spaces left in this way would collapse and become filled in. The angle of slope might therefore shed light on the form, function or characteristics of the original boundary. It would seem probable that the steeper the slope, the more rapidly it stabilised. A steeper slope may also indicate either maintenance or some form of revetting. A steep earthwork (i.e. one having an angle of approximately 45-75°) may stand closer to its original height than one with a shallower angle although a near vertical structure could also be reduced in height without impacting on the angle of the remainder. Where a near-vertical face was recorded in this study, the boundary was generally either built of coursed stone or related to the face of either an earth fast stone or the live rock face.

In four of the six Homestead Enclosures the angle of dominant slope is mainly shallow, but Croag Lea had no shallow slope and South Newing only 7%: just over half was near vertical, incorporating a rock face and stone. At Croag Lea, in much flatter terrain, the boundary with a steep angle of slope was not linked with feature height, stone size or stone density.

The Multiple Field Systems were dominated by shallow slopes, possibly reflecting a prolonged period of erosion since the Multiple Field System went out of use 3,000 years ago. Sumburgh Head and the Ness of Gruting have the greatest percentages of shallow slopes, being on the steepest sites and more prone to soil creep. However, Clevigarth, the flattest of the sites in the study, had a high proportion of shallow slope. There are several fragments of boundary within the Clevigarth system indicating repeated reuse. The destruction may have been due to cattle: Dockrill suggests that cattle would have been an important part of the economy (Dockrill, forthcoming). All the Multiple Field Systems included a length of boundary classified as steep and/or near-vertical. Some near-vertical areas at the Scord of Brouster only appeared so following excavation, revealing that survival does not necessarily reflect the original position.

If the steeper slopes are better preserved than shallower ones (suggested above), the steeper sections of boundary might be expected to be higher and therefore a better indication of original height. However, an examination of the angle of slope in relation to height demonstrates that there is no clear relationship.

For the majority of Iron Age boundaries, the angle of slope was shallow; very little of the face was near vertical (3%-4%). However, the steep slope at Tumblin suggests that the boundaries may have been intended to be imposing obstacles (whether to stock or unwelcome visitors).

Comparing the infield angle of slope with that of the boundary shared with the later township dyke tests the hypothesis that the reused boundaries survive better as they have been in use, maintained more recently, and therefore subject to less erosion. At Belmont 19% of the infield had steep slopes; the reused boundary included 40%. The difference between the two was even greater at Watlie (5% in the infield; 46% of the township). This suggests that the rebuilding/maintenance of the length of infield/township boundary has impacted on the angle of slope. Shallow slope predominated at Tumblin possibly arising from the location, a significant hillslope. The boundary also had more massive dimensions: factors which may have favoured the reuse of the boundary.

Direction of Dominant Slope Face

There are a number of factors which might affect which slope face is dominant within a construction. Where a Multiple Field System was located on a steep slope, the slope direction takes precedence in determining the principal direction of dominant slope face and, to a large extent, differences in feature height. Many of the results reflect the topography of the sites (e.g. Hill of the Taing, Ness of Gruting and the broch-field boundaries at Sae Breck and Tumblin) There are also significant natural slopes at both Watlie and Belmont, for much of the infield and for the infield/township boundaries. However, there are also exceptions, and so other possibilities require consideration.

South-facing dominant slopes might be favoured as this is the direction of maximum sunlight. Warmth would be desirable both for personal comfort as well as in maximising the growing season. As in Faroe (Mahler, 2007) a boundary face might be constructed in order to reflect the sun and retain warmth, particularly if the face was also internal. There may also have been social or religious significance to a southerly, sunny aspect. In order to establish whether facing the sun was a major factor determining dominant slope face, percentages were calculated for the amounts of slope facing between southwest and southeast. The range for both the Enclosure sites was 13%-73%; at the Multiple Field Systems it was 22% - 91%. The yards and infields at Belmont and Watlie had a majority of slopes facing between southeast and southwest, in contrast to the other yards. Four of the six Enclosures do favour a southerly direction of face, which is consistent with the aspects of the class of Homestead Enclosures, but the majority of the field systems do not appear strongly influenced by a desire to face the sun.

A dominant north face could potentially provide protection from cold winds. An internal dominant face might help contain something, probably stock, even if this was short-term. Three of the Norse yards faced northwest, although the differences in height are slight and may be a feature of survival.

Issues of prestige, or attempts to impress people outside might favour outward-looking earthworks. The broch-field boundaries at Sae Breck and Tumblin are dominated by lynchets which face outwards, following the contour of the hill. The down-slope side of the boundaries would therefore need to be greater in height, although not necessarily in angle, in order for the boundaries to be level, however the differences in height are greater than that. Although these boundaries are not part of the massive "defensive" banks and ditches (normally situated within 20-30m of the broch [e.g. Turner *et. al. 2005;* Turner and Fojut, forthcoming) their size is relatively massive for field boundaries and may be related to status.

The direction of dominant slope face may be created post-abandonment: the southern side of the Vassa boundary faces inwards due to adjacent peat cutting; immediately west of this, the dominant slope face is external.

Pinhoulland is the flattest of the Multiple Field Systems and its slopes face all eight recorded compass points. The site also includes a number of boundaries shared between fields. Of those boundaries at the edges of the field system, and therefore not shared, the mapped results indicate that they predominantly face into the fields: perhaps the fields were used to impound stock for periods. Clevigarth has the flattest terrain of the Multiple Field Systems, the majority of the boundary faces west, away from the cliff edge, posing less of an obstacle to salt spray than if it had faced east. Salt spray would favour a maritime heath rather than arable, therefore the area would be more suited to grazing than cultivation; this was supported by the micromorphology results.

The post-medieval township was located down-slope from the Norse site at Belmont, but the Norse site at Watlie is incorporated within the township. At Belmont the dominant face is within the township boundary and away from the Norse infield; at Watlie the reverse is true. At Belmont it is consistent with the direction of slope, but at Watlie the boundary is higher on the upslope side. This would have taken more effort to construct and maintain but would have helped keep animals out of the lower lying infield/township during the summer months.

FIELD FUNCTION

Three models have been proposed for the use of the Multiple Field Systems in the past. These are presented below in order to explore the contribution of boundary and shape analysis to the debate.

Whittle (1986) proposed that the Multiple Field Systems had an arable nucleus, extensive grazing and dispersed settlement. In this model barley was cultivated throughout the life of the site and with limited evidence for the husbandry of cattle, sheep and red deer. The balance of arable to grazing altered at different periods and when House 1 (the second house in the sequence) was constructed pastoral activity was dominant. Keith-Lucas (1986) identified two periods of scrub clearance from the pollen evidence, 4680±100 BP and 4180±100 BP, with arable activity between them. This timeframe was associated with "House 2", the earliest house, located between fields F1 and F2, which had an earlier wooden structure beneath the stone built remains. Bradley (1978) suggested that a phase of scrub or woodland regeneration could arise from soil impoverishment, necessitating longer periods of fallow, in turn creating grassland which became too tough to break up with an ard. There was no phase of contraction apparent in the structural evidence found at the Scord of Brouster; possibly the arable area changed focus for a period. A Middle Neolithic woodland regeneration has been recorded at a number of other Scottish sites (e.g. Machrie Moor, Arran and Black Loch, Fife) (Edwards and Whittington, 1999), although other authorities have queried this (Thomas, 1991). In Sweden this was a period of population expansion in a system where coppicing and garden plots thrived (Göransson, 1986).

An alternative model, presented by Fowler (1971), was that irregular fields with clearance cairns are "circumstantial evidence" for agriculture and that such areas were not in long term use. This is at variance with the longevity identified at the Scord of Brouster (Whittle, 1986; Ashmore, 1999). The presence of clearance cairns on the land would have hampered cross ploughing, although not spade cultivation. Bradley (1978) suggested that clearance cairns were not the products of initial phases of agriculture but only became necessary as the result of erosion, caused by either pastoral or arable activities. However some clearance cairns at Brouster predate some of the boundaries and boundary analysis identified this other sites (e.g. Pinhoulland).

Edwards and Whittington (1998) proposed a third model for the Multiple Field Systems on the basis of pollen analysis at Pinhoulland, Ness of Gruting, Troni Shun and Brunnatwatt. They identified "cereal-type" pollen in small quantities at each of the sites. With the caveat that the pollen they found in the thin mineral soils (3-4cm) predated the formation of the blanket peat, Edwards and Whittington drew the conclusion that the field systems were primarily grazings.

The period of scrubland regeneration and clearance identified at the Scord of Brouster was followed by a period when pollen evidence suggests that the arable becomes further reduced (Keith-Lucas, 1986). House 3, the latest structure at the site, contained a high concentration of grain, mainly hulled (Milles, 1986) which was better adapted to a harsher environment. The quantity of grain found suggests that it was in the process of being dried, perhaps prior to storage and infers a local crop rather than importation (Milles, 1986). Most of the lynchet colluvium, and at least one of the clearance cairns, date to this phase indicating intensive agricultural activity. Ard use might have increased at this time, accelerating erosion and increasing the formation of lynchets (Keith-Lucas, 1986). When the Scord of Brouster was finally abandoned however, the cultivated land continued to stay free of the encroaching peat for at least 1000 years (Whittle, 1986).

In field F6 at Pinhoulland, Edwards and Whittington (1998) identified a mixture of plants of dry areas (heather *Calluna vulgaris*, grasses *Poaceae undiff*, ribwort plantain *Plantago lanceolota*, dandelions *Lautucea* and greater plantain *Plantago major*) and those of damp areas (sedges *Cyperaceae*, lesser club moss *Selaginella selaginoides*, bog moss *Sphagnum* and royal fern *Osmunda regalis)*. A sample from Pinhoulland field F5 contained more heather, grass and ribwort plantain. Only one sample, just outside field F9, contained cereal *Hordendum* pollen, being otherwise similar to the sample from F5 although with less ribwort plantain. At the Ness of Gruting two of five samples contained "cereal-type" pollen, located within fields F6 and F4. No cereal pollen was found in a sample taken from field F3. All the grasses in the study are classified as undifferentiated, but Milles (1986) identifies heath grass *Danthonia decumbens* at the Scord of Brouster which Hillman (1981) cites as a grass associated with crop waste in Iron Age-Medieval contexts in Wales. It is probable that cereals would be under-represented in the pollen record, since grain was harvested rather than left in the field. The charred plant remains within the Scord of Brouster houses could all be contaminants of a cereal crop, particularly if the crop was reaped low on the straw, including rushes and sedges, since the fields probably contained wet areas (Milles, 1986). Charred plants, discovered within a lynchet, were interpreted as an indication that domestic ash was being used to fertilise the soil (*ibid*). The possibility that this may have related to vegetation clearance was not discussed.

The boundaries of Ness of Gruting fields F3 and F4, sampled by Edwards and Whittington (1998), are dominated by prominent lynchets. The upper end of Ness of Gruting field F6 is also a lynchet, whilst the lower boundaries are defined by banks. F6 is rather more regular in shape and rather larger than the other fields in the system. It also incorporates a later sheep fold and, therefore, it is possible that the banks which currently enclose it could post-date the prehistoric use of the field system. Fields F4 and F5 are crude mirror images of one another. It would therefore seem highly likely that they served similar functions. The cereal pollen from Pinhoulland was found just outside the visibly enclosed field system.

If the fields were grazed, rather than arable, it would not have been necessary to create terraces with lynchets, nor would it have been necessary to create a series of small enclosed areas with boundaries against which soil would build up. If it was necessary to restrict the movements of stock to such an extent, small numbers of animals (such as might have grazed one of these fields) could have been tethered, which would have required far less effort than would be involved in the creation, and constant maintenance, of boundaries. Tether posts were identified at the Sumburgh Runway House (Downes and Lamb, 2000), providing evidence of this practice in the Bronze Age. Rope could be made from the local reeds and grasses. It is possible that the small fields served as animal pens when the fields were fallow, serving to manure the field as well as supplement the amount of available grazing. To date, there is no evidence that animal dung was either burnt as fuel, or used as daub, either at the Scord of Brouster or any other excavated site in the Northern Isles.

The temporary enclosure of animals is suggested by the tendency of the Multiple Field System boundaries to face into the enclosed areas. A difference between internal and external ground height may reflect the use of the site, either during its life or at the point of abandonment. A lower interior might represent a deliberate attempt to increase the protective height of the boundary and could be intended to keep either animals or people in although it might also arise from regular cleaning of something such as dung. Conversely, the addition of manure or the amendment of soils inside an enclosure might cause it to become higher than the ground outside: this is the situation inside post-medieval/modern plantiecrubs. If the soils were not amended, regular use would erode them, causing them to lose volume and height. Waste products disposed of by throwing them over the boundary would gradually increase the height of the land outside. This may have occurred at the Beenie Hoose, Whalsay which was gradually thickened and refaced, incorporating midden material, during the Neolithic period (Calder, 1960-61:31; Turner, 2008: viii).

Different types of outfield vegetation would benefit from different styles of management. Woodland regeneration and heather are vulnerable to grazing damage in winter when more palatable foods are in short supply (Chapman, 2007). Blanket bog is also more vulnerable to erosion through trampling in winter. Managing the outfield would be as important to successful farming as managing the infield, and this would provide further good reason for containing animals within the arable fields during the winter. The type of animals husbanded might be determined by the character of the land available. Cattle favour quantity over quality, unlike sheep which eat more selectively. Cattle cause more damage due to trampling but, conversely, cause localised nutrient enrichment through their dung (Chapman, 2007). Sheep would therefore have been more suited to the Multiple Field Systems, which included boggy areas and steep slopes.

To advance this argument further, it is necessary to explore the economics of life in prehistoric Shetland. Fleming (1971) concluded that each adult in Medieval England required the grain from 1.5 acres, with another 0.5 acres required for seed corn. Fojut (1983; 2005) used the figures quoted by Fenton (1978: 336) to calculate that in pre-improvement eighteenth century Orkney the yield per hectare would be approximately 1000 kg/ha for human consumption, having set aside a proportion of the crop as seed corn. Fojut suggested that the Iron Age yield in Shetland would have been at least comparable with, if not better than, this. Fojut also quoted the requirement of an individual with a cereal-based diet as approximately 210 kg per year. Thus an arable hectare in early eighteenth century Orkney would have almost been sufficient to feed five people. However, there are significant differences between the geographies of Shetland and Orkney in terms of latitude (and therefore climate) as well as in the availability of flat, easily cultivable, land with light sandy soils being prevalent in Orkney but far more scarce in Shetland (concentrated in the South Mainland and the east coast of Unst).

Kemp (2001) calculated that a dairy herd of six cows and a bull, with a maintenance level of immature animals, would supply the daily energy requirement for 9.1 people during the lactation period. The Scottish Agricultural College Technical Note 586 (Chapman, 2007) advises that today, a suckler cow and calf represent 1 livestock unit (LU). One livestock unit is defined as the quantity of stock which can be supported by one hectare of grazing per annum. Beef cattle over 24 months old are only 0.8 LU and so can be kept at a slightly higher density. Sheep can be kept more intensively still, a ewe being rated at 0.12 LU (0.15 LU with a lamb). The Technical Note also provides guideline annual average stocking rates of a range of "semi-natural" habitats. Of relevance to Shetland are the unimproved upland grassland (e.g. Nardus) rated at 0.15-0.25 LU/ha/yr; young heather at 0.2 Lu/ha/yr; intermediate heather (20-40cm) at 0.05 LU/ha/yr; old heather at 0.02 LU/ha/yr and blanket bog at 0.06 LU/ha/yr. The type of light woodland which existed in early prehistoric Shetland would fall within the category of Moderate (woodland) fertility, rated at 0.07 LU/ha/yr. The figures can vary by 20-40% depending on soil fertility. The restoration of sites in very poor condition, whether under or over grazed, will also alter the potential stocking level, either up or down (*ibid*).

Fleming (1971) argued that woodland browsing was nutritious and that the level of effort required to clear it was not justified if the land was solely grazed. He quoted two Danish experiments, one of which demonstrated that it took 245 person hours to clear a hectare of woodland using iron tools, the other calculating that it took 2.5 weeks using iron implements, or 5 weeks using stone tools, to clear light woodland. However, the stocking rates recommended by the Scottish Agricultural College indicate that woodland browsing is not nutritious: even the "High fertility, lowland broadleaves" woodland has a value of 0.15 LU/ha/yr.

The areas of the sites were calculated as part of the Shape Analysis. If the Homestead Enclosures were used for agricultural purposes they could either have supported a maximum of a single ewe and lamb for a year (assuming that the grassland was improved to 1LU/ha/yr, which is optomistic) or, based on Fojut's calculations, grown sufficient grain for between 0.6 and 1.25 people (at South Newing and Croag Lea respectively). These calculations disregard the fact that part of the area of the Enclosure was actually occupied by the house. In either model, the Enclosures were clearly not the primary supply of food for their occupants. Either people grew crops and kept animals which lived outside the Enclosures, or they lived a more hunter-gatherer lifestyle. Whilst this may have involved a degree of seasonal movement, perhaps to tend animals and gather wild resources, the size and solidity of the houses suggests that settlement was essentially permanent. None of the Enclosures are far from the sea and the study of viewsheds indicate the importance of coastal resources: fish (including shellfish) seabirds and their eggs, supplemented by the occasional seal or cetacean, must have formed a significant part of the diet. Isotope analysis of human bone has led to the suggestion that by 5400BP people had abandoned eating marine derived food (Richards and Hedges, 1999:892) possibly the result of a taboo (Thomas, 2003: 70). This has been challenged on the basis of sample size (only three Scottish individuals, from Oronsay) and a more gradual move towards a terrestrial diet suggested for Southern Britain and Wales (Milner, *et al.,* 2003: 12). In a Shetland context such a taboo would be literally suicidal: this study demonstrates that it is only the use of the ubiquitous resources of the sea which makes life in the Neolithic/Bronze Age agricultural communities economically viable. Unfortunately the preservation of bone is generally poor in Shetland and the results of isotope analysis in progress not yet available (Montgomery, University of Durham).

Many individual fields within the Multiple Field Systems are smaller than the Enclosures; at most the areas are further reduced by clearance cairns. Evidence has already been presented as to how early in the development of the field system clearance cairns were created. The smaller fields in these field systems were therefore too small to support a single animal for a year and, even if kept fertile would supply as little as 14% of the grain required for an individual eating a cereal-based diet for a year. However, if the field systems were taken as whole, based on the visible field boundaries, and making the assumption that the fields were kept fertile, then four of the field systems would have supported a small group of adults eating a cereal-based diet: four adults at each of Clevigarth and Gallow Hill (1.0271 and 1.0052ha), six at the Scord of Brouster (1.4912ha) and eight very comfortably at Pinhoulland (2.1458ha). The total areas enclosed at Sumburgh Head and at the Ness of Gruting are far smaller (although, at the Ness of Gruting, the area enclosed was probably larger than the fields which could be measured, but other boundaries were too fragmentary to estimate the size of the areas which they may have enclosed with any degree of certainty). At Sumburgh Head farming appears more difficult, maximising the potential of every small terrace or flatter area of land. However this too indicates that their intention was arable, since animals could have roamed the hillside without requiring the creation of small terraces. Micromorphology at Pinhoulland demonstrates that the fields were cultivated, interspersed with periods of grazing, indicating that the proportion of the diet derived from cereal was relatively low.

Of the Norse settlement sites, the sizes of the infields at Gardie and Watlie demonstrate that, if fertile, they could have provided enough grain for 19 and 12 people respectively. Indeed, the infield at Gardie is likely to have been larger than the area measured and therefore may have exported grain. The infield at Belmont is far larger, but unpromising for cultivation: micromorphology showed no evidence of this but indicates its use as hay meadows. Excavation has demonstrated that the inhabitants of Belmont worked soapstone extensively, which was therefore traded and contributed to the farm economy (Larsen *et al.,* 2013). Trade developed with ease of mobility during prehistory and was well established in Viking society (Barratt, 2008:677ff).

Based on these calculations therefore, the amount of grain grown in any of the field systems under consideration, or the animals grazed in them, is likely to have contributed only a limited proportion of the diet of the community. Mahler (2007) described domestic animals as a "safe food-bank", which also contributed calves, lambs and dairy produce to the community. Mahler suggests that grain was also part of this "safe food-bank", pointing out that while growing small amounts of grain was time consuming, cereals nevertheless played a central role in the economy of Viking/Norse Faroe.

Another facet in understanding the Multiple Field System economy lies in how the field systems relate to the projecting boundaries which can be traced for considerable distances into the hill. Examples within this survey include a length running southwest from Pinhoulland and another west of Gallow Hill. A third, not plotted, is visible running northeast of the Scord of Brouster. Fojut (1993) suggests that these predate the field systems and cites two massive examples: the Funzie Girt dyke in Fetlar and the division across Fair Isle. However neither the Funzie Girt or Fair Isle dykes is associated with a field system, and these probably served a different function to those boundaries with a clear relationship to the field systems, hill ridges and chambered cairns. Fojut suggested that these are territorial boundaries created in response to the expected arrival of "as many as ten thousand persons", and that this represents a sophisticated pattern of land organisation (*ibid*).

In June 2010, the Royal Commission on Ancient Monuments of Scotland Survey Team plotted a 5x5 km area of Shetland, centred on the Bridge of Walls. This identified a number of these non-field dykes appearing at intervals in the peat. The results of this work will shed further light on the way in which these boundaries relate to the field systems. However, while they could be a sophisticated social phenomenon (Fojut, 1993) the boundaries may have been more utilitarian. The importance of the hill land between the settlements may have exceeded its value for summer grazing, as a managed supply of tools, timber, fuel and wild food resources. The division and ownership of the hill land may have been as important to the inhabitants as the fields themselves. Quarries for stone tools and working surfaces have been identified during the present study: above the Sumburgh Head field system and in sub-divided hill land on the West Side. The geology itself was clearly of economic value to the settlements. Rights to the hill may even have determined ownership of coastal resources of the sea: fish, whales, driftwood, seaweed and seabirds, which must all have contributed to the wellbeing of the community. This might explain why the inhabitants of the Multiple Field Systems did not share the need of the Homestead Enclosure residents for a view of the sea.

The Faroese Seyðebrævið, or "Sheep Letter", of 1298 provides a practical lawcode pertaining to agricultural practices in Norse Faroe. Since the person in charge of the Faroese inquiry which gave rise to the letter was simultaneously in charge of Shetland, the prescriptive rules within it may have also applied to Shetland (B. Smith, Shetland

Archivist, pers. comm.). The code laid down many rules for sheep husbandry and rights which related both to the infield and the outfield. It is clear that keeping sheep in the outfield, held in common by several people, was central to the Faroese Norse economy. The text also makes references to boundaries in the outfield, e.g. an injunction that newly established farms should be capable of supporting a minimum of three cows, indicating that there was pressure on Faroese land (although this law was not necessarily adhered to). Rights in the outfield included peat cutting and were linked with rights to the coastline (Mahler, 2007). Although the rules and practice for Norse farming were brought into Shetland (along with the Gulathing law which applied in Norway from before 930AD, and to the North Atlantic as it became colonised) the land divisions of Neolithic/Bronze Age Shetland suggest that such rules may have applied as much as 3,000 years earlier.

Allowing animals to graze wide areas is still practised in Shetland today. Large tracts of scattald (common or shared pasture belonging to a township community and held in proportion to the amount of arable) have been essential to crofting communities "from at least the sixteenth century" (Fenton, 1978, 36). Under this system, rights to the scattald included rights to resources. Animals from different crofts ran together over a wide area. They were identified either by tags or by distinctive shapes, "lug marks", cut out of their ears, examples of which are listed by Fenton (1978, 473ff). In 2001 Tavish Scott MSP expressed fears that if foot and mouth arrived in Shetland, it would spread from south to north uncontained, as the hill grazings ran into one another. "The problem in Shetland is that, to all intents and purposes, the islands are one agricultural unit. If, heaven forbid, the disease did reach Shetland then it would be practically impossible to stop." (Shetland Times, 30 March 2001). In the last few years however, there have been considerable changes in the way that the hill is managed in Shetland. During the course of this study, the Scord of Brouster and, in 2010, Gallow Hill, both on the scattald when recorded, were fenced and an individual has taken ownership of a portion of the grazing. Far from suggesting a sophisticated community, this proliferation of new fences indicates the way in which crofting is becoming more solitary, with people seeking independence from one another. They no longer need to gather at an agreed date and time in order to "caa sheep", whether for dipping or to bring them down into enclosed grazing: arguably this denotes the breakdown of crofting society. It also demonstrates that the other resources of the hill land, particularly peat cutting but also stone and fresh water, are no longer of any great value.

Efficiency

Shape Analysis demonstrates that the Homestead Enclosures were the most efficiently built type of field (efficiency being defined as being the means of enclosing the maximum amount of area with the minimum resources (labour and materials). The solidity of the areas enclosed, the close relationship between area and perimeter length and shape factor all suggest that efficiency was important. This may be the result of the limited availability of labour, materials, time or surplus resources to support the labourers. Alternatively it may have been influenced by common tenets within the social structure of the time. Efficient construction does not appear to have been important in any of the other the field systems. This may have been due to other factors overriding efficient construction: methods of agriculture or incorporating clearance cairns may have been more important than economy of effort in construction/maintenance.

Irregularity

The widest variation in the results of Shape Analysis is found amongst fields in the Multiple Field Systems. It would appear that a degree of irregularity had no significant adverse effect on the function of these fields, indeed, today meandering boundaries are locally claimed to stand up to the wind better. If the fields were being used for grazing, or were cultivated by hand, shape would be less important. Meandering boundaries would accommodate clearance cairns easily. The 75 broken ard points at the Scord of Brouster (Rees, 1986, 75) indicates a period of ploughing during which more regular fields might have had advantages. Clearance cairns would certainly hamper ploughing. However, both the feret ratios and the area: rectangular areas demonstrate that the elongated strip fields and rigs of post-medieval times were an anathema to prehistoric and Norse Shetland.

The Norse infields vary considerably in size which might reflect the amount of available land at each site. The irregular convex boundaries at Belmont may respect pre-existing boundaries. The exceptional size may also reflect the fact that this hill-land was relatively poor even in the Norse period. Of the 10 yards surveyed, two pairs are attached to single longhouse sites. In each of these cases, one yard has an exceptionally large area. This, together with the shape factor at Belmont [1] suggests that the yards may have served different functions; alternatively they might be of different dates. Plans from Jarlshof Phase 3 (the only phase with good plans of the yards) show that longhouses 2 and 3 had byre end entrances which opened outside the yard (Hamilton, 1956). When longhouses included byres, cattle would require easy access. The survey evidence from this study and the plans from Jarlshof demonstrate that the yard was a space from which cattle were routinely excluded; the lower (byre) end of the house opens directly into the infield (although at Belmont the yard boundary is too fragmentary to be certain). The yards might therefore be cultivated spaces; possibly garden areas where herbs, plants for healing and textile dying, as well as flax, could be grown. The two yards at South Sandwick were attached to a house dating between 1100-1300 (Bigelow, in preparation). The excavated middens within both yards contained both food and craft processing waste, including concentrated dumps of fish bone. Bigelow assumed a domestic use for the yard rather than an agricultural one. It is not possible to carry out shape analysis on the Sandwick yards as they were eroded extensively by the sea. The yards identified at Sandwick have a different relationship to the house in terms of both alignment and doorways, which may also indicate a difference in either use or date.

Massive Boundaries

Massive boundaries do not necessarily make more effective barriers, particularly if the angle of slope is shallow; a narrow but vertical boundary could present more of an obstacle. In this sense, the narrow broch-field boundary at Clevigarth could have been at least as effective as those at Tumblin and Sae Breck. A boundary surmounted by a fence or bushes would be more formidable. The direction of face might suggest that animals were kept outside, rather than on the higher land closer to the broch, although the topography and micromorphology at Clevigarth indicate the reverse. At Sae Breck there are small fields or enclosed areas at the foot of the hill, possibly arable or garden plots associated with the broch. These have slight boundaries, possibly the footings of fences or ridges created between cultivated plots, which would also have served for field clearance. Substantial boundaries are, however, in keeping with the broch defences and it may be that the broch boundaries served a less prosaic purpose, such as to announce the proximity of the broch to the visitor.

The Emerging Model for Soil Management

Table 8.4 set out the model for the use of agricultural soils, particularly cultivation, in the North Atlantic. Fig 10.4 presents this information graphically and also presents the results of the micromorphology in the same manner. It is immediately apparent that the question of landuse is complex and that there is more variation between the intensity and methods of cultivation over time than the original model suggested. Details of these have been set alongside a consideration of the soils environment. The information presented has been distilled from the detailed analysis of each site, most of which are represented by more than one soil profile and some of which demonstrate differing agricultural practices in use at the same time. Grazing and periods of fallow are under-represented in the figure, the focus being cultivation.

The model shows a progression in the intensity of landuse, commencing with low levels of cultivation activity in the Neolithic/Bronze Age, which then gradually rises. There is evidence of intensive use in both the Late Bronze Age/Early Iron Age, where Guttmann (2006) has proposed that cultivation took place on flattened middens, and the Late Iron Age, where Simpson *et al.* (undated internet paper) have suggested that this might relate to innovative agricultural practices being introduced by the *papar* (Pictish priests).

The soils within the model are dominated by light sandy silt loam soils, sandy soils and two examples of brown soils (Scord of Brouster and South Nesting) which became podzolised in the Neolithic/Bronze Age. The Post-Norse soils in Papa Stour are more atypical, being on peaty gleys. The majority of the soils in the model, however, are free draining, sandy and most commonly calcitic, although including quartz sands at Old Scatness. Together with brown soils, these soils are classified by Simpson *et al.* (undated, internet paper) as being the most desirable types of environment for working by early agriculturalists.

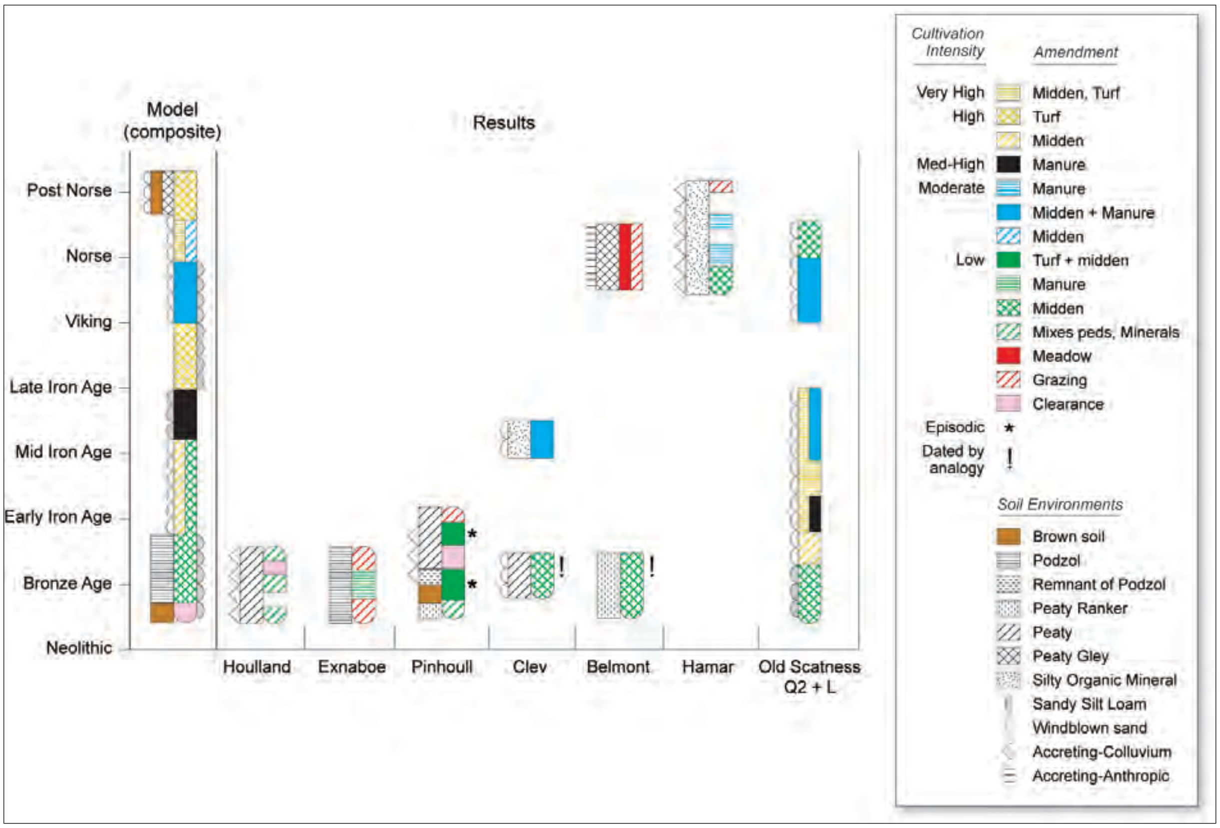


Fig 10.2 A comparison of the results of micromorphology from this study set against the model for soils in the North Atlantic, including information relating to soil type. (graphics: Bill Jamieson)

While the light soils would be those most easily worked with an ard or a spade, they would also be easily erodible, particularly in a windy island environment. Mixing organic material into the soil would provide an increased structure and stability to such fragile soils. This suggests a close relationship between amendment and the cultivation of light sandy soils. Calcareous soils have limitations, however; at Old Scatness these include high pH values contributing to serious trace element deficiencies with low levels of cobalt, copper and manganese (Dry and Robertson, 1982: 40). This also demonstrates the desirability of amendment. In cases where the sand continued to accrete, soils would become increasingly deep and the need for amendment would be particularly important: the profile at Old Scatness Q2 was over 3m deep. The depth of these soils makes them relatively easy to identify and favours the good preservation of associated structural remains, as clearly demonstrated at Old Scatness and Jarlshof in Shetland's South Mainland. As most of the previous work on anthropic soils has been associated with the archaeological excavation of well preserved structural remains, this introduces a potential bias in favour of soils which can be easily identified in the field as being either amended, or cultivated with ard or spade marks evident.

This study demonstrates that, in Shetland at least, agricultural settlements were not restricted to areas where the soils were light. The study examined soils initially identified as being from "single period" sites. Whilst soil pits were excavated from the most promising of those augured, in the field most did not appear amended. They were selected due to their location within identifiable field systems and as such they added a more complex dimension to the model.

The Neolithic/Bronze Age/Early Iron Age soils at Clevigarth, Old Scatness and Belmont conform to the model, the soils being amended with midden at low intensities. Consistent with the model, episodes of clearance by burning were identified at Houlland and Pinhoulland, occurring at both following episodes of cultivation, neither being primary. However, manure is present in the soils at Exnaboe and there are several episodes of turf and manure being mixed with midden material at Pinhoulland, introducing new methods of amending soils to the suite of options open to the early agriculturalists. It has been suggested that manuring was a Mid Iron Age introduction (Guttmann, 2006) and it is conceivable that the low levels of manuring at these sites could result from seasonal grazing rather than a more pro-active collection and dumping of manures. The turf at Pinhoulland may have entered the soil as a by-product of the midden, perhaps decayed turf structures, an interpretation which also holds good for the Iron Age. These results challenge the previous model.

The ashy Iron Age midden identified close to the broch at Old Scatness (Guttmann, 2006; 2008) was not reflected at sites in this study. Midden material occurred with manure and no ash at Clevigarth. Of the two new profiles at Old Scatness, Profile Q, at the NE edge of the site, was less ashy than Guttmann's profile (2006) although it became ashier later. The soils to the south, Profile L, included turf (from a wet upland environment) some ash and silicaceous material, the ash content gradually decreasing. The nature of the midden material changed, but probably remained domestic.

There was no turf component to the Viking/Norse sites in the study: at Belmont there was no cultivation, the infield and yard being grazed and used as hay meadows. At Hamar there was an initial stage at which low levels of domestic waste were added to the soils; subsequently the soils were manured in phases, before reverting to grazing. The new Old Scatness profiles demonstrated the initial addition of midden and manure, subsequently reverting to low levels of domestic midden.

Domestic midden was the most commonly added material throughout time, perhaps because it was readily available. As noted previously it is possible that the use of domestic midden was in part a response to the sustainable disposal of waste and it is possible that manuring strategies through time are a pragmatic response to using whatever was available. Clearly the use of manure would require a mixed farming economy: there is every indication that this was practised to a greater or lesser extent throughout Shetland's past.

The potential for the survival of pedofeatures in thin acidic soils

At the beginning of the study it was not clear whether, or to what extent, the thin acid soils on which the majority of well-preserved field systems survive would retain cultural evidence. Previous work has been concentrated on sandy soils and the Scord of Brouster samples were taken from beneath boundaries and structures which therefore predated acidification and peat growth, and were buried as the result of a rapid event (Romans, 1986).

The early soils at Pinhoulland included brown soils, as well as thin acid peaty rankers and peaty soils. The soils at Houlland, Exnaboe, Pinhoulland, Clevigarth and Belmont were all thin and acidic; at Belmont and Pinhoulland some areas were eroding; at Hamar the soils were thin, acidic and stripped. At Clevigarth, the later soil on the unenclosed side of the Iron Age boundary was described as organo-mineral due to the amendment having significantly changed the nature of the soil, demonstrating that this was possible even in an acidic environment.

Thin acidic soils occurred at the majority of Shetland sites associated with the survival of well preserved field system boundaries. The evidence at all the early (i.e. Neolithic/Bronze Age) agricultural sites in this study is one of low intensity cultivation. The evidence from the thin acid soils is comparable with the evidence found from the light sandy soils at Tofts Ness and Old Scatness (Simpson, 1998; Guttmann, 2006). The study demonstrates that the unpromising, thin, acidic, soils can retain the full range of pedofeatures already identified on sandy soils: from ard marks to clay and silt accumulations, linearity to diatoms and mixed aggregates. This might be partially due to a lack of worms and micro-organisms in such environments. This is a significant finding, since it indicates that micromorphology could be successfully applied far more widely, both within archaeological excavation and to the study of field systems, than is immediately apparent during recording in the field.

<u>The impact of soil environment on function</u>

One aspect of this study explored how the pre-cultivation soil environment influenced how the soils were managed. Shetland has limited areas of easily worked light sandy soils; today it is dominated by a range of histosols, podzols, rankers and gleys. A study of Papar sites (comparing soil types with the occurrence of the *papar* place name element) found that, in Shetland, these names are found in equal numbers on podzolic soils and peaty gleys, rated second and fourth (the worst) in a ranking of cultivable soils (Simpson, *et al.,* undated, internet paper: 7 & 3). The only Neolithic/Bronze Age soil found on a light sandy soil during the study, was at Old Scatness where the cultivated soil overlies several layers of pure sand. There were traces of an early brown soil at Pinhoulland, as had also been the case at the Scord of Brouster (Romans, 1986:130). There was also a peaty ranker at Pinhoulland, and another at Belmont. One site, Exnaboe, was podzolic (Simpson, *et al.'*s category 2 soils, *ibid*) and there were traces of a disturbed podzol at Pinhoulland. With the exception of Clevigarth, the peaty soils had fallen out of cultivation by the end of the Late Bronze Age/Early Iron Age: the peaty gley at Belmont was subsequently grazed. At Clevigarth the soils outside the Iron Age boundary were cultivated subsequent to its construction, there being a high level of accreting sand mixed with the peat.

Soil Type	**Management**	**Location**
Light sandy soils	Domestic midden & ash; Midden and turf	Old Scatness
Organo mineral (peaty with wind blown sand)	Midden, manure, turf	Clevigarth
Histosols	None	Houlland
Pozolic	Manure (low levels)	Exnaboe
	Midden with turf	Clevigarth
Brown Soil	None	Pinhoulland
Ranker (brown)/organo mineral base rich	Midden Midden & manure	Hamar
Peaty ranker/peaty gley	Midden	Belmont
	Turf & manure	Pinhoulland

Table 10.3 Soils Environment before amendment and management applied

Table 10.3 demonstrates that there is no clear relationship between soil type and management. The brown soil at Pinhoulland and the histosol at Houlland were both initially cultivated without any sign of amendment. Turf and midden was added at Pinhoulland as it became peatier: domestic midden was added at Clevigarth and Belmont, to the sandy Neolithic/Bronze Age soils at Old Scatness, and in the first (Viking) use of the base-rich organo-mineral soils at Hamar. The Iron Age organo-mineral soils at Clevigarth were amended with midden, manure and turf – although in nothing like the quantities seen at Old Scatness. The Viking/Norse peaty ranker/peaty gleys at Belmont were not cultivated: although there are suggestions of low level Bronze Age cultivation. No site in the study had been amended by hill-turf stripped and applied directly to the field seen in post-medieval Papa Stour (Davidson and Carter,1998) although turf/peat has been cut at several locations.

The role of accretion in the sustainable cultivation of peaty acidic soils

The lack of bases found in peaty and podzolic soils has the effect of protecting plant litter by tanning the cell walls; as a result of tanning that micro-organisms cannot easily break the litter down and earthworms cannot live in it (Limbrey, 1975:137). Plant residues therefore accumulate at the surface rather than mixing into the lower strata and the soil profile becomes water saturated. Palatable plants cannot grow in this environment which becomes increasingly less suitable for grazing anything other than cows (Limbrey, 1975:137).

Whilst most of the sites in the study were located in acidic environments, most were also found to be in accreting environments. The sources of the accretion were variously the result of colluvium, windblown sand, or human activity (cultivation upslope was recorded as colluvium; soapstone working was recorded as anthropogenic). Of all the recorded attributes, accretion is the single most unifying factor between the sites: absent only from Exnaboe, the earliest activity at Belmont and some contexts at Pinhoulland. This suggests that accretion was an important factor in enabling acidic soils to be used for cultivation; it refreshed the mineral content of the worked soil and helped to create a looser, and therefore better drained, structure to the soil. The presence of peat upslope would significantly reduce levels of accretion, particularly that resulting from colluvium with a consequent impact on the sustainability of down-slope soils, even if they were not themselves peat covered.

Work at the Scord of Brouster demonstrates that there is a point at which soils can become too stony to be workable (Romans, 1986:126). Here, the fine organo-mineral component and smaller minerals had eroded (and presumably accreted on the lower land). At Old Scatness increasing sand blow apparently contributed to a decrease in the levels of post-Norse activity (Turner, *et al.*, 2010:202). Thus while some accretion was clearly beneficial, the balance was critical. Although soils were amended, replenishing nutrient deficient soils, the correlation between use and accretion suggests either that locations for settlement were carefully pre-selected due to a pre-existing degree of natural fertility or that attempts to settle failed in areas where there was little or no natural renewal of fertility, or where erosion was excessive.

Intensity of Use

The sites examined indicate that Neolithic/Bronze Age cultivation was always low intensity, although the material added to the soils varied. At Houlland and some contexts at Pinhoulland, it is not obvious that anything was added, these being characterised by mixed peds and pedofeatures related to cultivation. Where soils continued in use for a longer period (Pinhoulland, Clevigarth, Old Scatness) intervention became essential for continued fertility. Although peat growth seems to have impaired, if not halted, cultivation at some sites, the results from Pinhoulland and Clevigarth, at the Scord of Brouster (Romans, 1986), demonstrate that, amending the soils could prolong their useful life. Low intensity amendment is not restricted to early prehistoric soils, low levels of midden material being added at both Viking Hamar and Norse Old Scatness. Low intensity amendment/cultivation alone is therefore not a perfect cultural indicator.

The model shows intensive levels of cultivation in the Early Iron Age (Old Scatness), some Late Iron Age (papar) sites, some (but not all) Norse sites, and in the Post Norse period. The only intensive activity identified in this study was Late Bronze Age - Mid Iron Age Old Scatness. In contrast, Mid Iron Age Clevigarth was amended with midden and manure and was moderately intensive. A similar level of activity was evident in the Viking period at Old Scatness and the Norse period at Hamar. The archaeobotanical evidence from Hamar demonstrates that this moderate level of activity was capable of producing extremely healthy, high quality barley (Bond *et al.*, 2013) and at Old Scatness flax, a demanding crop, was introduced at this time (Bond, 2010:12). It has previously been suggested (Adderley, *et al.,* 2000) that the Post-Norse soils at Papa Stour were amended beyond the need to maintain fertility. Evidence from this study adds further weight to this argument, indicating that a moderate level of amendment was sufficient to produce a good quality crop. The overprovision of amending material at Iron Age Old Scatness could be explained by the use of flattened middens, or the amount of waste material available. Immediately post-broch roundhouses at Old Scatness were subsequently used as dumps for ashy midden material: clearly there was a surplus available in the Mid – Late Iron Age, and therefore in the Viking and Norse periods. The disposal of waste is a problem which humans have always faced and burning peat produced high levels of waste ash. At the Neolithic/Bronze Age Beenie Hoose in Whalsay, midden was used as a layer of insulation, placed between the walls in successive modifications of the house (Calder, 1960-61:33; Turner, 2008: viii). It is possible that dumping waste onto the fields or cultivating on top of middens was as much about sustainable waste disposal as it was about improving fertility.

INHERITANCE: LONGEVITY AND SUSTAINABILITY

Introduction

The majority of sites examined in this study were selected as fairly complete, or well-preserved, field system boundaries relating to a single period and therefore unpromising for exploring questions of inheritance. Nevertheless some of the sites were shown to have a greater longevity than anticipated. Pinhoulland demonstrated multiple phases of cultivation, interspersed with periods of fallow with increased accretion, indicating that cultivation was rotational within the field system. Clevigarth, Belmont and Hamar all proved to have a previously unexpected longevity of use.

Inheritance: Homestead Enclosures and Multiple Field Systems

Each Multiple Field System includes a field where the Shape Factor and Convexity is commensurate with that of a Homestead Enclosure, other than Gallow Hill, where two fields fall just outside it. Only the Scord of Brouster [2] has both perimeter and area measurements which also fit perfectly; the earliest stone-built house was located at the edge of this field (Whittle, 1986): a similar situation as at Vassa. Clevigarth [4] includes a house site, and although area and perimeter measurements are smaller than those in the Homestead Enclosure group, this is explained by damage to the east edge due to coastal erosion. Of the other field systems, the Ness of Gruting [5], Pinhoulland [1] and Sumburgh Head [2][4] each share Shape Factor and Convexity values with the Homestead Enclosures but the area and perimeter length do not fit quite so well. The evidence suggests that the

Multiple Field Systems developed from Homestead Enclosures. Multiple Field Systems were long lived and some may have been established later or in areas with no earlier Homestead Enclosures. It is traditionally assumed that Homestead Enclosures predate Multiple Field Systems on the grounds of both simplicity and the correlation in shape between some oval houses, with heel-shaped façades, and chambered cairns. Few Homestead Enclosures have been excavated and those which have been did not provide good dating evidence, Catpund being dated as Bronze Age on the basis of the pottery (Ballin Smith, 2005). It is therefore possible that Enclosures were contemporary with Multiple Field Systems, perhaps with less long-term sustainability, although there were several episodes of cultivation at Houlland, where the intensity of use fluctuated, indicating that it was relatively long lived. Micromorphology demonstrated that the Enclosures at Houlland and Exnaboe were both used for cultivation, the results being consistent with those from the Pinhoulland Multiple Field System. Cultivation of the fields at Pinhoulland was also sporadic, although the continued use of the field system unit was demonstrated by episodes of accretion.

The evidence therefore suggests that Homestead Enclosures could be relatively long lived and that Homestead Enclosures on the west of Shetland developed into Multiple Field Systems. This might include the re-use of previously unenclosed land or land enclosed with a less permanent boundary. Soils field work carried out at South Nesting demonstrated that Bronze Age houses could be associated with fields which were largely unenclosed (Dockrill et al, 1988). Conversely, areas where the Homestead Enclosures survive alone may have been unsuitable for developing into Multiple Field Systems (perhaps constrained by unavailable or poor quality land).

Relative Chronology: Multiple Field Systems

Shape Analysis can be used to demonstrate which of the Multiple Field System elements were primary, secondary or even tertiary within the complex. Convex fields, resembling Homestead Enclosures, are thought to be primary on grounds of both the Shape Analysis results and the convexity of the boundaries. Unless constrained by physical factors, primary fields are likely to be convex rather than concave, this being a more efficient shape (see above). A less likely possibility is that Homestead Enclosures were superimposed onto a pre-existing field system. There are four fields with both exceptionally large areas and convex boundaries. With the exception of Gallow Hill [2], which has concave boundaries, possibly an amalgamation of two fields, the large fields appear to be secondary, or in the case of Pinhoulland [9], tertiary, to other field systems in the area. At Gallow Hill, the field with the second largest area, Gallow Hill [3] is irregular and more concave, and therefore likely to be secondary.

The fields with larger areas appear to enclose land between other, pre-existing, fields. It is probable that when the area was first cultivated, the best land was used first. There are a number of reasons as to why secondary fields might be larger: deteriorating land quality or using less productive land might require a larger area to achieve the same output. Alternatively, larger fields might reflect the need to increase output. A third possible explanation is changing agricultural practice.

This raises the question of whether large fields within other Multiple Field Systems were secondary. The largest field at Gruting [6] may have been secondary. The irregular shape of Scord of Brouster [5] suggests that this was also secondary. This field includes the second stone built house site in the sequence, located in the heart of the field system. At Sumburgh Head the largest field in the system [2] was not attached to any other fields and so it is impossible to determine relative chronology.

Boundary Analysis and Sinuousity did not prove useful tools in identifying field system chronology although some of the Multiple Field Systems elements are characterised by a single feature type, suggesting a single episode of construction.

Chronology and Inheritance: Clevigarth

Shape Analysis indicates that the field system at Clevigarth is somewhat different from the other field systems within the multi-field category. Clevigarth [4] fits the Homestead Enclosure pattern and other elements of the field system appear to respect it, adding to the impression that Clevigarth [4] was primary.

Clevigarth [1] comprises a length of dyke potentially associated with the broch. The dyke lies to the north of the broch whereas the rest of the field system under consideration is located to the south of the broch. Shape analysis suggests that Clevigarth [2] and [3] are atypical of the Multiple Field Systems. When location and shape analysis are considered together, it seems probable that the field system at Clevigarth is not a Multiple Field System. Instead, Clevigarth [2] and [3] may comprise a drove way relating to moving cattle potentially contemporary with the broch. Dockrill (forthcoming) has a suggested that brochs in more isolated situations, such as Clevigarth, were associated with cattle rearing; shape analysis of the earthworks at Clevigarth supports this interpretation. This study therefore comprises the first identification of a complex field system associated with a broch. It also makes the case for the inheritance of landscape directly from the early prehistoric period through to the Iron Age.

Brochs and Longhouses

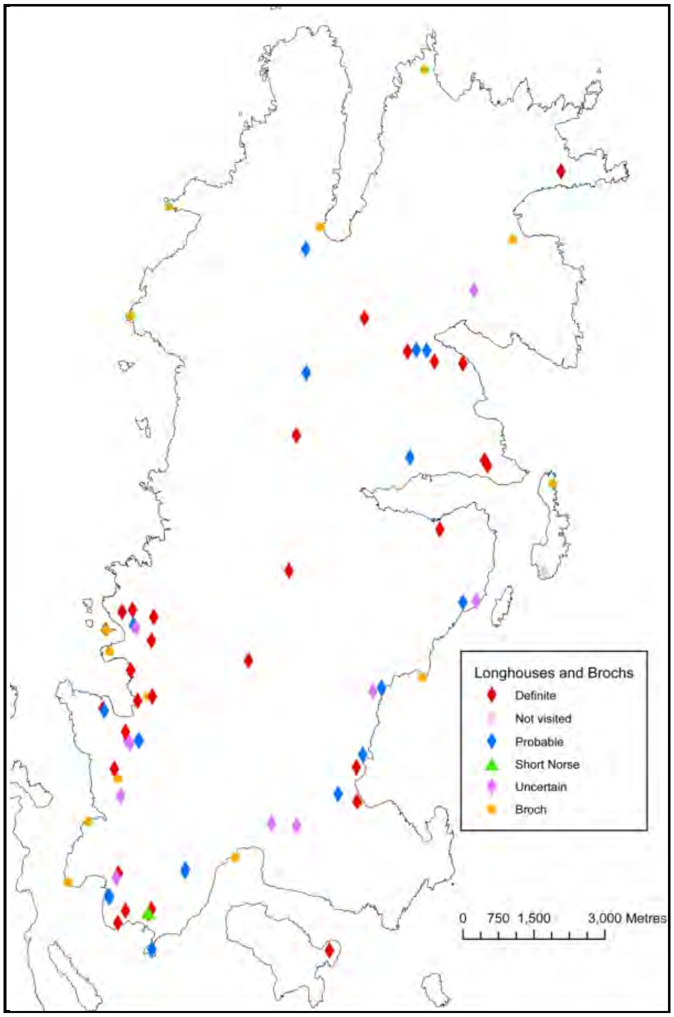


Fig 10.3 Map of Unst showing locations of Brochs and Longhouses (taken from Shetland SMR).

Brochs precede longhouses at both Old Scatness and Underhoull, however Clevigarth, Tumblin and Sae Breck do not appear to have a Viking/Norse phase. Old Scatness and Underhoull were closer to bays suitable for longships, however, the map of longhouses in Unst demonstrates that not all longhouses had coastal locations. The brochs and longhouses of Unst have been plotted (fig 10.4) to examine whether a coincidence of

Viking/Norse head farms and brochs exists. Apart from Underhoull, the only other close association is found at Snabrough, a little further south. A strong link exists between both site types and the coast, but at least nine brochs have no clear association with longhouses, only two displaying a close link. Salvage recording of a longhouse at Norwick (Ballin Smith, 2013) also identified Iron Age remains and there are local claims for a broch in the area. Of all the longhouses excavated in Unst to date (Underhoull x 2; Hamar x 2; Belmont and Sandwick) Upper Underhoull, the closest to a broch, is perhaps the least well constructed, with a greater reliance on turf (Bond *et al.*, 2013). This is perhaps surprising in view of the proximity of Underhoull Broch, a potential source of dressed stone: perhaps issues of status and ownership precluded the inhabitants of Upper Underhoull from accessing it. A sprung floor and good quality artefacts indicate that the farm was not impoverished.

The excavations at Old Scatness (Dockrill, forthcoming) demonstrate that the site was occupied throughout the Iron Age, through the Viking and Norse eras, and into the 20th century. This is not reflected in the soils evidence: the Late Iron Age is unrepresented and the Post-Medieval area of cultivation contracted, being absent from all four soil profiles. The soils evidence demonstrates that the land was first used in the Bronze Age period. This suggests that the inheritance of cultivated soils was important. However the sites in the study do not reflect a Viking desire to reuse broch land or to claim to broch territories. This is something to be explored in more detail in the light of the evidence which now exists for Unst.

The Norse site at Belmont was located in a landscape which had been used before, although there was no structural evidence of this. Two sets of cupmarks, one on a rock outcrop, the other seen in the bedrock close to the longhouse during excavation (Larsen *et al.,* 2013) are probably Bronze Age in date. Ard or spade cultivation seen in the micromorphology may be Bronze Age. No later activity can be positively identified until the Norse period. Stove also had a prehistoric phase: there was a prehistoric building down-slope from the longhouse, not investigated in this study. Hamar displays no evidence of earlier occupation, although it clearly became a thriving farm.

<u>Post-Medieval/Modern Landuse</u>

Several sites display a Post-Medieval or Modern crofting use of the land. In most cases (Scord of Brouster, Clevigarth, Ness of Gruting, Pinhoulland and Underhoull) this is in the form of a plantiecrub, or sheep shelter, utilising a convenient source of stone rather than inherited landuse. The post-broch boundary at Sae Breck divides the area, possibly for sheep or perhaps territorially. South of Belmont there is a small crofthouse and kaleyard, shown as roofless on the 1882 First Edition Ordnance Survey map; there is a crofting settlement with house, outbuilding and yards to the north of the longhouse at Watlie which is roofed in 1882 but roofless in 1876 (Second Edition map). Hamar had been abandoned by the 17^{th} century (Bond *et al.*, 2013). At three sites the boundary was reused by the township: both the broch at Tumblin and the longhouse at Belmont fell outside the area thus enclosed, unlike Watlie. In Faroe the basic present day farm structure appears to have been introduced by the 12^{th} – 13^{th} centuries, or perhaps even earlier (Mahler, 1991). In Iceland, early farms had already been abandoned by 1000AD (Sveinbjarnardóttir, 1992).

The field evidence does not indicate continuity of use either to today or into the crofting recent past.

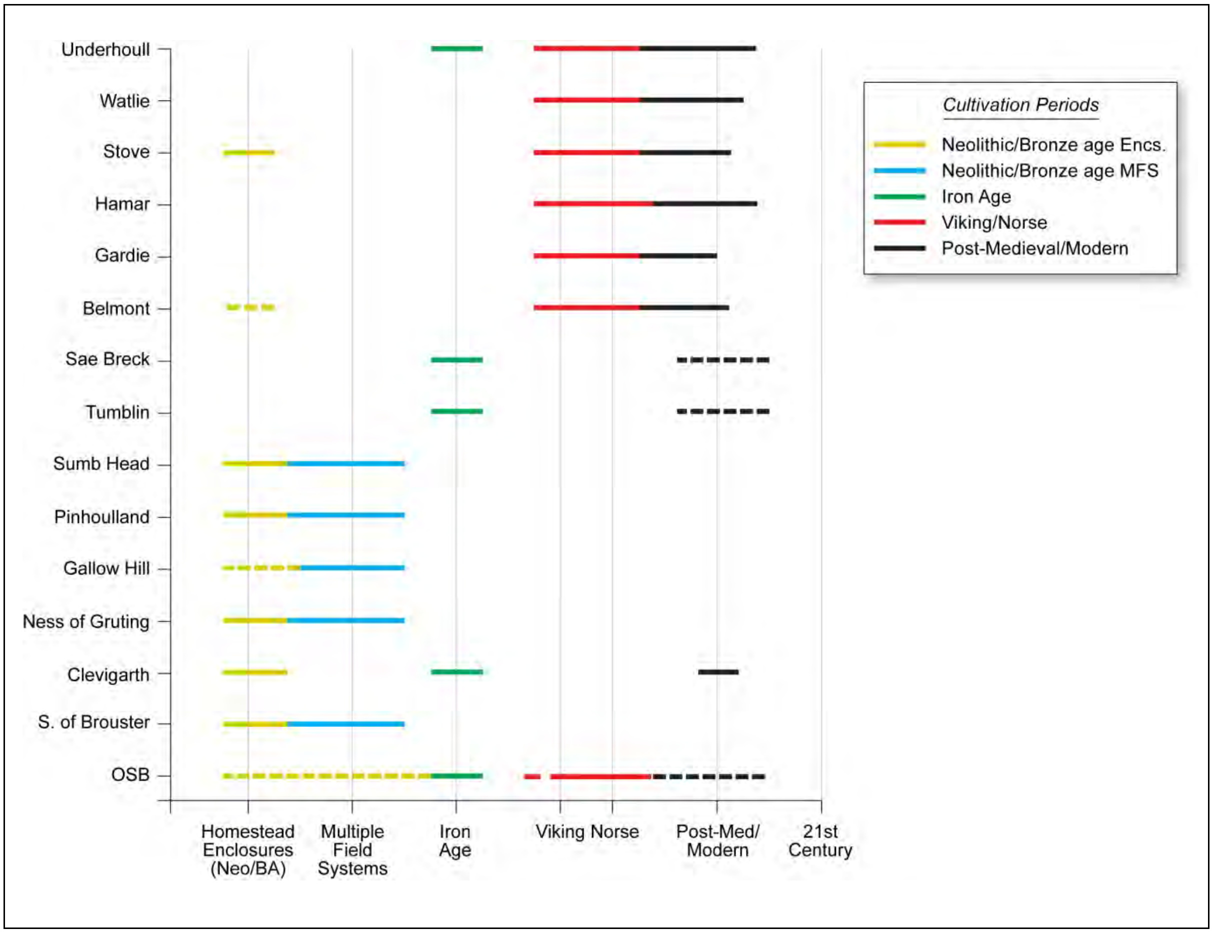


Fig 10.4 Summary of the periods during which land was cultivated derived from micromorphology, demonstrating longevity of use/ inheritance. (Dotted line indicates uncertainty seen in the soils Old Scatness & Ness of Gruting, although there are related structures present.) (Graphics: Bill Jamieson)

Fig 10.4 summarises the use of the land at the sites in this study. When land was cultivated it appears to have been used for lengthy periods, over many generations. Once it was abandoned however, the incidence of reuse was not high, suggesting either that it was used to the point of exhaustion or that reuse after a hiatus required too much effort to be undertaken. Although sites in this study were selected for their strong single-period characteristics and there is a danger of a circular argument, the number of field systems which were worked for an extended period and then largely abandoned suggests that these sites are representative. Hill-land was used intensively in either the Neolithic/Bronze Age or in the Viking/Norse period but not both. Where there is a prehistoric presence at the Viking/Norse sites of Stove and Belmont, they are not accompanied by surviving field boundaries. Further, the Multiple Field Systems are concentrated on the West Side and the Norse sites in Unst. These locations may have been favoured for reasons which are nothing to do with the soils: locally, Haroldswick, Unst is held to be the first footfall of the Vikings in the North Atlantic. None of the soils are in good condition today, being thin and acidic, and it is possible that soil exhaustion made the prospect of resettlement unattractive rather than the reverse. The only soils which supported settlement in the long term were the deep sandy soils at Old Scatness. Even at the multi-period site of Underhoull, cultivation is dispersed over a considerable distance across the hillside encompassing four modern fields. The only potential location for long-lived deep soils is at the foot of the hill, beside the coast, where Mackenzie (2006) identified soils deepened in the crofting period without identifying evidence of a lengthy chronological span. The practice of stripping soils for turf has clearly removed valuable evidence from some field systems and certainly contributes to the current poor state of the soil.

This study has demonstrated that stripping the land for turf was more widespread than previously appreciated, hitherto thought to be restricted to a few areas such as Papa Stour. Stripping for peat is more easily observed, as at Vassa. Excavation demonstrated that this had taken place at 17th century Hamar (Bond *et al.*, 2013) but it is also probable that the thin soils at Belmont, Gardie, Scord of Brouster and Gallow Hill were also scalped. Fertile soils are unlikely to have been stripped unless in response to a disaster leading to a lack of people to work the available land. The turf stripping at Hamar corresponds with the Little Ice Age, resulting in poor harvests and famines from the 1620s – 1690s, starvation leading to "the frequent death of the labourers of the ground" in Orkney and in much of the ground being tenantless (Thompson, 1987: 185-186). Something similar may also have occurred at the end of the Bronze Age/Early Iron Age, another period of climatic deterioration. The presence of fewer people in desperate conditions would result in less animal husbandry, and therefore less manure available, which would jeopardise soil fertility.

The conclusion must be that, in Shetland, the inheritance of fertile soils across these periods of stress, as evidenced at Old Scatness and Jarlshof, was exceptional. The soils of Shetland have far less in common with the sands and multi-period farm mounds of Orkney, but are more akin to the soils of Faroe, Iceland and the North Atlantic which were never farmed before the Viking period.

Chapter 11: Conclusions – Outcomes and Future Work

DEVELOPING THE LANDSCAPE APPROACH

Adopting a landscape approach to this study has involved focusing on "the area beyond the site": a study of the fields in their own right rather than as an adjunct to the archaeological excavation of a structure, e.g. Old Scatness (Simpson, *et al.* 1998; Guttmann *et al.* 2006) or targeted towards questions relating to a structure e.g. Clevigarth broch (Guttmann *et al.,* 2008). Field systems associated with structures (usually house sites) were selected as the settlement form supplied corroborative dating evidence. The field survey has demonstrated how much new information is visible, but goes unobserved, in the landscape. Using field survey as the framework for this study has enabled the application of a number of new tools. It demonstrates the value of using the landscape rather than the domestic building as the framework for investigation. This approach has been successful in a variety of ways and the results have shown that the relationship between field form and function is far more complex than the observably different boundary forms initially suggested.

The study is clearly important to Shetland's Archaeology because it has added so much new information to the understanding of field function and therefore the economy of prehistoric and Norse Shetland. This has implications for settlement in similar locations. The features relating to field systems identified in this study can now be sought elsewhere, both in the north and west of Scotland, but also more widely, in the North Atlantic area. However, the importance of the study goes beyond these discoveries in many different respects.

Topographical field survey

The survey has led to the identification of several new field elements previously unobserved in the Shetland landscape. These include the first recorded observation of non-defensive boundaries with a direct relationship to Brochs, for which agriculture is the most convincing explanation, identified at four sites and the identification of small rectilinear fields associated with the brochs at Sae Breck and at Underhoull, which may also have an Iron Age date. (These add weight to the suggestion that some Iron Age agriculture was carried out in garden plots (Guttmann, 2006) although there is no evidence that these new examples were related to earlier middens). The survey comprised the first mapping of unexcavated Viking/Norse yards outside of excavation and comprises the first recorded observations for the survival of Viking/Norse infield boundaries in the North Atlantic. The field survey also led to the identification of shallow stone-tool quarry pits, initially at Sumburgh Head and subsequently on the West Side. This demonstrates the importance of the hinterland in the Neolithic/Bronze Age and provides an interpretation for the territorial dykes associated with the Multiple Field Systems.

Place Analysis

The examination of field systems in terms of location has been revealing. Fojut's suggestion of a link between broch building and geology is supported, although this may relate more to broch survival than to the selection of their locations. The quarries associated with two Multiple Field Systems and the occurrence of soapstone close to Viking Belmont, also highlight the importance of geology and the hinterland to both location and settlement economy of settlement, in addition to its effect on soil fertility. Place Analysis also demonstrated that the Multiple Field Systems expanded along the slope rather than down, making cultivation easier and reducing soil creep down slope. The Spatial Analyst functions of GIS provided useful results in terms of viewshed and aspect. The viewshed results demonstrate that the Homestead Enclosures had a greater reliance on coastal resources than might have been anticipated and, along with the economic evidence presented (linked to Topographical Survey and Shape Analysis) contradicts new theories about the abandonment of the sea by the Neolithic population. Aspect results demonstrate the importance of the sun to the Homestead Enclosures and that those in more favourable locations are those which develop into Multiple Field Systems.

Shape Analysis

Shape Analysis, a tool developed to examine microscopic objects, was applied to the macroscopic field systems. It proved particularly useful in ascribing attributes to the Homestead Enclosures, enabling these to be identified within the Multiple Field Systems and providing a starting point for the investigation of inheritance. In defining parameters for particular field systems it highlighted elements which were exceptional; elements which were primary and secondary; inherited elements; and elements which fell outside the category and required a different interpretation. This has led to the first identification of a field system likely to be linked to Iron Age cattle rearing. Shape Analysis also illuminated understanding of issues such as the cultural importance or otherwise of efficient construction, regularity of fields and inheritance between cultural periods. Even the most straightforward of the measurements, area, has been highly informative concerning issues of economy and sustainability demonstrating for example that the sea was fundamental to the economy, the agricultural units not being big enough to support the residents.

Shape Analysis is therefore a tool which could be applied to field systems of any period throughout the world. Shetland is exceptional in the range of field systems which survive well and was the ideal testing ground for the methodology. In future Shape Analysis could be used either within a single field system comprising several elements or with a group of single fields, dependent on the research question.

Boundary Analysis

This is the first time that archaeological records made during field survey have been transformed into a rigorous data gathering exercise and analysed. The hypothesis was that this might reveal sets of diagnostic parameters related to cultural period. This proved not to be the case: the results suggest that boundary construction was pragmatic with earthworks and built dykes used within the same field system. However, the results have contributed to an understanding of field form and function throughout time (e.g. the number of Homestead Enclosures and individual fields within the Multiple Field Systems having a dominant single feature type suggesting a single phase of construction; areas of difference potentially representing seasonal repair; and the strong correlation between lynchets, direction of dominant face and hillslope). Within agricultural units these lynchets and terraces and small enclosed areas for cultivation (not grazing animals) and grain have been shown to play an essential role in the "safe food-bank"

The application of the Sinuousity Index, a measurement devised for describing water courses, proved not to be useful, being more appropriate to linear features rather than curvilinear ones. The discussion of boundaries has a relevance beyond Shetland, particularly in upland Britain and the margins of the North Atlantic, as people faced common issues in similar situations across the region. While the intensity of recording carried out in this study may not be repeated, the study demonstrates the value of a more rigorous approach than is generally applied to landscape features.

Soils Investigations

Augering and micromorphology are becoming increasingly recognised as important tools in understanding settlement. Marrying micromorphology to field survey rather than excavation has facilitated a wider appreciation of how field systems and economies function. At the commencement of work it was unknown whether soils from the centres of field systems, not buried as the result of an identifiable rapid event, would contain micromorphology evidence. The results demonstrated that full range of cultural indicators could be found in such soils, although survival is not guaranteed. Profiles which looked unpromising when inspected visually in the field were found to contain key information. Kubiena tins are usually inserted on the basis of visual inspection: this study demonstrates the value of applying the methodology more widely: an approach which can be adapted for any ancient landscape.

Thin acidic soils have been shown to retain cultural information and this study demonstrates the particular value of micromorphology in wet upland landscapes both in Britain the North Atlantic area. The existing model of soil management has been explored in the North Atlantic, and shown that the picture is more complex than that previously recognised. One reason for these differences may relate to the concentration of previous work on lighter soils, although no direct relationship between soil environment and management practice has been established. However, accretion has been identified as being crucial to maintaining fertility in peaty soils.

Testing the model for soil management in the North Atlantic has demonstrated that methods of soil management were understood early, and that issues of fertility were addressed rather more pragmatically than by applying a particular cultural response, challenging a perspective that land management can be used as a clear cultural indicator. Intensity was found not to be a cultural indicator (low intensities of amendment and use being visible in both the Neolithic/Bronze Age and the Viking/Norse periods). The incorporation of manure and (separately) turf from the Neolithic/Bronze Age challenges the soils model for the North Atlantic, identifying different strategies at different locations contemporaneously. Domestic midden was identified as the most common material added to soils. This may be linked to sustainable waste disposal and might explain an over-amendment at Iron Age Old Scatness.

FIELD FORM, FUNCTION AND INHERITANCE

This study demonstrates that there is a complex relationship between field form and function: there are observable shape differences relating to different periods, some of which can be defined using Shape Analysis. Boundary Analysis demonstrates that construction methods themselves are remarkably similar and pragmatic throughout time, probably including now invisible organic materials. Micromorphology suggests that soil management was also fairly pragmatic, with differing materials being used contemporaneously in different places.

Forman suggests that, on the basis of 30-50 years representing two generations, sustainability should be thought of in terms of periods of between 500-2000 years (Forman, 2001: 486). The study has demonstrated a continuity/inheritance between some of the Homestead Enclosures, the Multiple Field Systems and the field system at Clevigarth which would fit this definition. Insolation was critical to the original sighting of the Homestead Enclosures and it is those on the brighter, west, of Shetland which were attractive for continued settlement. No clear relationship between Iron Age and Viking territories were observed: where a degree of continuity/reuse exists at Old Scatness and Underhoull, the area of landuse either changes focus or reduces in intensity. Post-Medieval landuse is offset from the Norse use, and the inheritance of the boundary does not necessarily involve reuse of the same land. Other than at Old Scatness land is cultivated in either the Neolithic/Bronze Age or the Viking/Norse period, but not both. Where there is an Iron Age component, at Old Scatness and Clevigarth, there is more evidence of continuity. Two episodes of discontinuity have been observed: the end of the Bronze Age/Early Iron Age and the 17th century AD. This may relate directly to climatic stress leading to a destruction of the hill land in an effort to make the lower ground sustainable for a smaller number of people. These actions showed no appreciation of the sustainability of the hill land, which was destroyed in perpetuity by soil stripping.

FUTURE DIRECTIONS

It is a truth widely acknowledged that archaeological work raises more questions than it answers. This study has been no exception to that, and there are a number of areas which this author would like to explore within Shetland, as well as issues which could be taken forward on a global scale.

Future Directions for the Author: The Field Systems and Beyond

The next step in understanding the economies and practices of Homestead Enclosures, and also of the solitary house sites with no visible field systems attached would be to explore whether a wider area was cultivated or whether cultivation contributed a very restricted, or no, part of the "safe food-bank". Locations for further micromorphological sampling could be determined selected using field survey incorporating more physical landscape features: breaks of slope, water courses, etc, or possibly in partnership with Historic Scotland through the Next Directives (aerial photography) initiative.

Recent mapping and field walking results undertaken by RCAHMS in Shetland in June 2011 could be used in order to use the pre-existing peat dykes to identify the hinterland of the Multiple Field Systems. A more detailed investigation of the Broch and Viking territories in Unst, is required to assess whether the apparent lack of inheritance conceals a more complex picture: this would also tie into Shetland Amenity Trust's Viking Unst project. This study also provides a starting point for further spatial analysis, exploring distances between sites and broadening this out to territories. A contrasting approach would be to apply a phenomenological approach, exploring how people experience these field systems.

The new Iron Age Field Systems discovered in this study require further analysis. Micromorphology has only scratched the surface of the story at Clevigarth. Further micromorphology is required within the various elements of the Clevigarth field system and also elsewhere in the valley to the west, in order to investigate areas at a greater distance which might have grown grain for this broch community. Both the broch field boundary and the small rectangular fields at Sae Breck require micromorphological investigation to explore Iron Age agriculture and its role in broch economies.

The study has created a number of maps, including surveys superimposed on exceptional vertical air photography supplied to Scottish Government through the Next Directives initiative. Shetland attracts visitors who spend time walking in the hills; the Shetland Tourism Survey (2002) identified that 77% of visitors come to Shetland for heritage reasons. A partnership with Historic Scotland might enable these surveys and photographs to be developed into an "app" to making the mapping available to walkers through Smart Phones.

<u>National and International Directions for further work</u>

The tools developed during this study could be applied more widely, and need not be restricted to Northern Europe. It would be interesting, for example, to test the extent to which the open centres of fields in arid areas returned similar success rates to the wet acidic areas of Northern Europe. Shape Analysis could be applied to field systems throughout the world and the results compared. Using these tools in other parts of Britain and the North Atlantic, where soils and field function are relatively similar, would provide comparative information relating to economy and society, to ascertain how universal some of the parameters, and therefore human thought and processes, were.

Further studies which test the model for soils management in the North Atlantic are now required, including those on well-dated soils of all periods. It is not clear to what extent the results which exist both in the model and in this study are normal or exceptional. A greater body of work needs to be created in order to advance understanding. One way of doing this would be to engage more with the archaeological community, including CPD for Regional Archaeologists who specify briefs for commercial archaeological work.

The survival of cultural indicators in soils of differing conditions should also be explored. Very dry, arid, soils would provide an interesting contrast with the wet acidic ones of the North Atlantic. More detailed studies are required on the acidic soils, particularly in soils where previous use has been well-documented.

Postscript

This study set out to investigate a range of questions related to the sustainability and inheritance, and the form and function of field systems. As discussed above, not all were answered with equal degrees of success; however, this study has advanced knowledge in these areas and raised questions and solutions for dealing with such questions world-wide. I hope that it has thrown down the gauntlet to future researchers as well as providing me with a life-time's worth of future research!

Bibliography

Adderley, P. (2001) Micromorphometric Analysis of Soils: An elementary guide to equipment and software. Unpublished, University of Stirling

Adderley, W.P., Simpson, I.A., Lockheart, M.J., Evershed, R.P. and Davidson D.A. (2000) Modeling Traditional Manuring Practice: Soil Organic Matter Sustainability of an Early Shetland Community? *Human Ecology,* 28. No. 3. 415 - 431

Adderley, W.P. and Simpson, I.A. (2005) Early-Norse Home-Field Productivity in the Faroe Islands. *Human Ecology*, 33. No. 5. 711-736

Adderley, W.P., Simpson, I.A. and Vésteinsson, O. (2008) Local-Scale Adaptations: A Modeled Assessment of Soil, Landscape, Microclimatic, and Management Factors in Norse Home-Field Productivities. *Geoarchaeology: An International Journal,* 23. No. 4, 500–527

Adderley, W.P., Wilson C.A., Simpson, I.A. and Davidson, D.A. (2010) Anthropogenic Features in Stopes, G., Marcelino V. and Mees F *Interpretation of Micromorphological Features and Regoliths* 569-588 Elsevier. Netherlands.

Anderson, D.E., Binney, H.A., and Smith, M.A. (1998) Evidence for abrupt climatic change in Northern Scotland between 3900 and 3500 calendar years BP. *Holocene*, 97-103.

Arge, S. (1991) The Landnám in the Faroes. *Arctic Anthropology* 28, 101-120.

Arge, S.V. (2005) "Cultural Landscapes and Cultural Environmental Issues in the Faroes" in Mortensen, A. and Arge, S.V. ed. *Viking and Norse in the North Atlantic.* 22-38 Faroese Academy of Sciences. Torshavn.

Arge, S., Sveinbjarnardóttir, G., Edwards, K. J., Buckland, P. C., and Simpson, I. A. (2005).Viking and medieval settlement in the Faroes. *Human Ecology* 33, 597–620.

Armit, I. (1998) Human responses to marginality. In Mills, C.M. and Coles, G. (eds) *Life on the edge: human settlement and marginality*. Symposia of the Association for Environmental Archaeology 13: 31-38. Oxbow Monograph 100, Oxford

Armit, I. (2002) Land and Freedom: implications of Atlantic Scottish settlement patterns for Iron Age Land-holding and Social Organisation. In Ballin-Smith, B. and Banks I. (eds) *In the Shadow of the Brochs* 15-26 Tempus, Stroud.

Armit, I (2005) Land-holding and Inheritance in the Atlantic Scottish Iron Age. In Turner, V.E., Nicholson, R., Dockrill, S.J. and Bond, J.M. (eds) *Tall Stories: 2 millennia of Brochs.* 129-143 Shetland Amenity Trust, Lerwick.

Ashmore, P.J. (1999) Radiocarbon Dates for Archaeological Sites in Shetland. Owen, O. and Lowe, C. *Kebister: the four-thousand-year-old story of one Shetland township.* Society of Antiquaries of Scotland Monograph Series 14, 308-320 Edinburgh

Ashmore, W. and Knapp, A.B (eds) (1999) *Archaeologies of Landscape. Contemporary Perspectives.* Blackwell Publishers Ltd, Oxford

Aston, M. and Rowley, T. (1974) *Landscape archaeology : an introduction to fieldwork techniques on post-Roman landscapes* David & Charles, Newton Abbot

Austad, I. and Øye, I. (2001) Den tradisjonelle vestlandsgården som kulturbiologisk system. In Skar, B (ed) *Kulturminner og miljø. Forskning i grenseland mellom natur og kultur.* Norsk institutt for kulturminneforskning, 135-250, Oslo.

Ballin Smith, B. (ed) (1994) *Howe, four millennia of Orkney Prehistory.* Society of Antiquaries Monograph Series 9, Edinburgh

Ballin Smith, B. (2005) *Catpund: a prehistoric house in Shetland,* Scottish Archaeological Internet Report 7, Society of Antiquaries of Scotland

Ballin Smith, B. (2013) Norwick - Shetland's earliest Viking settlement? In Turner, V.E., Bond, J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Barclay, G.J. (1996) Neolithic Buildings in Scotland. In Darvill, T. and Thomas, J. *Neolithic Houses in Northwest Europe and Beyond*. 61-75 Oxbow Monograph 57, Oxbow, Oxford

Barclay, G.J. (1997) The Neolithic. In Edwards, Kevin J. and Ralston Ian B. M. *Scotland: Environment and Archaeology, 8000BC - AD 1000* 127-149 Chichester, Wiley.

Barclay, G.J. (2001) Neolithic Enclosures in Scotland. In Darvill, T. and Thomas, J. *Neolithic Enclosures in Atlantic Northwest Europe.* 144-154 Oxbow, Oxford.

Barrett, J.C. (1982) Aspects of the Iron Age in Atlantic Scotland. A case study in the problems of archaeological interpretation. *Proceedings of the Society of Antiquaries of Scotland.* 111 205-219

Barrett, J. (1991) *The Archaeology of Social Reproduction.* In Barrett J., Bradley, R. and Green M. *Landscape, Monuments and Society: The Prehistory of Cranborne Chase.* 6-8 Cambridge University Press, Cambridge

Barrett, J.C. (1994) *Fragments from Antiquity: an archaeology of social life in Britain, 2900-1200BC* Blackwell, Oxford.

Barrett, J.H. (2000) What was the Viking Age and When Did it Happen? A View from Orkney. *Norwegian Archaeological Review* 33. no.1, 1-39

Barrett, J.H. (2003) Culture Contact in Viking Age Scotland. In Barrett, J.H. (ed) *Contact, Continuity and Collapse, The Norse Colonization of the North Atlantic* 73-112 Brepois Publishers, Belgium.

Barrett, J.H. (2005) Economic Intensification in Viking Age and Medieval Orkney, Scotland: Excavations at Quoygrew. In Mortensen, A. and Arge, S.V. *Viking and Norse in the North Atlantic.* 11-21 The Faroese Academy of Sciences, Torshavn.

Barratt, J.H. (2008) What caused the Viking Age? *Antiquity 82* 671-685

Barrett, J. H., Beukins, R., Simpson, I. A., Ashmore, P., Poaps, S., and Huntley, J. (2000) What was the Viking Age and when did it happen? A review from Orkney. *Norwegian Archaeological Review* 33. 1–39

Bell, M., Fowler, P.J. and Wilson, S.W. (1996) *The Experimental Earthwork Project, 1960-1992*. CBA Research Report 100. Council for British Archaeology. York.

Bender, B. (ed.) (1993) *Landscapes: Politics and Perspectives.* Berg, Oxford

Bennett, K.D., Boreham, S., Sharp, M.J. and Switsur, V.R. (1992). Holocene history of environment, vegetation and human settlement on Catta Ness, Lunnasting, Shetland. *Journal of Ecology* 80, 241-273.

Bigelow, G.F. (1985) Sandwick, Unst and Late Norse Shetland Economy. In Smith B. (ed) *Shetland Archaeology* 95-127 Shetland Times, Lerwick.

Bigelow, G.F. (1987) Domestic Architecture in Medieval Shetland. In *Review of Scottish Culture* 3. 23-28

Bigelow, G.F. in prep. Excavations in Sandwick, Unst

Bintliff, J. (1996) Interactions of theory, methodology and practice. *Archaeological Dialogues,* 3 246-255

Birnie, J.F., Gordon, J.E., Bennett, K.D. and Hall, A.M. (1993) *The Quaternary of Shetland: Field Guide* Quaternary Research Association. Cambridge.

Bradley, R (1994) In Renfrew C. and Zubrow E.B. (eds) *The Ancient Mind, Elements of Cognitive Archaeology.* Cambridge University Press, Cambridge

Bradley, R.J. (1978) *The Prehistoric Settlement of Britain.* Routeledge and Kegan and Paul, London.

Bradley, R. (1998) Ruined buildings, ruined stones: enclosures, tombs and natural places in the Neolithic of south-west England. In *World Archaeology* 30 (1) 13-22 *The Past in the Past* Routeledge

Blume, H.P. (1998) History and impact of plaggen soils in Europe. 16th World Congress of Soil Science, Montpellier, France: *CD ROM, Conference Proceedings.*

Bond, J.M., Braby, A.R., Dockrill, S.J., Downes, J. and Richards, C.C. (1995) Stove Bay: A New Orcadian Grooved Ware Settlement. *Scottish Archaeological Review* 125-130.

Bond, J.M. (1994) *Changes and Continuity in an Island System: The Palaeoeconomy of Sanday, Orkney*. Unpublished PhD Thesis, University of Bradford

Bond, J.M. (2002) *Pictish Pigs and Celtic Cowboys: Food and Farming in the Atlantic Iron Age.* In Ballin-Smith, B. and Banks, I. (eds) *In the Shadow of the Brochs* 177-190 Tempus, Stroud.

Bond, J.M.(ed) (2007) *The Biological Evidence* in Hunter, J. Investigations in Sanday, Orkney. 1: Excavations at Pool Sanday. A multi-period settlement from Neolithic to Late Norse times. 169-286 The Orcadian, Orkney.

Bond, J.M., Guttmann, E. and Simpson, I.A. (2004) *Bringing in the Sheaves: farming Intensification in the Post-Broch Age.* In Housley, R.A. and Coles, G. *Atlantic Connections and Adaptions. Economies, environments and subsistence bordering the North Atlantic.* 120 – 127 Symposia of the Association for Environmental Archaeology No 21. Oxbow Books, Oxford

Bond, J.M., Nicholson R.A. and Cussans, J.E. (2010) Biological Evidence. in Dockrill, S.J., Bond, J.M., Turner, V.E., Brown, L.D., Bashford, D.J., Cussans, J.E., Nicholson, R.A. *Excavations at Old Scatness, Shetland. Volume 1: The Pictish Village and Viking Settlement*. 131-195 Shetland Heritage Publications, Lerwick.

Bond, J.M. (2013) Excavations at Hamar and Underhoull. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Bond, J.M., Nicholson, R.A. and Cussans J.E. (forthcoming) Biological Evidence. in Dockrill, S.J., Bond, J.M., Turner, V.E., Brown, L.D., Bashford, D.J., Cussans, J.E., Nicholson, R.A. *Excavations at Old Scatness, Shetland. Volume 2: The Broch and Iron Age Village* Shetland Heritage Publications, Lerwick.

Brown, L.D (2013) The coarse pottery from Hamar, in Bond, J.M. *et al.,* Excavations at Hamar and Underhoull. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Buckland, P (1992) Holt in Eyjafjallstveit, Icelend. A Palaeoecological Study of the Impact of Landnåm. In Bigelow G.F. (ed) *Acta Archaeologia* 61, 252-271 Copenhagen

Buckland, P. C., Dugmore, A. J., Perry, D., Savory, D., and Sveinbjarnardóttir, G. (1991) Holt in Eyjafjallasveit, Iceland: A palaeoecological study of the impact of Landn´am. *Acta*

Archaeologica 61: 267–271

Buckland, P.C., Edwards, K.J., Blackford, J.J., Dugmore, A.J., Sadler, J.P. and Sveinbjarnardóttir, G. (1995) A question of landnám: pollen, charcoal and insect studies on Papey, Eastern Iceland. In*: Ecological Relations in Historical Times: Human Impact and Adaption.* R.A. Butlin and N. Roberts (eds.) 245-263 Blackwell, Oxford

Bullock, P., Federoff, N., Jongerius, A., Stoops, G., Tursina, T. and Babel, U. (1985) *The Handbook for Soil Thin Section Description.* Waine Research Publications. Wolverhampton.

Burbidge, C.I. (2003) *Luminescence Investigations and Dating of Anthropogenic Palaeosols from South Mainland Shetland.* PhD Thesis. University of Wales. Aberystwyth.

Calder, C.S.T. (1950) Report on the excavation of a Neolithic temple at Stanydale in the Parish of Sandsting, Shetland. *Proceedings of the Society of Antiquaries of Scotland* 84, 185-205

Calder, C.S.T. (1956) Report on the discovery of numerous Stone Age house-sites in Shetland. *Proceedings of the Society of Antiquaries of Scotland* 89, 340-397

Calder, C.S.T. (1960-61) Excavations in Whalsay, Shetland. 1954-5 *Proceedings of the Society of Antiquaries of Scotland* 94, 28-45

Canti, M. (1997) An investigation of microscopic calcareous spherulites from herbivore dungs. *Journal of Archaeological Science* 24, pp. 219-231

Canti, M. (1999) The production and preservation of faecal spherulites: animals, environment and taphonomy. *Journal of Archaeological Science* 26, pp. 251-258

Canti, M. (2003) Earthworm activity and archaeological stratigraphy: a review of products and processes. *Journal of Archaeological Science* 30, pp. 135-148

Carter, S. (1998) The use of peat and other organic sediments as fuel in northern Scotland: identifications derived from soil thin sections. in Mills C.M.and Coles G. (eds.), *Life on the Edge: Human settlement and marginality.* Oxbow Monograph 100:89-102. Oxford

Carter, S. P. and Davidson, D. A. (1998) An evaluation of the contribution of soil micromorphology to the study of ancient arable agriculture. *Geoarchaeology 13*, no. 6, 535-547.

Carter, S. P. and Davidson, D. A. (2000) A reply to Macphail's comments on “An evaluation of the contribution of soil micromorphology to the study of ancient arable agriculture”. *Geoarchaeology 15*, no. 5:499-502

Caulfield, S. (1978) Neolithic fields: the Irish evidence. In Bowen C. and Fowler P. (eds) *Early Land Allotment* 137-44 BAR 48, Oxford

Caulfield, S. (1983) The Neolithic Settlement of North Connaught in Reeves-Smyth T. and Hamond F (ed) *Landscape Archaeology in Ireland.* Oxford 195-216

Ceron-Carrasco, R. (1998) Interpretation of Fishing Activities in Sharples, N. *Scalloway. A broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* 118-119 Oxbow Monograph 82, Oxford

Chapman, P. (2007) *Conservation Grazing of Semi-Natural Habitats.* Scottish Agricultural College, Technical Note 586, March 2007. SEERAD, Edinburgh.

Chrystall, F.H. (1994) *Formation Processes of Anthropogenic Soils in Fair Isle.* Unpublished BSc Dissertation, Department of Environmental Science, University of Stirling

Church, M.J., Arge S.V., Brewington, S., McGovern T.H., Woollett, J.M., Perdikaris, S., Lawson I.T., Cook, G.T., Amundsen, C., Harrison R., Krivogorskaya, Y. and Dunbar E. (2005) Puffins, Pigs, Cod and barley: palaeoeconomy at Undir Junkarinsfløtti, Sandoy, Faroe Islands. *Environmental Archaeology* 10 179-197

Clark, C. and Haswell, M.R. (1967) *The Economies of Subsistence Agriculture* 3rd edition, Macmillan, London.

Clark, P.J. and Evans, F.C. (1954) Distance to nearest neighbor as a measure of spatial relationships to populations. *Ecology* 35, 445

Clarke, D.V. and Sharples N. (1985) Settlements and Subsistence in the Third Millennium BC. In Renfrew C, (ed.) *The Prehistory of Orkney*. 54-82. Edinburgh University Press. Edinburgh.

Cleere, H. (1995) Cultural Landscapes as World Heritage *Conservation and Management of Archaeological Sites* 1 Issue 1, 63-8

Cluett, J.P. (2007) *Soil and Sediment-based Cultural Records and the Heart of Neolithic Orkney World Heritage Site Buffer Zones.* Unpublished PhD thesis, University of Stirling.

Cooney, G. (1997) Images of Settlement and the Landscape in the Neolithic. in Topping, P. (ed) *Neolithic Landscapes* Neolithic Studies Group Seminar Papers 2, 1-14 Oxbow Monograph, 86, Oxford

Cooney, G., Bayliss, A., Healy, F., Whittle, A., Danaher, E., Cagney, L., Mallory, J., Smyth, J., Kador, T. and O'Sullivan M. (2011) Ireland in Whittle, A., Healy, F. and Bayliss, A. *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland.* Oxbow. Oxford. *562-657*

Courty, M-A., Goldberg, P. and Macphail, R.I. (1989) *Soils and micromorphology in archaeology*. Cambridge University Press, Cambridge

Cowley, D.C. (2005) Architecture, Landscape and the political Geogrphy of Iron Ahe Caithness and Sutherland. in Turner, V.E., Nicholson, R.A., Dockrill S.J. and Bond, J.M. (eds) (2005) *Tall Stories? 2 Millennia of Brochs.* 180-189 Shetland Amenity Trust, Lerwick.

Crandell, G. (1993) *Nature Pictorialised: The "view" in landscape history.* John Hopkins University Press, London.

Crawford, B.E. (1984) Papa Stour: Survival, Continuity and Change in one Shetland Island. In Fenton A. and Palsson H. (eds.) *The Northern and Western Isles in the Viking World: Survival, Continuity and Change. pp. 40-58*

Crawford, B.E. (2003) The Bishopric of Orkney. In Imsen, S. (ed.) *Ecclesia Nidrosiensis 1153-153*,143-158. Sentre for Middelalderstudier, NTNU. Skifter nr.15.Tapir Akademisk Forlag, Trondheim

Curwen, E.C. (1983) The Hebrides: A Cultural Backwater *Antiquity* 12 (47) 261-89

Dark, P. (1999) The Environment of Britain in the First Millenium AD. Duckworth, London.

Darvill, T. (1997) Neolithic Landscapes: Identity and Definition in Topping, P. (ed) *Neolithic Landscapes* Neolithic Studies Group Seminar Papers 2, 1-14 Oxbow Monograph, 86. Oxford

Davidson, D.A. (2002) Bioturbation in old arable soils: quantitative evidence from soil micromorphology. *Journal of Archaeological Science* 29. 1247-1253.

Davidson, D.A., Carter, S.P. and Quine, T.A. (1992) An evaluation of micromorphology as an aid to archaeological interpretation. *Geoarchaeology* 7. 55-65.

Davidson, D.A., Harkness, D.D. and Simpson, I.A. (1996) The formation of farm mounds on the island of Sanday, Orkney. *Geoarchaeology* 1. 45-60.

Davidson, D.A. and Carter, S.P. (1998) Micromorphological evidence of past agricultural practices in Cultivated soils: the impact of a traditional agricultural system on soils in Papa Stour, Shetland. *Journal of Archaeological Science* 25, 827-838.

Davidson, D.A. and Simpson, I.A. (1984) The formation of deep topsoils in Orkney. *Earth Surface Processes and Landforms* 9. 75-81.

Davidson, D.A. and Simpson I.A., (1994) Soils and Landscape History: Case Studies from the Northern Isles of Scotland, in Foster, S. and Smout, T.C. (eds.) *The history of soils and field systems*. 66-74.Scottish Cultural Press, Aberdeen.

Davidson, D.A. and Simpson I.A. (2001) Archaeology and Soil Micromorphology in Brothwell, D.R., and Pollard, A.M. (eds) *Handbook of Archaeological Sciences.* Chichester

Davidson, D.A. and Smout, T.C. (1996) Soil change in Scotland: the legacy of past land improvement processes. in Taylor, A.G., Gordon, J.E. and Usher, M.B. (eds.) *Soils, sustainability and the natural heritage*. 44-54 HMSO. Edinburgh.

deMenocal, P.B. (2001) *Cultural responses to climatic change during the Late Holocene.* Science 292, 667-673

Dickson, C. (1983) The plant remains. 114 In Hedges J.W. Trial Excavations on Pictish and Viking Settlements at Saevar Howe, Birsay, Orkney. *Glasgow Archaeological Journal* 10 73-124

Dockrill, S.J. (1992) *The South Nesting Palaeolandscape Project: Report on 1991 Fieldwork.* Archaeological Sciences, University of Bradford.

Dockrill, S.J. and Batt, C.M. (2004) Power Over Time: an overview of the Old Scatness Broch excavations. In Housley, R.A. and Coles, G. *Atlantic Connections and Adaptions. Economies, environments and subsistence bordering the North Atlantic.* 128 – 137 Symposia of the Association for Environmental Archaeology No 21. Oxbow Books, Oxford.

Dockrill, S.J., Bond, J.M., Milles, A., Simpson, I.A. and Ambers, J. (1994) Toft's Ness, Sanday, Orkney. An integrated study of a buried Orcadian landscape. In Luff, R. and Rowley-Conwy, P. (eds.) *Whither environmental archaeology?* Oxbow Monograph 38, Oxbow, Oxford, pp.115-132.

Dockrill, S.J., Bond, J.M., and O'Connor, T.P. (1998) Beyond the Burnt Mound: the South Nesting Palaeolandscape Project. In Turner, V. (ed.) *The Shaping of Shetland.* 61-82. Shetland Times Ltd., Lerwick.

Dockrill, S.J. and Simpson, I.A. (1994) The identification of prehistoric anthropogenic soils in the Northern Isles using an integrated sampling methodology. *Archaeological Prospection* 1, 75-92.

Dockrill, S.J. and Bond J.M. (2003) Investigations at Clevigarth Broch in Dockrill, S.J., Bond J.M., Nicholson R.A. and Turner V.E. *Old Scatness Broch and Jalshof Environs Project. Field Season 2003. Data Structure Report.* 41-42 Unpublished report. Shetland Amenity Trust/University of Bradford

Donaldson, A.M. and Nye, S. (1989) The Botantical Remains. In Morris, C.D. *The Birsay Bay Project 1 1976-1982*. 262-267 Durham Department of Archaeology, Monograph no 1. Durham

Downes, J. and Lamb, R. (2000) *Prehistoric Houses at Sumburgh in Shetland. Excavations at Sumburgh Airport 1967-74*. Oxbow Books, Oxford.

Dry, F.T. and Robertson, J.S. (1982). *Soil and land capability for agriculture: Orkney and Shetland.* The Macaulay Institute for Soil Research, Aberdeen.

Dugmore, A.J., Borthwick, D.M., Church, M.J., Dawson A., Edwards, K.J., Keller, C., Mayewski, P., McGovern, T.H., Mairs, K-A., Sveinbjarnardottir, G. (2006) *The Role of Climate in Settlement and Landscape Change in the North Atlantic Islands: An Assessment of Cumulative Deviations in High-Resolution Proxy Climate Records* in Human Ecology 35, issue 2, 169-178

Dugmore, A.J., Larsen G. and Newton A.J. (1995) Seven Tephra Isochrones in Scotland. Holocene 5, issue 3, 257-266

Edmonds, M. (1999) *Ancestral Geographies of the Neolithic. Landscapes, monuments and memory.* Routledge, London.

Edwards, K.J. (1988) The hunter-gatherer/agricultural transition and the pollen record in the British Isles. In: Birks H.H., Birks H.J.B. Kaland P.E., Moe D., (eds) *The Cultural Landscape: Past. Present and Future.* 255-266 Cambridge University Press., Cambridge

Edwards, K.J. (1996) A Mesolithic of the Western and Northern Isles of Scotland? Evidence from pollen and charcoal. in: Pollard T. and Morrison A. (ed), *The Early Prehistory of Scotland.* Edinburgh University Press, Edinburgh, 23-38. Edinburgh, Edinburgh University Press. Dalrymple Monograph.

Edwards, K.J., Borthwick D., Cook G., Dugmore A.J., Mairs K-A., Church M.J., Simpson I.A., and Adderley W.P. (2005) A Hypothesis-Based Approach to Landscape Change in Suduroy, Faroe Islands *Human Ecology,* 33, No. 5, 621-650.

Edwards, K.J., Buckland, P.C., Craigie, R., Panagiotakopulu, E., and Hansen, S.S. (1998) Landscapes at landnam: palynological and palaeoentomological evidence from Toftanes, faroe Islands. *Fróđskaparritt* 48, 41-54

Edwards, K.J. and Moss, A.G., (1993) Pollen data from the Loch of Brunatwatt, West Mainland. Birnie, J.F., Gordon, J.E., Bennett, K.D., and Hall, A.M. *The Quaternary of Shetland: Field Guide*, 126-129. Cambridge.

Edwards, K. J. and Whittington, G. (1997) Vegetation Change. In Edwards, K.J. and Ralston, I.B.M. *Scotland Environment and Archaeology, 8000BC - AD 1000*. 63-82.

Chichester, Wiley.

Edwards, K.J. and Whittington, G. (1998) Landscape and Environment in Prehistoric West Mainland, Shetland. *Landscape History*, 20: 5-17. Birmingham

Edwards, K.J. and Whittington, G. (1999) Disturbance and Regeneration Phases in Pollen Diagrams and their Relevance to Concepts of Marginality. In Mills C.M. and Coles G. *Life on the Edge. Human settlement and marginality.* 61-66 Oxbow Monograph 100, Oxford

Fabech, C., Hvass S., Näsman, U., Ringtved J, and Lillehammer, A. (1999) "Settlement and Landscape" – a presentation of a research programme and a conference. In Fabech, C. and Ringtved J *Settlement and Landscape.* 13-28 Arhus University Press, Aarhus.

Fenton, A. (1978) *The Northern Isles: Orkney and Shetland.* John Donald, Edinburgh.

Fisher, I. (2002) Crosses in the Ocean: Some papar sites and their sculpture. in: B. Crawford (Editor), *The Papar in the North Atlantic: Environment and History.* 39-58. University of St Andrews, St Andrews.

FitzPatrick, E.A. (1993). Soil microscopy and micromorphology. Chichester: Wiley

Flemming, A. (1971) "Bronze Age Agriculture in Marginal Lands of North-east Yorkshire" in *British Agricultural History Review* 19: 1-24. London.

Flemming, A. (1971) Territorial Patterns in Bronze Age Wessex. *Proceedings of the Prehistoric Society* 37(1) 138-166

Flemming, A. (1978) The Dartmoor reaves: a nineteenth-century fiasco *Antiquity* 52, 16-19

Flemming, A. (1988) *The Dartmoor Reaves. Investigating Prehistoric Land Divisions.* BT Batsford, London.

Flemming A. (1989) The genesis of coaxial field systems. In Torrence R. And Leeuw S. Van der, *What's New? A Closer Look at the Process of Innovation.* 63-81 London

Flemming A. (2006) Post-processual landscape Archaeology: A critique. *Cambridge Archaeological Journal* 16 (3) 267-80

Flemming A. (2008) *the Dartmoor Reaves: Investigating Prehistoric Land Divisions.* Second edition. Oxbow Books, Oxford.

Fojut, N. (1980) *The Archaeology and Geography of Shetland Brochs* Unpublished PhD thesis, University of Glasgow

Fojut, N. (1983) "Towards a Geography of Shetland Brochs" *Glasgow Archaeological Journal, 9:* 38-59

Fojut, N. (1993) *A Guide to Prehistoric and Viking Shetland.* Shetland Times, Lerwick

Fojut, N. (2005a) "Towards a Geography of Shetland Brochs" in Turner, V.E., Nicholson, R., Dockrill, S.J. and Bond, J.M. (eds) *Tall Stories: 2 millennia of Brochs* 144-165. Shetland, Amenity Trust, Lerwick.

Fojut, N. (2005b) "Any Closer Towards a Geography of Shetland Brochs" in Turner, V.E., Nicholson, R., Dockrill, S.J. and Bond, J.M. (eds) *Tall Stories: 2 millennia of Brochs* 166-171. Shetland, Amenity Trust, Lerwick.

Fojut, N. (2006) *Prehistoric and Viking Shetland.* Fifth edition. Shetland Times, Lerwick

Forman, R.T.T. (2001) *Land mosaics: The Ecology of Landscapes and Region*s. Cambridge University Press, Cambridge.

Foster, S. and Smout, T.C. (1994) *The History of Soils and Field Systems*. Scottish Cultural Press, Aberdeen

Fowler, P.J. (1971) "Early prehistoric agriculture in Western Europe: some archaeological evidence" in Simpson D.D.A. *Economy and Settlement in Neolithic and Early Bronze Age Britain* 153-82 Leicester

Fox, C. (1923) *The Archaeology of the Cambridge region* unpublished PhD thesis, Magdalene College, Cambridge

French, C.I.A. (2003) *Geoarchaeology in action: studies in soil micromorphology and landscape evolution*. Routledge, London

French, C. (2005) Analysis of the Soil Deposits at Barnhouse and Maeshowe. In: Richards C, (Ed.) *Dwelling among the monuments: the Neolithic village of Barnhouse, Maeshowe passage grave and surrounding monuments at Stenness, Orkney* 371-380. McDonald Institute for Archaeological Research, Cambridge.

Gerritsen, F. (1999) The Cultural Biography of Iron Age Houses and the long-term transaformation of settlement pattern in the Southern Netherlands. In Fabech, C. and Ringtved. J. *Settlement and Landscape* 139-148 Arhus University Press, Aarhus.

Golding, K.A., Simpson, I.A., Schofield, J.E., and Edwards, K.J. in prep. *Norse Inuit Interaction and Landscape Change in Southern Greenland? A Geochronological, Pedological and Palynological Investigation.*

Gőransson, H. (1986) Man and the forests of nemoral broad-leaved trees during the Stone Age. *Striae* 24, 145-152

Guttmann, E.B.A. (1998) *Research on Deep Anthropogenic Arable Soils and their associated settlements.* unpublished report, University of Stirling

Guttmann, E.B.A. (1999) *The Effects of a Traditional Agricultural System on Soils at Bragasetter Farm, Papa Stour, Shetland* unpublished report, University of Stirling

Guttmann, E.B. (2001) *Continuity and Change in Arable Land Management in the Northern Isles: Evidence from Anthropogenic Soils.* PhD Thesis. Department of Environmental Science, University of Stirling.

Guttmann, E.B.A.(2005) Midden Cultivation in prehistoric Britain: arable crops in gardens. In *World Archaeology* 37(2) 224-239 *Garden Agriculture*

Guttmann, E. B., Simpson, I. A., Davidson, D. A., Dockrill, S. J. (2006) The Management of Arable Land from Prehistory to the Present: Case Studies from the Northern Isles of Scotland. *Geoarchaeology: An International Journal,* 21, No. 1, 61–92

Guttmann, E.B. Simpson, I.A. Nielsen, N. and Dockrill, S.J. (2008) Anthrosols in Iron Age Shetland: Implications for Arable and economic Activity. *Geoarchaeology: An International Journal,* 23, No 6, 799-823.

Hannon, G.E., Wastegård, S., Bradshaw, E., and Bradshaw, R.H.W. (2001) Human impact and landscape degradation on the Faroe Islands. *Proceeding of the Royal Irish Academy* 101B, 129-139

Hamilton, J.R.C. (1956) *Excavations at Jarlshof, Shetland.* HMSO, Edinburgh.

Hamilton, J.R.C. (1968) *Excavations at Clickhimin, Shetland.* HMSO, Edinburgh.

Hamlet, L.E. and Simpson, I.A. (2013a) Thin Section Micromorphology at Houses 1 and 2, Hamar, Unst, in Bond, J.M. *et al.,* Excavations at Hamar and Underhoull. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Hamlet, L.E. and Simpson, I.A. (2013b) Thin Section Micromorphology at Upper House, Underhoull, Unst, in Bond, J.M. Excavations at Hamar and Underhoull. In Turner, V.E., Bond, J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Hedges, J.W. (1984) Gordon Parry's West Burra Survey. *Glasgow Archaeological Journal* 11, 41-59

Hedges, J.W. (1987) Bu, Gurness and the Brochs of Orkney. 1: Bu. BAR British Series 163

Hedges, J.W. (1987) Bu, Gurness and the Brochs of Orkney. 2: Gurness. BAR British Series 164

Hedges, J.W. (1987) Bu, Gurness and the Brochs of Orkney. 3: The Brochs of Orkney. BAR British Series 165

Hillman, G. (1981) Reconstructing crop husbandry practices from charred remains of crops. In Mercer, R. (ed) *Farming Practice in British Prehistory.* 123-62 Edinburgh University Press: Edinburgh

Hingley, R. 1996 Ancestors and Identity in the Later Prehostory of Atlantic Scotland: The reuse and reinvention of Neolithic Monuments and Material Culture. 231-43 *World Archaeology* 28

Hirsch, E. (1995) Landscape: between place and space. In Hirsch E. and O'Hanlon, M. (eds) *The Anthropology of Landscape: Perspectives on Place and Space.* Clarendon Press, Oxford

Hodder, I. (1981) Towards a mature archaeology. In Hodder, I., Issac G. and Hammond, N. (eds) *Pattern of the Past.* 1-13 Cambridge University Press, Cambridge.

Holden, T. and Boardman, S. Crops in Sharples, N. (1998) *Scalloway. A broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* 99-106 Oxbow Monograph 82, Oxford.

Holm, I. (1999) Clearance Cairns. The farmer's and the archaeologists' views. In Gazin-Schwartz, A. and Holtorf, C. *Archaeology and Folklore.* Routledge, London and New York

Holm, I. (2002) A Cultural Landscape beyond the Infield/Outfield catagories: An example from eastern Norway. *Norwegian Archaeological Review.* 35, no.2 67-80

Hoskins W.G. (1955) *The Making of the English Landscape* Penguin, Harmondsworth

Hoskins, W.G. (1997) *The Making of the English Landscape* Hodder and Stoughton: London

Hoskins, W.G. (1981) *The Making of the English Landscape* Book Club Associates: London

Hunter, J.R. (1996) *Fair Isle: The Archaeology of an Island Community*. HMSO. Edinburgh.

IUSS Working Group WRB. 2006. *World reference base for soil resources 2006*: A framework for international classification, correlation and communication. World Soil Resources Reports No. 103. Food and Agricultural Organisation, Rome.

Ingold, T. (1992) Culture and the perception of the environment. In Croll E. and Parkin D. (eds) *Bush Base – Forest Farm: Culture, Environment and Development.* 39-56 Routledge, London.

Jakobsen, J. (1985) (reprint of 1928 edition) *An Etymological Dictionary of the Norm Language in Shetland.* 1. The Shetland Times. Lerwick.

Johansen, O. S. & Vorren, K.-D. (1986) The prehistoric expansion of farming into ''Arctic'' Norway: a chronology based on 14C dating. *Radiocarbon* 28, (2A), 739–747.

Jongerius, A. (1970). Some morphological aspects of regrouping phenomena in Dutch soils. *Geoderma* 4, pp. 311-331.

Jongerius, A. (1983) The role of micromorphology in agricultural research. In Bullock, P. and Murphy, C.P. (eds.) *Soil Micromorphology. Volume 1: Techniques and Applications*. 111-138. AB Academic Publishers Ltd., Herts.

Jóhansen, J. (1975) Pollen diagrams from the Shetland and Faroe Islands. *New Phytologist* 75: 369-387.

Jóhansen, J. (1978). Cereal cultivation in Mykines, Faroe Islands AD 600. *Danmarks Geologiske Undersøgelser Årbog 1978*: 93-103.

Jordan, D. (1999) The Survey of Soils and Sediments. in Owen, O. and Lowe, C. (1999) *Kebister: the four-thousand-year-old story of one Shetland township.* Edinburgh, Society of Antiquaries of Scotland. Monograph Series 14. Edinburgh.

Johnson, N. and Rose, P. (1994) *Bodmin Moor. An Archaeological Survey. 1: The Human Landscapes to c1800* English Heritage Archaeological Report no 24, RCHME, supplementary series no 11, London.

Keith-Lucas, M. (1986) Neolithic impact on vegetation and subsquent vegetational development at Scord of Brouster. In Whittle, A., Keith-Lucas, M., Milles, A., Noddle, B., Rees, S. and Romans, J. C. C. *Scord of Brouster: An Early Agricultural Settlement in Shetland.* 9, 92-118. Oxford University Committee for Archaeology, Oxford.

Kemp, L. (2001) *Preliminary Assessment of Iron Age Cattle Farming associated with the Brochs of Shetland.* unpublished Final Year Undergraduate Dissertation, Department of Archaeological Sciences, University of Bradford

Kemp. R. A (1998) Role of micromorphology in palaeopedological research. *Quaternary International* 51/52, 133-141

Kemp, R.A. (1999) Micromorphology of loess–palaeosol sequences: a record of palaeoenvironmental change. *Catena* 35, 179-196

Knapp, A.B. and Ashmore, W. (1999) Archaeological Landscapes: Constructed, Conceptualized, Ideational in Ashmore W. and Knapp A.B (eds) *Archaeologies of Landscape. Contemporary Perspectives.* Blackwell Publishers Ltd, Oxford

Kooijmans, L.P.L. (2000) Living in the Neolithic: Habitation and Landscape in Ritchie A. (ed.) *Neolithic Orkney in its European context.* 323-332 McDonald Institute Monographs, Cambridge

Lamb, R.G. (1984) *The Archaeological Sites and Monuments of Scotland, 23. Eday and Stronsay (with adjacent small islands) Orkney Island Area. An Archaeological Survey".* RCAHMS, Edinburgh.

Lamb, R.G. and Turner, V.E. (1991) An Insular View. In Hanson W.S. and Slater E.A. *Scottish Archaeology. New Perceptions.* 167-177 Aberdeen University Press, Aberdeen.

Larsen, A-C. (2013) The excavation at Belmont, Wadbister, Unst, Shetland. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland* Shetland Heritage Publications, Lerwick

Leach, R.H. (1983) Settlements and groups of small cairns on Birkby and Birker Fells, Eskdale, Cumbria. Survey undertaken in 1982 *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* Jan 1, 1983. 83, Issue 1983

Lelong, O. and Pollard, T. (1998) The Excavation and Survey of Prehistoric Enclosures at Blackshouse Burn, Lanarkshire. *Proceedings of the Society of Antiquaries of Scotland,* 128, 13-54

Lillehammer, A. (1999) Farm and Village, the problem of nucleation and dispersal of settlement- seen from a Norwegian perspective. In Fabech, C. and Ringtved J *Settlement and Landscape* 131-137 Arhus University Press, Aarhus.

Limbrey S. (1975) *Soil Science and Archaeology* Academic Press, London

Llobera,M. (1996) Exploring the topography of the mind: GIS, social space and archaeology. *Antiquity* 70, 612-622

Low, G. (1779) *A Tour Through the Islands of Orkney and Schetland 1774* reprinted 1978. Melvern Press, Inverness.

McCullagh, R.P.J. and Tipping, R. (eds) (1998) The Lairg Project 1988-1996 : the evolution of an archaeological landscape in Northern Scotland. Scottish Trust for Archaeological Research, Edinburgh.

McGovern, T.H. (1992) Bones, buildings and boundaries: palaeoeconomic approaches to Norse Greenland in Morris, C.D. and Rackham, D.J. (eds) *Norse and Later Settlement and Subsistence in the North Atlantic* 193-229 University of Glasgow department of Archaeology, Glasgow.

McGovan, T.H., Vestsinsson O., Fridriksson, A., Einarsson, A., Dugmore A., Cook G., Perdikaris, S., Edwards K.J., Thomson, A.M., Adderley, W.P., Newton A., Lucas, G., Edvardsson R., Aldred O., and Dunbar E. (2007) Landscapes of Settlement in Northern Iceland: Historical Ecology of Human Impact and Climate Fluctuation on the Millennial Scale. *American Anthropologist*, 109, No. 1, 27-51

McGovern, T.H., Bigelow, G.F., Amorosi, T., Russell, D. (1988) Northern islands, human error and environmental degradation: a preliminary model for social and ecological change in the Medieval North Atlantic, *Human Ecology* 16, 45–105

MacKenzie, W.S., and Adams, A.E. (2009) *A Colour Atlas of Rocks and Minerals in Thin Section* Manson Publishing, London.

McKenzie, J.T. (2006) *Deep Anthropogenic Topsoils in Scotland: A Geoarchaeological and Historical Investigation into Distribution, Character, and Conservation under Modern Landcover.* PhD Thesis, University of Stirling.

Macphail, R.I., Cruise, G.M., Mellalieu, S.J. and Niblett, R. (1998) Micromorphological interpretation of a ‘turf-filled’ funerary shaft at St. Albans, United Kingdom. *Geoarchaeology: An International Journal,* 13, No. 6, pp. 617-644.

Mahler, D. (1991) Argisbrekka. New evidence of shielings in the Faroe Islands. *Acta Archaeologica* 61: 60–72.

Mahler, D. (1995) Sheilings and their Role in the Viking Age Economy in Batey C.E., Jesch J. and Morris C.D. (eds) *The Viking Age in Caithness, Orkney and the North Atlantic* 487-505 Edinburgh University Press, Edinburgh.

Mahler, D. L. (2007) *Sæteren ved Argisbrekka.* Faroe University Press. Torshavn.

Maslow, A.H. (1943) A Theory of Human Motivation. *Psychological Review* 50 (4), 370-396

Milner, N., Craig O.E., Bailey G.N., Pedersen K. and Andersen S.H. (2004) Something fishy in the Neolithic? A re-evaluation of stable isotope analysis of Mesolithic and Neolithic coastal populations. *Antiquity* 78 9-22

Milles, A. (1986a) Charred remains of barley and other plants from Scord of Brouster. Whittle, A., Keith-Lucas, M., Milles, A., Noddle, B., Rees, S., and Romans, J. C. C. *Scord of Brouster: An Early Agricultural Settlement in Shetland.* 9, 119-122. Oxford, Oxford University Committee for Archaeology.

Milles, A. (1986b) Comparative analysis of charred plant remains from Ness of Gruting. Whittle, A., Keith-Lucas, M., Milles, A., Noddle, B., Rees, S., and Romans, J. C. C. *Scord of Brouster: An Early Agricultural Settlement in Shetland.* 9, 123-124. Oxford, Oxford University Committee for Archaeology.

Mitchell, A. (1880-81) Notice of Buildings Designed for Defence on an Island in a Loch at Hogsetter, in Whalsay, Shetland in *Proceedings of the Society of Antiquaries of Scotland* 15, 303-315

Mikkelsen, D.K. (1999) Single farm or village? Reflections on the settlement structure of the Iron Age and the Viking period. In Fabech, C. and Ringtved J *Settlement and Landscape* 177-193 Arhus University Press, Aarhus.

Moss, R. H. Malone, E. L., and Brenkert, A. L. (2002) *Vulnerability to Climate Change: A Quantitative Approach.* Pacific Northwest National Laboratory. http://www.globalchange.umd.edu/data/publications/Vulnerability_to_Climate_Change.PDF

Murray, J. (2011) *Cultivating the Divine: Ritual Deposition of Agricultural Equipment in Shetland Peat Bogs.* Unpublished M. Litt. Dissertation, University of the Highlands and Islands.

Myhre, B. (1985) Arable fields and farm structure *Archaeology and Environment* 4, pp. 69–82.

Myhre, B. (1999) Together or Apart – the problem of nucleation and dispersal of settlements. In Fabech, C. and Ringtved J *Settlement and Landscape* 125-130 Arhus University Press, Aarhus.

Napier Commission (1884) *Evidence taken by Her Majesty's Commissioners of Inquiry into the Condition of the Crofters and Cottars.* British parliamentary Papers, Agriculture 23, HMSO (reprinted, Irish University Press)

Nilssen, E. (1988) Development of the cultural landscape in the Lofoten area, North Norway. In H. H. Birks, H. J. B. Birks, P. E. Kaland & D. Moe, (eds) *The Cultural Landscape, Past, Present and Future* 369–380. Cambridge University Press. Cambridge.

Noddle, B. (1986) Animal Bones. Whittle, A., Keith-Lucas, M., Milles, A., Noddle, B., Rees, S., and Romans, J. C. C. *Scord of Brouster: An Early Agricultural Settlement in Shetland.* 9, 132. Oxford, Oxford University Committee for Archaeology.

O'Sullivan, T. (1998a) Birds in Sharples, N. *Scalloway. A Broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* 116-117. Oxbow Monograph 82, Oxford.

O'Sullivan, T. (1998b) The Mammal Bone in Sharples, N. *Scalloway. A Broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* 91, 106-110 & 127-130. Oxbow Monograph 82, Oxford.

O'Sullivan, T. (1998c) Marine Mammals in Sharples, N. *Scalloway. A Broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* 111-112. Oxbow Monograph 82, Oxford.

Oswald, A., Dyer, C. and Barber, M. (2001) *The creation of monuments: Neolithic causewayed enclosures in the British Isles.* English Heritage, Swindon.

Owen, O. (1983) Tuquoy, Westray, Orkney: A challenge for the future? In C.E. Batey, Jesch J. and C.D. Morris (ed) *Caithness, Orkney and the North Atlantic in the Viking Age.* 318-339 Edinburgh University Press, Edinburgh.

Owen, O. and Lowe, C. (1999) *Kebister: the four-thousand-year-old story of one Shetland township.* Edinburgh, Society of Antiquaries of Scotland. Monograph Series 14. Edinburgh.

Pape, J.C. (1970) Plaggen soils in the Netherlands. *Geoderma* 4, 229-255.

Parker Pearson, M. (2004) From Machair to Mountains Archaeological Survey and Excavation in South Uist. Oxbow Books, Oxford

Peacham, H. (1606) *The Art of drawing with the pen and limming in water colours*. Richard Braddock, London; reprinted Da Capo, New York 1970)

Reprinted under two titles in 1612: Graphice, or The most *auncient and excellent art of drawing and limming, disposed into 3 bookes.* Also as *The gentlemans exercise*. Wiliam Stansby London

Pedersen, E.A. (1999) Transformations to sedentary farming in eastern Norway: AD100 or 1000BC? In Fabech, C. and Ringtved J *Settlement and Landscape* 45-52 Arhus University Press, Aarhus

Perdikaris, S. (1999) From Chiefly Provisioning to Commercial Fishery: Long-Term Economic Change in Rowley Conwy P. (ed) *Arctic Norway.* World Archaeology 30 (3) 388–402.

Rackham, D.J. (1989) The Biological Assemblage: Discussion. In Morris C.D. *The Birsay Bay Project 1 1976-1982.* 267-271 Durham Department of Archaeology, Monograph no1. Durham

Renfrew, C. (1979) *Investigations in Orkney.* Society of Antiquaries of London. Reports of the Research Committee no.38. Thames and Hudson.

Ritchie, A. (1985) Orkney in the Pictish Kingdom. In The First Settlers. Refrew, C. (ed) *The Prehistory of Orkney BC 4000 - 1000AD*. 183-204 Edinburgh, Edinburgh University Press.

Richards, C. (1993) Monumental Choreography, Architecture and Spatial Representation in Late Neolithic Orkney. In Tilley C. (ed) *Interpretive Archaeology*. Berg, Oxford. 143-78

Richards, M.P. and Hedges, R.E.M. (1999) A Neolithic revolution? New evidence of diet in the British. *Antiquity* 73, 891-897

Rindel, P.O. (1999) Development of the Village Community 500BC – 100AD in West Jutland, Denmark. In Fabech, C. and Ringtved J *Settlement and Landscape* 79-99 Arhus University Press, Aarhus.

Roberts, B.K. (1987) *Landscapes of settlement: prehistory to the present.* London Routledge

Romans, J.C.C. (1986) Some notes on the Soils at the Scord of Brouster, Shetland. In Whittle, A., Keith-Lucas, M., Milles, A., Noddle, B., Rees, S., and Romans, J. C. C. *Scord of Brouster: An Early Agricultural Settlement in Shetland.* 9, 125-131. Oxford, Oxford University Committee for Archaeology.

Romans ,J.C.C. and Robertson, L. (1983) The general affects of early agriculture on the soil profile. The Testimony of the Topsoil. In Maxwell, G.S.(ed) *The Impact of Aerial Reconnaissance on Archaeology.* 136-41. CBA Research Report 49. Council for British Archaeology, London.

Romans, J.C.C. and Robertson, L. (1975) Some Genetic Characteristics of the Freely Drained Soils of the Ettrick Association of East Scotland. *Geoderma* 14, 297-317

Rousell, A. (1934) *Norse Building Customs in the Scottish Isles*. Levin and Munksgaard, Copenhagen; Williams and Norgate Ltd, London

Rowlands, M. (1993) The role of memory in the transmission of culture. *World Archaeology,* 25, 141-51

Russ, J.C. (1999) *The Image Processing Handbook* 3rd Edition. CRC Press LLC, Boca Ratton, Florida

Sahlins, M. (1974) *Stone Age Economics.* Tavistock Publications

Sauer, C.O. (1925) The morphology of landscapes *University of California Publications in Geography* 2, 19-54

Semler, L.E. (2004) Breaking the Ice to Invention: Henry Peacham's "The Art of Drawing" (1606) in *The Sixteenth Century Journal,* 35, No. 3 (Fall, 2004), 735-750

Schama, S. (1995) *Landscape and Memory* Harper Collins, London

Sharples, N. (1998) *Scalloway. A broch, Late Iron Age Settlement and Medieval Cemetery on Shetland.* Oxbow Monograph 82, Oxford.

Shetland Times (2001). *Ban on movements set to stay in place.* Fri 30 March p10. Shetland Times. Lerwick.

Simpson, B. (2001) Sumburgh Head Trial Trenches 1999 in Dockrill S.J., Bond, J.M. and Turner, V.E. *Old Scatness Broch and Jarlshof Environs Project: Field Season 2000* Data Structure Report 6, 1: 77-84.

Simpson, I.A. (1997) Relict properties of anthropogenic deep top soils as indicators of infield management in Marwick, West Mainland, Orkney. *Journal of Archaeological Science* 24: 365-380.

Simpson, I.A. (1998) Early land management at Toft's Ness, Sanday, Orkney: the evidence of thin section micromorphology. in Mills, C.M. and Coles, G. (eds.) *Life on the edge: human settlement and marginality*. Oxbow Monograph 100, Oxford, pp. 91-98.

Simpson, I.A., Adderley, W.P., Guðmundsson, G., Hallsdóttir, M., Sigurgeirsson, M. Á., and Snæsdóttir M. (2002) Soil Limitations to Agrarian Land Production in Premodern Iceland. *Human Ecology.* 30, No. 4, pp. 423-443

Simpson, I.A. and Barrett, J.H. (1996) Interpretation of midden formation processes at Robert's Haven, Caithness, Scotland using thin section micromorphology. *Journal of Archaeological Science* **23**, pp. 543-556.

Simpson, I. A., Bryant, R. G., and Tveraabak, U. (1998c). Relict soils and early arable land management in Lofoten, Norway. *Journal of Archaeological Science* 25: 1185–1198.

Simpson, I.A., Crawford, B. and Ballin-Smith, B. (undated, last accessed 2010) *Papar place-names in the Northern and Western Isles of Scotland: a preliminary assessment of* *their association with agricultural land potential.* http://www.paparproject.org.uk/agricultural.html

Simpson, I.A., Dockrill, S.J., Bull, I.D. and Evershed, R.P. (1998a) Early anthropogenic soil formation at Toft's Ness, Sanday, Orkney. *Journal of Archaeological Science* 25:729-746.

Simpson, I.A., Dockrill, S.J. and Lancaster, J. (1998b) Making arable soils: anthropogenic soil formation in a multi-period landscape. In Nicholson, R.J. and Dockrill, S.J. (eds.) *Old Scatness Broch: Retrospect and Prospect*. 111 – 126 University of Bradford/ Shetland Amenity Trust/ North Atlantic Biocultural Organisation. Bradford.

Simpson, I.A. and Guttmann, E.B. (2002) Transitions in early arable land management in the Northern Isles: the *papar* as agricultural innovators? In Crawford, B.E. (ed.) *The papar in the North Atlantic: environment and history*. 59-67 St. John's House Papers 10, St. Andrews.

Simpson, Ian A., Garðar Guðmundsson, Amanda M. Thomson, and Jon Cluett (2004) Assessing the Role of Winter Grazing in Historic Land Degradation, Mý　vatnssveit, North-East Iceland. *Geoarchaeology: An International Journal*. 19, 471–503.

Simpson, I.A., Guttmann, E.B., Cluett J., and Shepherd, A. (2006) Characterizing Anthropic Sediments in North European Neolithic Settlements: An Assessment from Skara Brae, Orkney. *Geoarchaeology: An International Journal*. 21, No. 3, 221–235.

Simpson, I.A., Vésteinsson O., Adderley W.P. and McGovern T.H. (2003) Fuel resource utilisation in landscapes of settlement. *Journal of Archaeological Science* 30, 1401–1420

Simpson, I.A., Barrett, J.H. and Milek, K. B. (2005) Interpreting the Viking age to Medieval period transition in Norse Orkney through cultural soil and sediment analyses. *Geoarchaeology* 20, 357-379

Sinclair, J. (ed.) (1791-1799) *The First Statistical Account of Scotland*. 5, no XII, 182-202 Island and Parish of Unst in Shetland. Edinburgh. (facsimile, ed. E.S. Reid Tait, pub: T&J Manson, Lerwick 1925)

Small, A. (1966) Excavations at Underhoull, Unst, Shetland. *Proceedings of the Society of Antiquaries of Scotland* 98, 225-248

Smith, B. (2000) *Toons and Tenants. Settlement and Society in Shetland 1299-1899.* Shetland Times, Lerwick

Soil Survey of Scotland (1982) *Orkney and Shetland – 1:250,000 Sheet 1.* Aberdeen: Macaulay Institute for Soil Research.

Stoddart, S. (2000) Early Studies of Landscapes: Editorial Introduction. In Stoddart S. (ed) *Landscapes from Antiquity.* 1-5 Antiquity Publications Ltd, Cambridge

Stoklund, B. (1999) Turf manuring on the Danish island of Laeso. *Geografisk Tidsskrift: Danish Journal of Geography (Special Issue)* 1, 209-214

Stoops, G. (2003) *Guidelines for analysis and description of soil and regolith thin sections*. Soil Science Society of America, Inc. Madison, Wisconsin

Stoopes, G., Marcelino V. and Mees, F. (eds) (2010) *Interpretation of Micromorphological Features of Soils and Regoliths.* Elsevier, Amsterdam and Oxford

Summers. J. (2013) The archaeobotanical remains from Hamar Unst, in Bond, J.M. Excavations at Hamar and Underhoull. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland.* Shetland Heritage Publications, Lerwick

Sveinbjarnardóttir, G. 1992 Farm Abandonment in Medieval and Post-Medieval Iceland: an Interdisciplinary Study. Oxbow Monograph 17, Oxford

Szabó, M. (1980) Clearing of stony ground and cultivation in Sweden. An interplay between expertise, organisation and technique. *Tools and Tillage IV* 3-35

Thomas, J (1998) Neolithic explanations revisited, The Mesolithic-Neolithic transition in Britain and South Scandinavia. *Proceedings of the Prehistoric Society,* 54, 59-66

Thomas, J. (1991) *Rethinking the Neolithic.* Cambridge University Press, Cambridge

Thomas, J. (2003) Thoughts on the "repacked" Neolithic Revolution. *Antiquity* 77 (295) 67–75

Thomson, W.P.L. (1981) Common land in Orkney. *Orkney Heritage* 1, 73-91

Thomson, W.P.L. (1987) *History of Orkney.* Mercat Press, Edinburgh

Thomson, W.P.L. (1998) Township, "House" and Tenant-Holding: The Structure of Run-Rig Agriculture in Shetland in Turner V *The Shaping of Shetland.* 107-127 The Shetland Times, Lerwick.

Thorpe, I.J.N. (1997) From Settlements to Monuments: Site Succession in Late Neolithic and Early Bronze Age Jutland. In Nash G. (ed) Semiotics of Landscapes: Archeology of the Mind BAR International Series 661 71-79

Tilley, C. (1994) *A Phenomenology of Landscape: places, Paths and Monuments.* Berg, Oxford

Turner, V.E. (1987) Results of Survey Work carried out in the Caldbeck Fells, Cumbria, *in transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society,* LXXXVII, 19-25. Kendal

Turner, V.E. and Purdey A.V. (1996) The Jarlshof Environs Survey in Dockrill, S.J., Bond, J.M., Turner, V.E. and Purdy A.V. *Old Scatness Broch and Jarlshof Environs Project: Field Season 1996* Data Structure Report 2. 1, 22-37

Turner, V.E. (1998) *Ancient Shetland,* BT Batsford, London Historic Scotland

Turner, V. (1998) *The Shaping of Shetland* The Shetland Times, Lerwick

Turner, V.E. (2001) Topographical Survey in Dockrill, S.J., Bond, J.M. and Turner, V.E. *Old Scatness Broch and Jarlshof Environs Project: Field Season 2000* Data Structure Report 6. 1, 77-84

Turner, V.E. (2008) Foreword in Stewart J. *An Outline of Shetland Archaeology*: *A reprint of the series of articles first published in August and September, 1956 in "The Shetland Times".* vii-x Shetland Amenity Trust, Lerwick.

Turner, V.E., Bond J.M. and Larsen, A-C. (2013) *Viking Unst. Excavation and Survey in Northern Shetland.* Shetland Heritage Publications, Lerwick

Turner, V.E., Chrystall F., Simpson I.A. and Guttmann E (2004) Form and Function in Shetland Prehistoric Field Systems. In Housley, R.A. and Coles, G. *Atlantic Connections and Adaptions. Economies, environments and subsistence bordering the North Atlantic.* 120 – 127 Symposia of the Association for Environmental Archaeology No 21. Oxbow Books, Oxford

Turner, V.E. and Fojut, N., forthcoming "Thinking Iron Age Thoughts" in Dockrill, S.J., Bond, J.M., Turner, V.E., Brown, L.D., Bashford, D.J., Cussans, J.E., Nicholson, R.A *Excavations at Old Scatness, Shetland. Volume 2: The Iron Age Broch and Village*. Shetland Heritage Publications, Lerwick

Turner V.E., Gater J., Simpson B., Melton N., Simpson I. and Guttmann E. (2001) The Jarlshof Environs Survey in *Old Scatness Broch and Jarlshof Environs Project: Field Season 2000* Interim Report No. 6. Shetland Amenity Trust, University of Bradford. Bradford

Turner, V.E., Guttmann-Bond, E.B.A, Burbidge, C.I., and Simpson, I.A. (2010) "Old Scatness: the Viking and Norse anthrosols" in Dockrill, S.J., Bond, J.M., Turner, V.E., Brown, L.D., Bashford, D.J., Cussans, J.E., Nicholson, R.A. *Excavations at Old Scatness, Shetland. Volume 1: The Pictish Village and Viking Settlement*, 197-203 Shetland Heritage Publications, Lerwick

Turner, V.E., Guttmann-Bond, E.B.A, Burbidge, C.I., and Simpson, I.A., in press, "Old Scatness: the Iron Age anthrosols" in Dockrill, S.J., Bond, J.M., Turner, V.E., Brown, L.D., Bashford, D.J., Cussans, J.E., Nicholson, R.A. *Excavations at Old Scatness, Shetland. Volume 2: The Iron Age Broch and Village*, Shetland Heritage Publications, Lerwick

Turner, V.E., Nicholson, R.A., Dockrill S.J. and Bond, J.M. (eds) (2005) *Tall Stories? 2 Millennia of Brochs.* Shetland Amenity Trust, Lerwick

Turner V.E. and Simpson I.A. (2013) In Search of the Infields: Viking / Norse Field Systems in Unst. In Turner, V.E., Bond J.M. and Larsen, A-C. *Viking Unst. Excavation and Survey in Northern Shetland.* Shetland Heritage Publications, Lerwick

U.K. Metrological Office Aviation Data (2010) *Climatological Statistics for British Isles Airfields* (http://secure.metoffice.com/aviation/climatestats/index.jsp)

Vésteinsson, O. (2000). The archaeology of Landnám: early settlement in Iceland. In: *Vikings: The North Atlantic Saga.* W.W. Fitzhugh and E.I. Ward (ed) 164-174 Smithsonian Institution Press, Washington and London

Vorren, K.D., Nilssen E. and Mørkved B (1990) Age and agricultural history of the –stađir farms of North and Central Norway. In *Norsk geogr Tidsskr.* 44, 79-102 Oslo

Whittle, A. (1989) Islands of history: second millennium change in the north of Scotland, in *Transactions of the British-Scandinavian Colloquium in Stockholm, May 10-11, 1985.* Bronze Age Studies 6*,* 163-172 (ed.) Nordström, H-Ǻ and Knape A, Statens Historiska Museum, Stockholm

Whittle, A. (1997) Moving On and Moving Around: Neolithic Settlement Mobility. in Topping, P. (ed) *Neolithic Landscapes* Neolithic Studies Group Seminar Papers 2, 15-22 Oxbow Monograph, 86, Oxford

Whittle, A., Bayliss, A and Healy, F. (2011) Gathering Time: the social dynamics of change. in Whittle, A., Healy, F. and Bayliss, A. *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland. 848 -914* Oxbow. Oxford.

Whittle, A., Healy, F. and Bayliss, A. (2011) Gathering Time: causewayed enclosures and the early Neolithic of Southern Britain and of Ireland. in Whittle, A., Healy, F. and Bayliss,

A. *Gathering Time. Dating the Early Neolithic Enclosures of Southern Britain and Ireland.1-16* Oxbow. Oxford.

Whittle A., Keith-Lucas M., Millies A., Noddle B., Rees S., and Romans J.C.C. (1986) *Scord of Brouster: An Early Agricultural Settlement on Shetland*, Oxford University Committee for Archaeology Monograph 9, Oxford.

Whittington, G. (1973) Field systems of Scotland. In Baker, A.R.H. and Butlin, R.A. (1973) *Studies of field systems in the British Isles*. 530-579 Cambridge University Press, Cambridge

Whittington, G. (1978) A sub-peat dyke at Shurton Hill, Mainland, Shetland. *Proceedings of the Society of Antiquaries of Scotland,* 109, 30-35 Edinburgh

Whittington, G and Edwards, K.J (1997) Evolution of a machair landscape: pollen and related studies from Benbecula, Outer Hebrides. *Transactions of the Royal Society of Edinburgh: Earth sciences* 87, 515-531

Whittington, G. and Edwards, K.J. Climate Change. (1997) in Edwards, K.J. and Ralston I.B.M . *Scotland: Environment and Archaeology, 8000BC - AD 1000*. 11-22 Chichester, Wiley.

Øvrevik, S. (1985) The Second Millennium and After. Refrew, Colin. The Prehistory of Orkney BC 4000 - 1000AD. 131-149 Edinburgh University Press. Edinburgh.

Øye, I. (2003) Outfields as Part of the Medieval Farm. Four Archaeological Case Studies from Western Norway. In Bergstøl J (ed). *Scandinavian archaeological practice – in theory. Proceedings from the 6th Nordic TAG, Oslo 2000. Norwegian Archaeological papers 1* 400-411 Oslo

Øye, I. (2005) Farming and Farming Systems in Morse Societies of the North Atlantic. In Mortensen, A. and Arge, S.V. *Viking and Norse in the North Atlantic.* 359-370 The Faroese Academy of Sciences, Torshavn

Appendix A: Shape Factor Attributes

NEOLITHIC	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Croag	3135.36	217.94	0.83	63.18	76.92	66.70	50.71	7208.56	5804.80	4669.09	0.98	3186.75	219.59
Exnaboe	1766.62	161.44	0.85	47.43	53.66	49.43	42.46	3690.42	3243.53	2878.25	0.99	1790.70	163.69
Hill of the Taing	1722.3	170.31	0.75	46.83	63.55	52.34	37.92	4343.88	3674.84	2736.14	0.91	1897.9	172.45
Houlland	2384.35	188.79	0.84	55.1	67.94	59.03	50.23	5061.09	4614.56	3939.1	0.98	2437.33	194.92
Newing	1660.68	161.85	0.80	45.98	59.33	49.73	39.9	4289.59	3921.31	3295.82	0.96	1725.68	165.05
Vassa	2269.86	182.01	0.86	53.76	59.81	55.59	50.79	4792.23	4503.31	4268.08	0.99	2286.27	184.47

Appendix A.1.Attributes of Homestead Enclosures

NEO/BA	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Brouster1	1279.37	160.49	0.62	40.36	53.54	48.11	40.5	3687.59	3160.79	2670.72	0.89	1441.38	158.06
2	2750.22	211.84	0.77	59.18	74.84	63.75	52.38	6985.45	6181.77	5018.52	0.95	2902.14	211.74
3	1828.89	183.09	0.69	48.26	67.80	56.24	40.40	5234.94	4286.96	3174.99	0.95	1963.95	184.23
4	2051.94	226.76	0.5	51.11	77.67	66.21	50.81	7024.98	5711.69	4683.01	0.8	2552.89	220.3
5	3202.45	318.80	0.4	63.86	108.56	86.66	62.82	14020.8	12376.42	9436.2	0.69	4656.58	282.11
6	1820.31	175.35	0.74	48.14	64.08	54.92	39.56	4780.46	4089.32	2815.6	0.95	1922.87	179.75
7	901.65	132.91	0.64	33.88	50.50	39.42	27.05	2898.91	2627.08	2214.46	0.9	997.65	129.61
8	1077.65	147.66	0.62	37.04	50.56	44.19	34.67	3154.39	2911.48	2361.21	0.88	1220.7	144.87

Appendix A.2.Attributes of Multiple Field Systems at Scord of Brouster

NEO/BA	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Clevigarth 1	2325.23	275.18	0.39	54.41	127.25	86.64	28.03	16630.06	12691.87	5439.15	0.95	2444.66	287.61
2	1265.29	266.99	0.22	40.14	107.86	77.6	36.53	12368.87	10838.25	7048.91	0.44	2848.38	256.76
3	5287.89	346.5	0.55	82.05	108.17	98.76	81.77	16208.96	14159.28	11785.4	0.82	6471.49	328.74
4	1392.9	147.49	0.80	42.11	51.79	46.25	35.66	3455.98	3102.43	2268.18	0.97	1442	149.72

Appendix A.3 Attributes of Multiple Field Systems at Clevigarth

NEO/BA	Area m²	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m²	Rectangular min m²	Rectangular Mean m²	Convexity	Convex Area m²	Convex perimeter m²
Gallow Hill 1	1402.39	154.86	0.73	42.26	55.49	47.28	37.11	3782.08	3276.19	2523.98	0.91	1548.51	155.11
2	3675.83	252.89	0.72	68.41	82.98	75	64.13	8869.1	8373.7	7703.92	0.93	3973.66	249.49
3	2669.5	245.22	0.56	58.3	90.76	71.85	53.81	9612.57	7220.94	5644.54	0.83	3209.18	236.8
4	756.61	114.09	0.73	31.04	38.29	35.1	30.7	1919.79	1760.47	1583.95	0.93	817.59	115.16
5	1547.82	176.45	0.62	44.39	57.53	51.92	45.14	4397.99	3886.4	3505.24	0.9	1711.21	170.94

Appendix A.4 Attributes of Multiple Field Systems at Gallow Hill

NEO/BA	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Ness of Gruting 1	460.17	98.33	0.60	24.21	33.71	29.93	25.02	995.46	789.21	892.31	0.88	521.02	98.28
2	841.05	127.99	0.65	32.72	45.58	38.17	25.38	1696.98	1073.64	1432.30	0.91	928.29	126.87
3	494.71	92.69	0.72	25.10	32.76	28.51	21.92	910.30	682.60	803.47	0.91	542.89	93.97
4	930.55	131.11	0.68	34.42	52.81	40.70	24.24	1813.61	1219.68	1577.27	0.95	979.55	135.72
5	984.69	126.12	0.78	35.41	48.52	39.02	26.12	1653.11	1259.65	1471.03	0.97	1014.16	128.41

Appendix A.5 Attributes of Multiple Field Systems at Ness of Gruting

NEO/BA	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Pinhoull1	456.33	85.41	0.79	24.1	29.26	26.61	22.25	1112.78	986.08	811.58	0.93	488.33	85.92
2	722.72	114.05	0.7	30.33	37.6	34.47	26.95	1891.11	1776.45	1642.58	0.91	797.28	111.63
3	1124.51	144.11	0.68	37.84	54.61	43.83	32.03	3131.9	2376.3	1990.61	0.92	1223.18	141.94
4	7198.18	605.71	0.25	95.73	137.21	121.85	101.41	23194.19	21452.64	18399.11	0.72	10012.77	400.45
5	1429.67	177.01	0.57	42.67	69.99	53.8	31.68	4785.63	3418.15	2429.01	0.94	1519.52	177.49
6	1796.31	190.92	0.62	47.82	67.45	57.25	44.58	5004.99	4335.27	3485.23	0.86	2079.88	189.31
7	1554.99	168.1	0.69	44.5	56	51.13	41.69	4231.19	2587.29	2791.96	0.89	1754.86	168.45
8	2445.26	223.6	0.61	55.8	79	66.02	48.25	6771.74	5744.91	4213.03	0.88	2773.28	217.88
9	4730.38	329.61	0.55	77.61	110.13	95.98	63.97	15998.78	14469.91	12862.42	0.83	5677.24	311.6

Appendix A.6 Attributes of Multiple Field Systems at Pinhoulland

NEO/BA	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Sum Head 1	548.98	103.48	0.64	26.44	41.98	31.76	18.4	1986.54	1593.94	1137.58	0.95	577.04	105.45
2	734.37	107.6	0.8	30.58	39.98	34.2	23.96	2030.98	1676.41	1073.73	0.97	754.11	111.94
3	402.14	83.49	0.72	22.63	29.22	25.67	21.76	1146.56	949.7	708.55	0.92	438.05	84.44
4	247.68	61.04	0.84	17.76	19.64	18.92	17.81	526.59	504.3	487.88	0.97	256.15	61.37
5	181.69	63.31	0.57	15.21	26.92	20.24	11.38	799.59	683.55	426.85	0.95	190.99	66.56

Appendix A.7 Attributes of Multiple Field Systems at Sumburgh Head

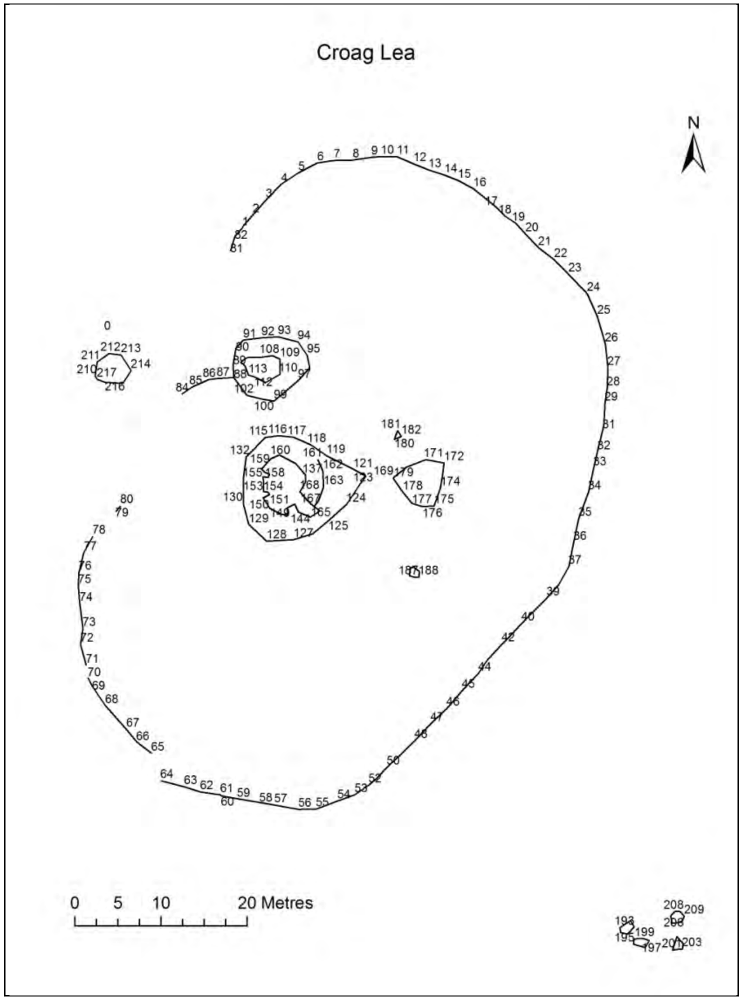
NORSE - yards	Area m^2	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m^2	Rectangular min m^2	Rectangular Mean m^2	Convexity	Convex Area m^2	Convex perimeter m^2
Belmont 1	52.07	29.31	0.76	8.14	11.00	9.31	6.34	96.05	69.75	84.70	0.91	57.33	28.70
Belmont 2	675.83	146.19	0.40	29.33	51.30	38.54	23.01	1596.35	1167.40	1395.71	0.82	819.30	124.77
Eastshore	917.08	135.77	0.63	34.17	56.46	42.35	27.13	3663.56	2926.21	2287.79	0.92	1000.87	139.54
Gardie	1657.57	168.68	0.73	45.94	56.81	50.33	41.64	4238.92	3824.49	3065.93	0.94	1763.24	165.85
Hamar 1	665	113.8	0.65	29.1	38.35	34.03	28.57	1826.94	1560.12	1300.9	0.87	762.36	111.86
Hamar 2	446.26	96.26	0.61	23.84	37.08	29.44	17.25	1458.38	1100.19	684.39	0.88	504.71	96.41
Quoy	513.24	99.36	0.65	25.56	36.88	31.03	22.81	1664.45	1495.28	1227.95	0.95	540.88	104.24
Stove	290.17	68.49	0.78	19.22	26.12	21.49	16.14	648.98	592.85	461.29	0.95	306.23	69.11
Watlie 1	692.97	114.79	0.66	29.7	42.65	34.39	26.82	2256.9	1814.69	1322.9	0.91	762.73	112.14
Watlie 2	1778.93	182.25	0.67	47.59	67.59	53.87	40.66	5183.97	3730.61	3068.35	0.93	19134.31	176.24
Gue	*2298.38*	*200.78*	*0.72*	*54.1*	*79.09*	*62.92*	*40.71*	*7287.42*	*6006.11*	*3525.9*	*0.96*	*2405.37*	206.63
	1077.65	147.66	0.62	37.04	50.56	44.19	34.67	3154.39	2911.48	2361.21	0.88	1220.7	144.87

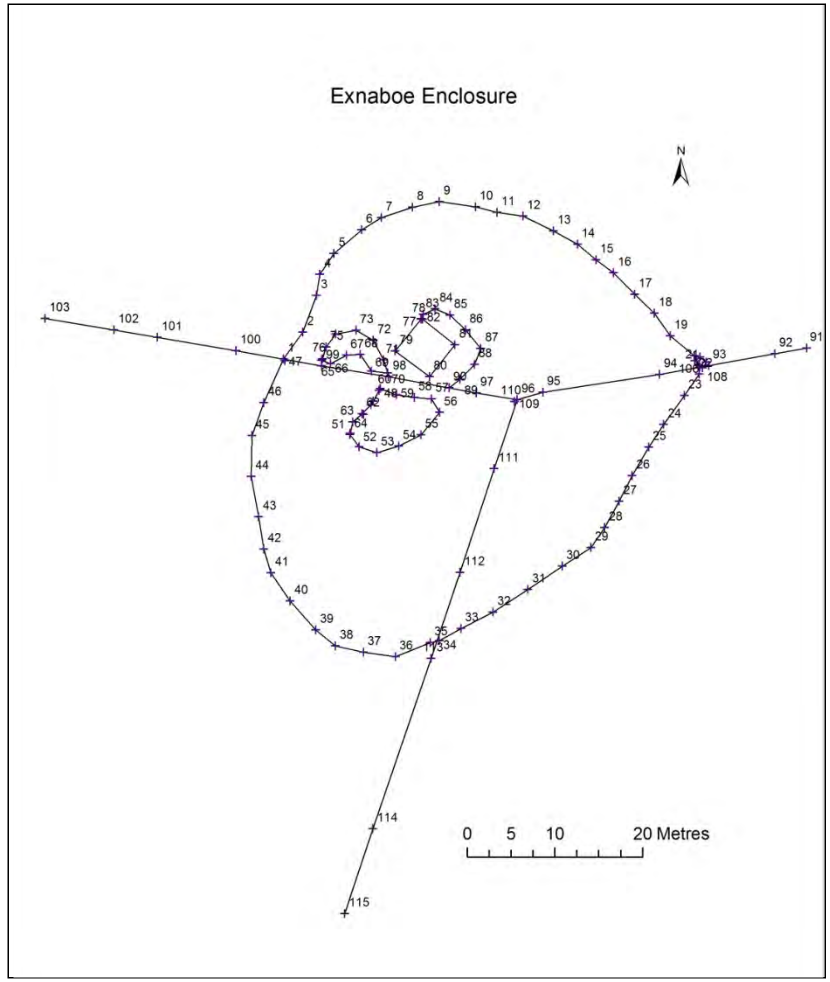
Appendix A.8 Attributes of Norse Yards

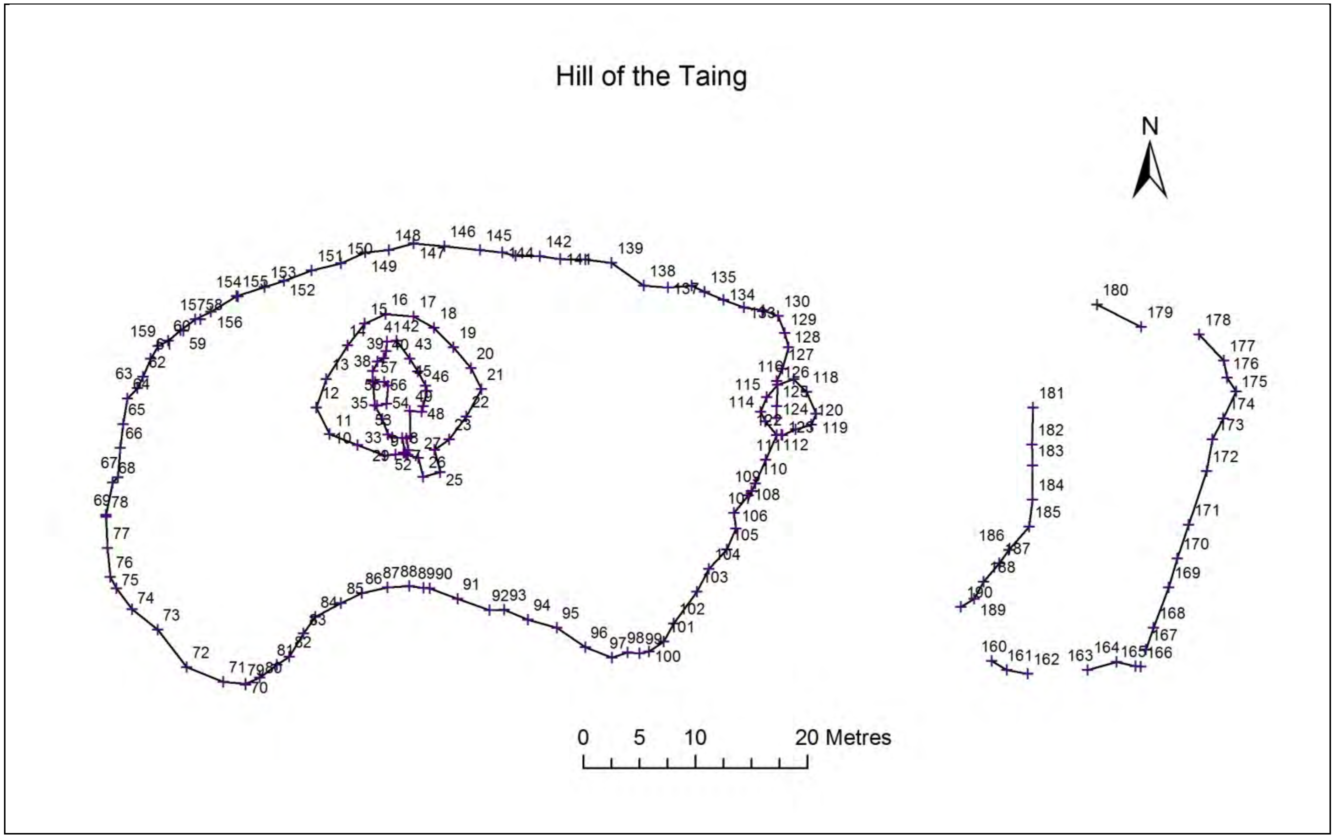
NORSE - infields	Area m²	Perimeter m	Shape Factor	ECD m	Feret Max m	Feret Mean m	Feret Min m	Rectangular max m²	Rectangular min m²	Rectangular Mean m²	Convexity	Convex Area m²	Convex perimeter m²
Belmont	3493.52	332.81	0.40	66.69	103.09	79.86	58.61	6902.46	5290.78	6174.17	0.87	4025.04	263.02
Gardie	48189.92	926.93	0.7	247.7	330.75	285.41	191.11	140859.4	128008.1	106099.4	0.95	50949.09	958.21
Stove	4899.24	331.04	0.56	78.98	125.82	102.01	62.47	18271.38	16119.88	9275.98	0.92	5306.51	327.55
Watlie	28787.96	728.91	0.68	191.45	244.86	217.52	159.54	78446.45	62496.43	44177.8	0.95	30304.69	713.25

Appendix A.9 Attributes of Norse Infields

Appendix B: Field Survey Points



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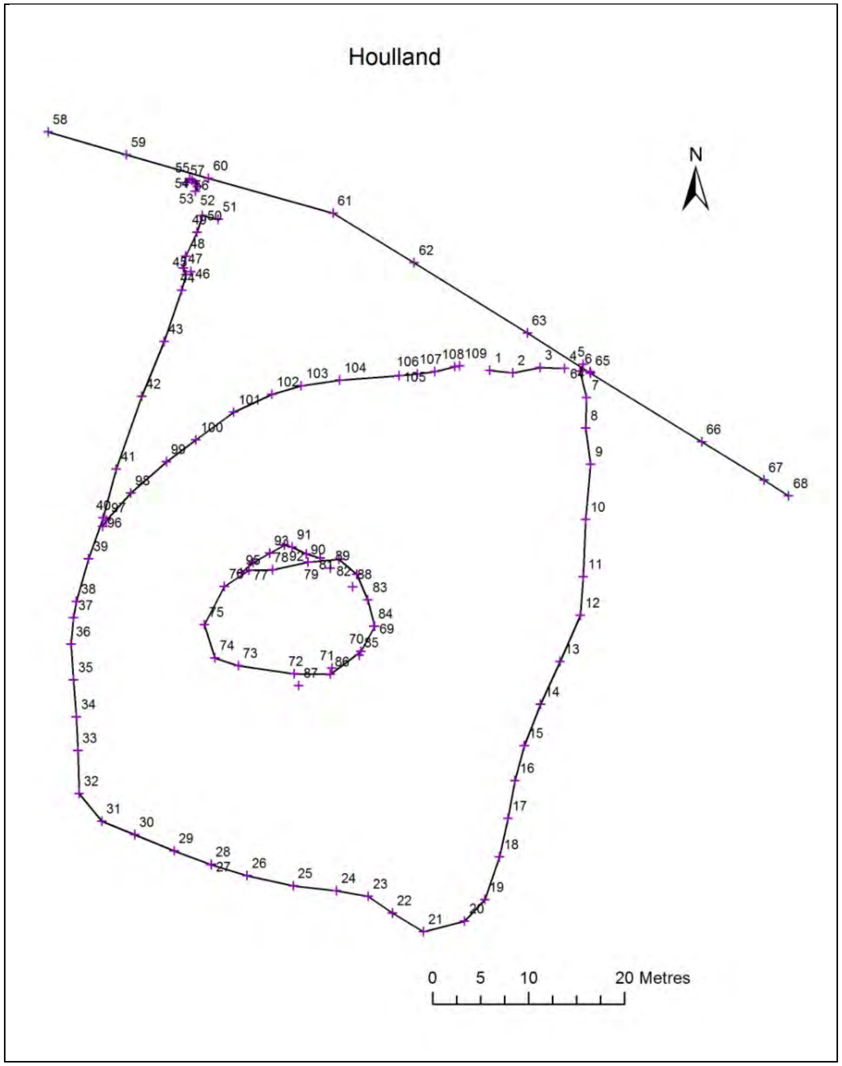
Houlland
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10
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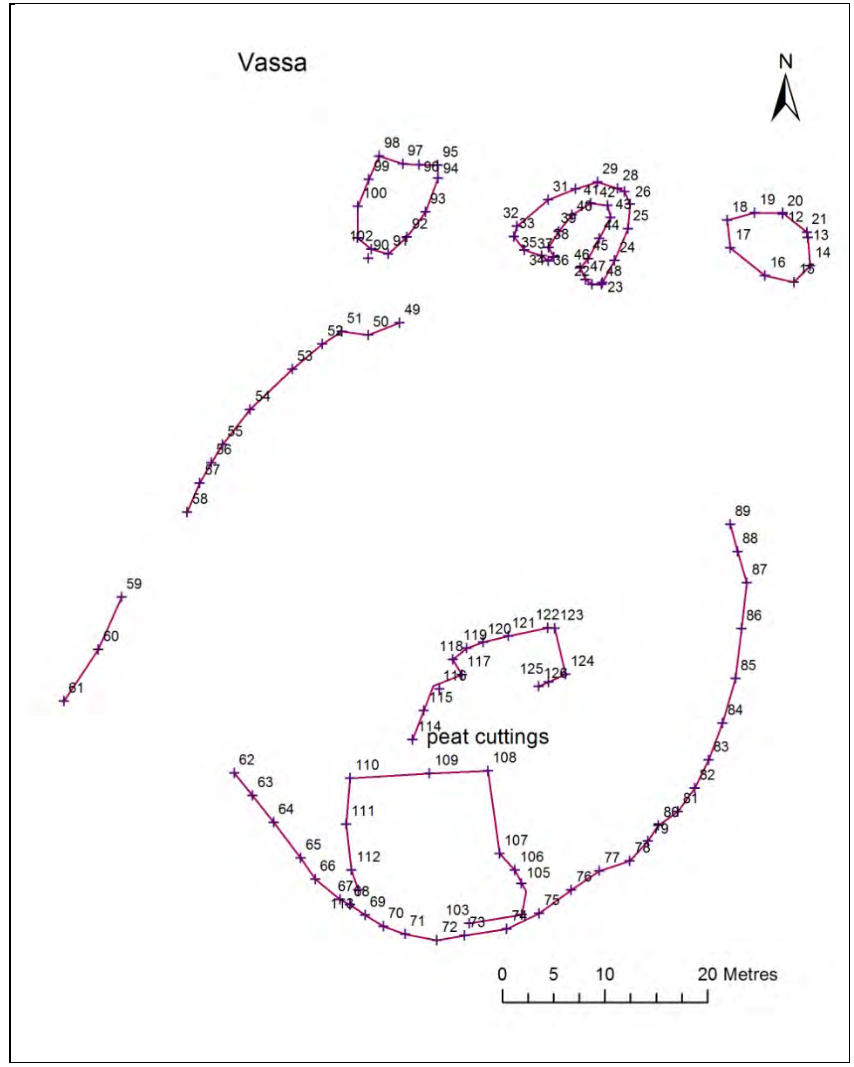
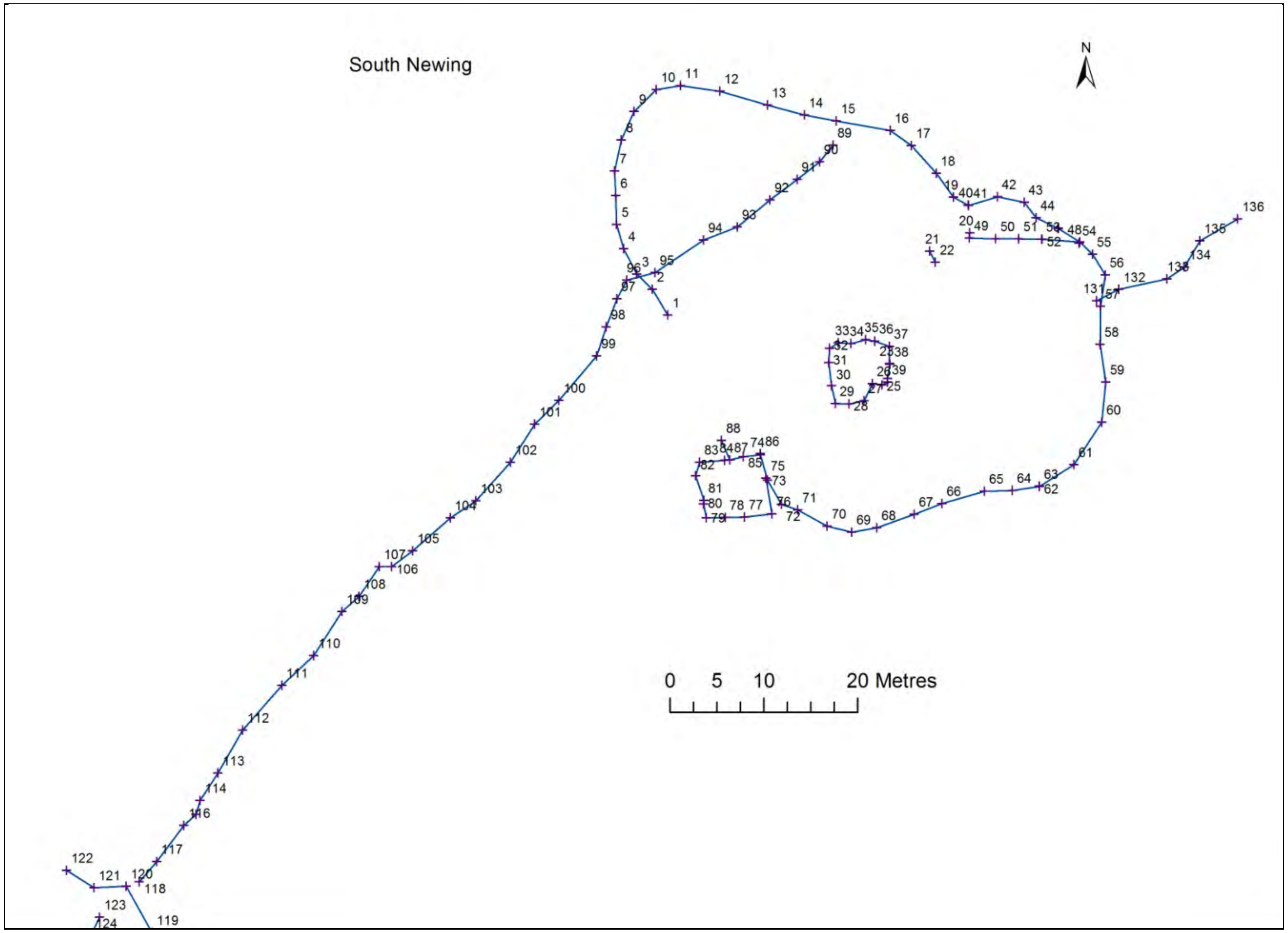

Vassa
N
peat cuttings
0
5
10
20 Metres


South Newing
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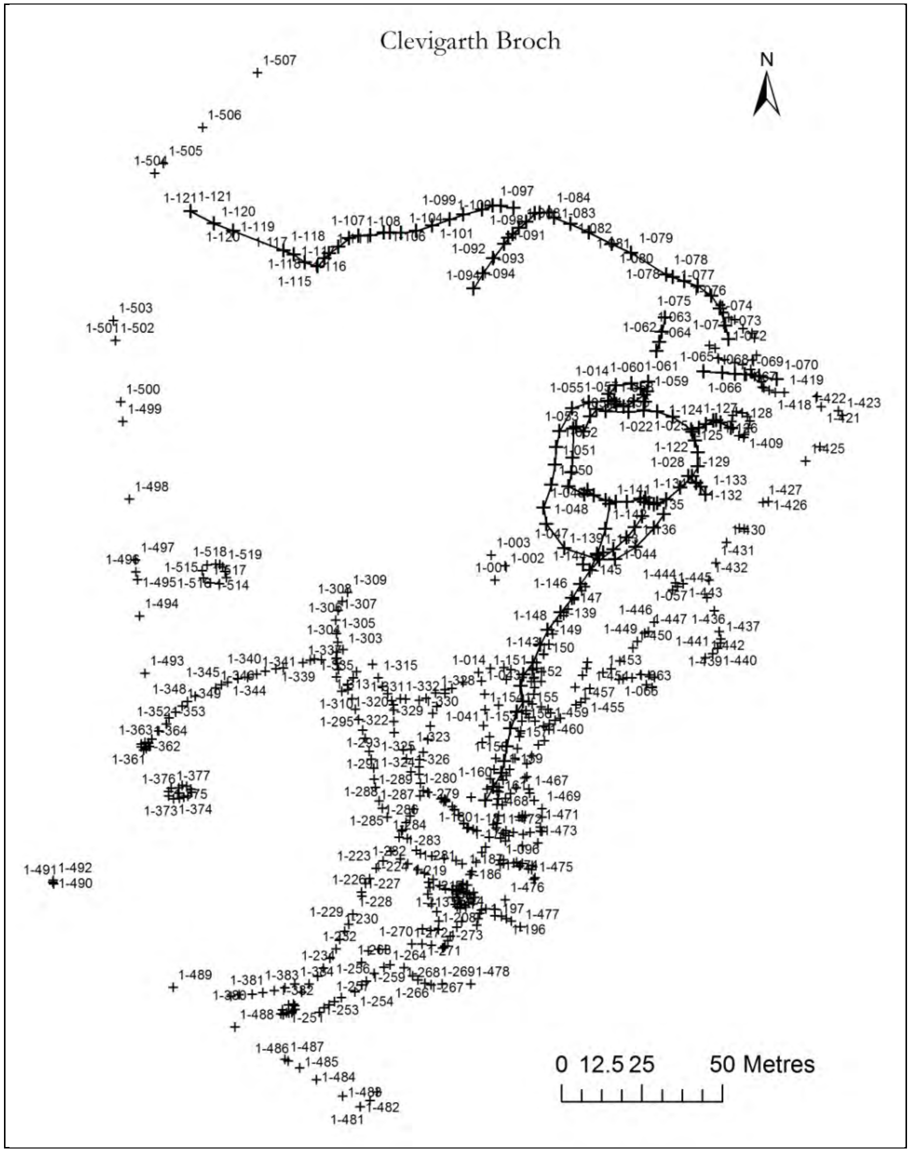
Clevigarth Broch
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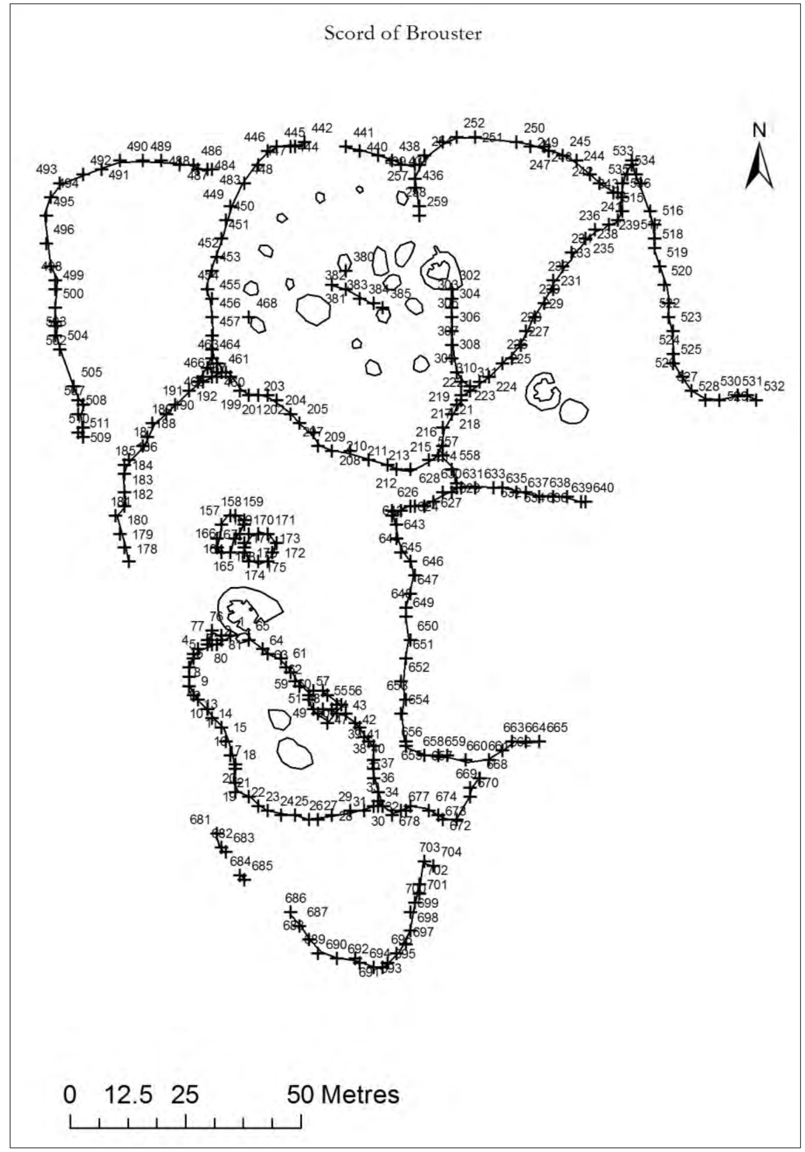
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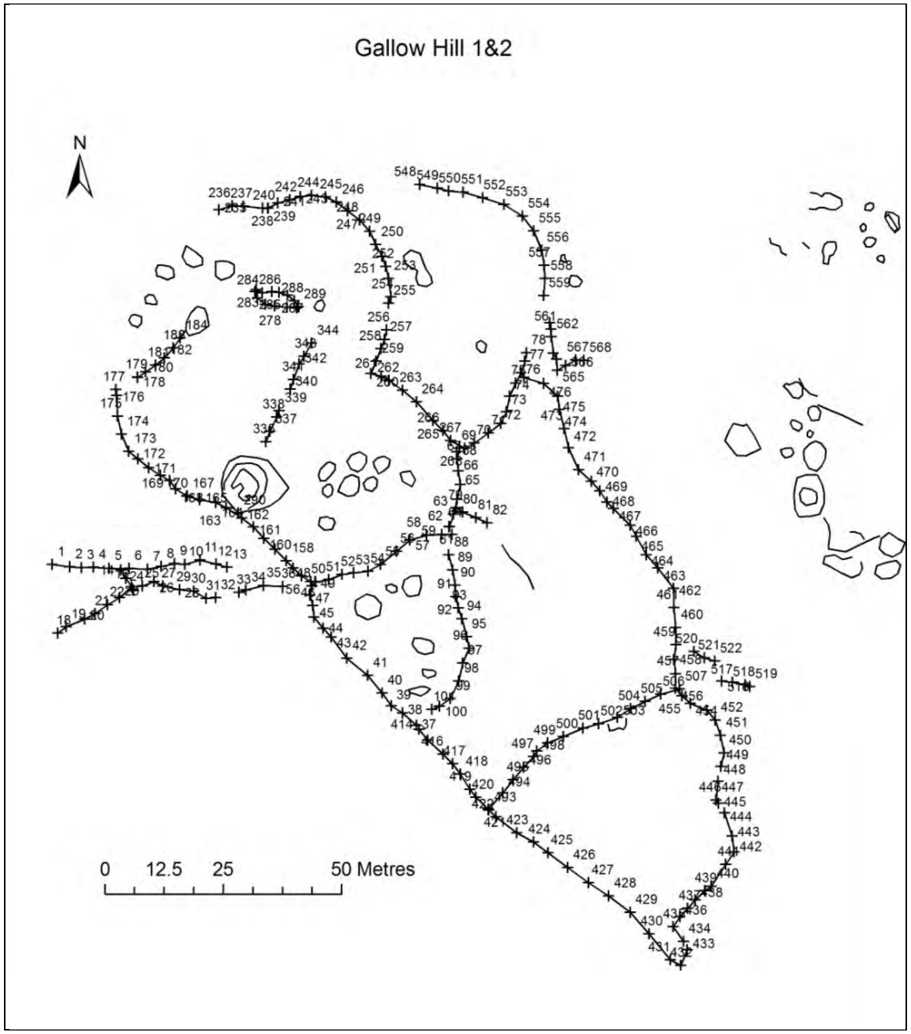
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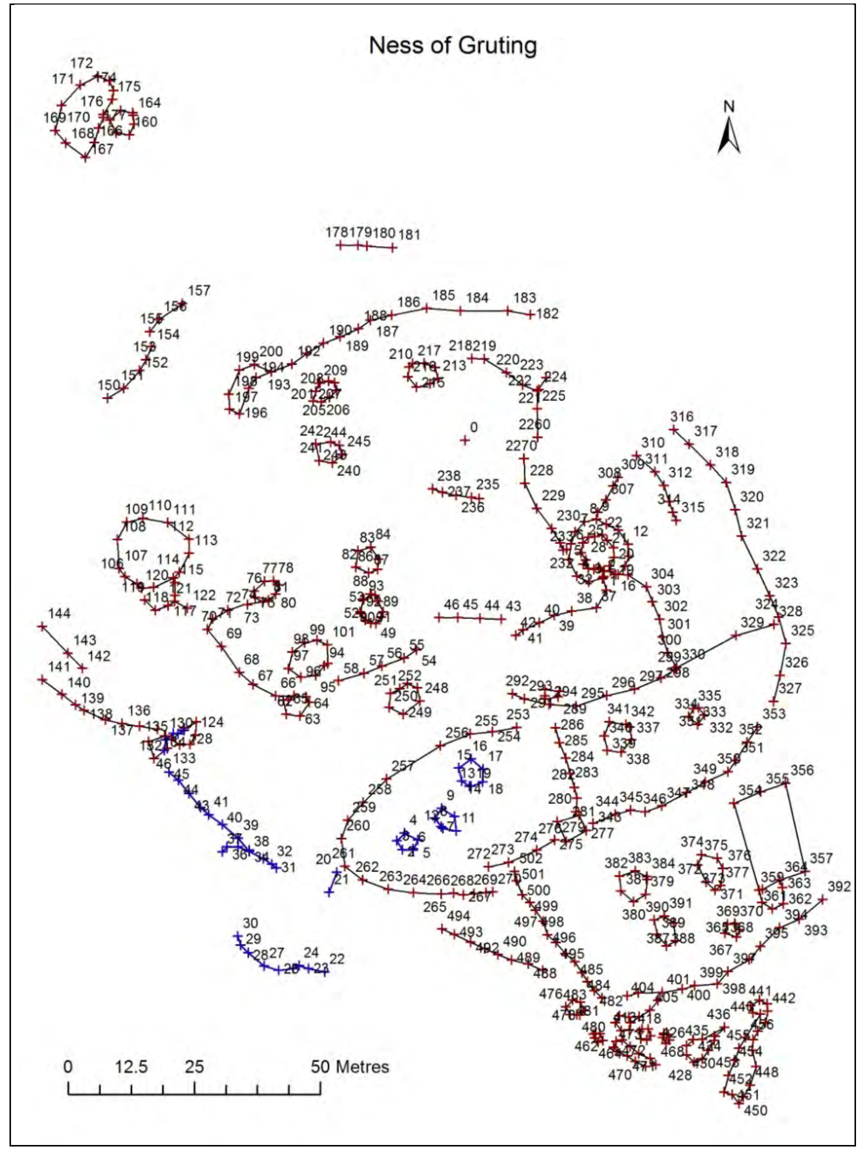
Ness of Gruting
N
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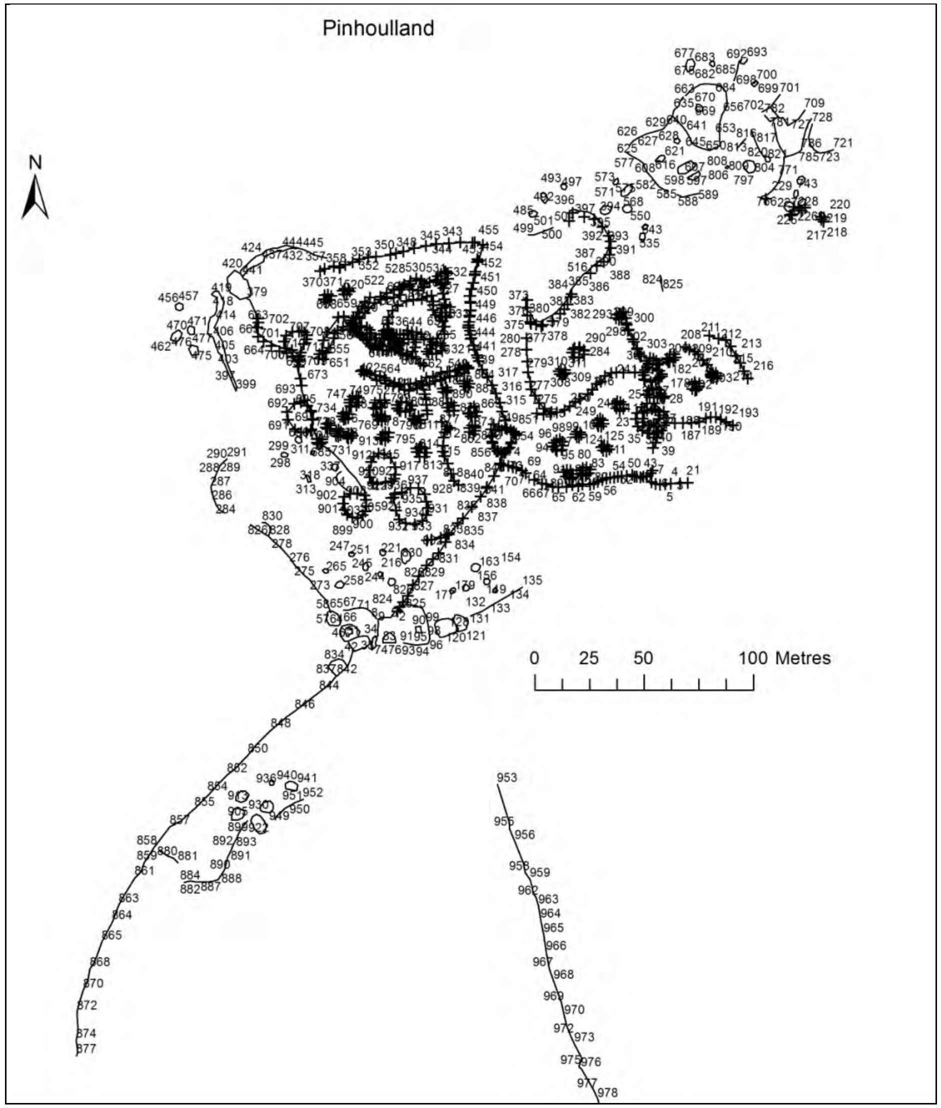
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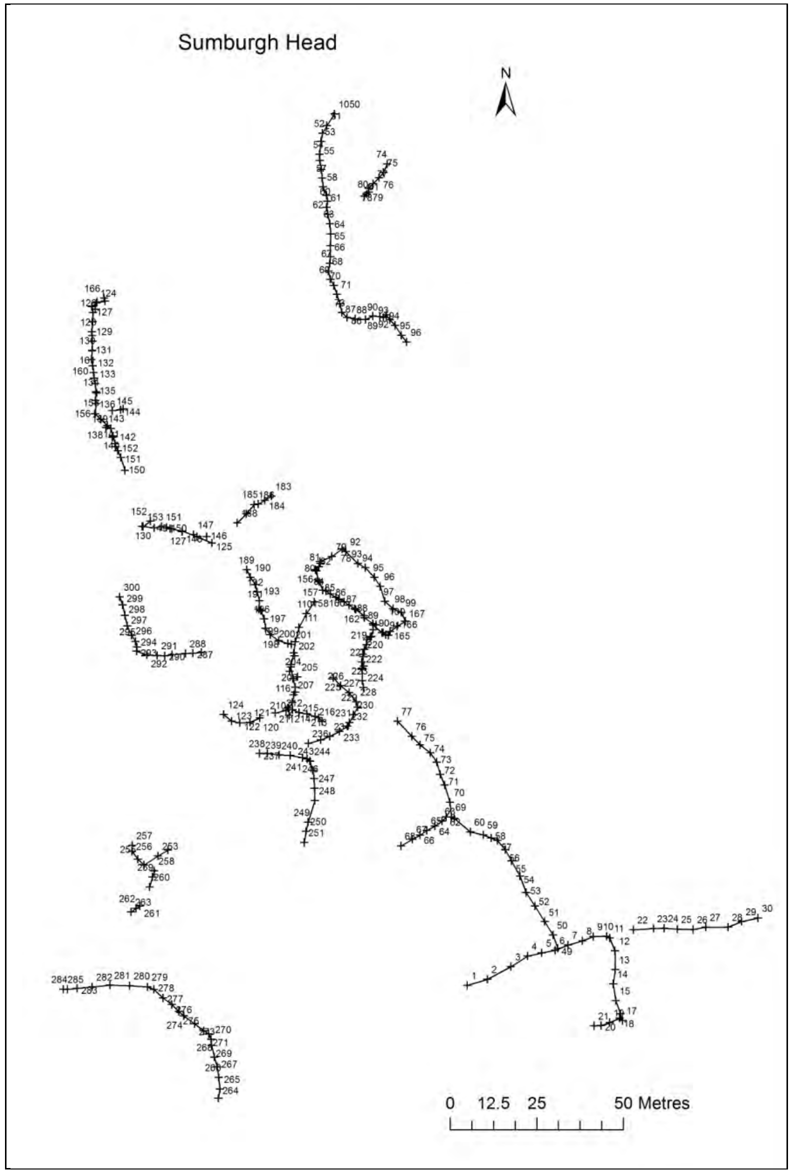
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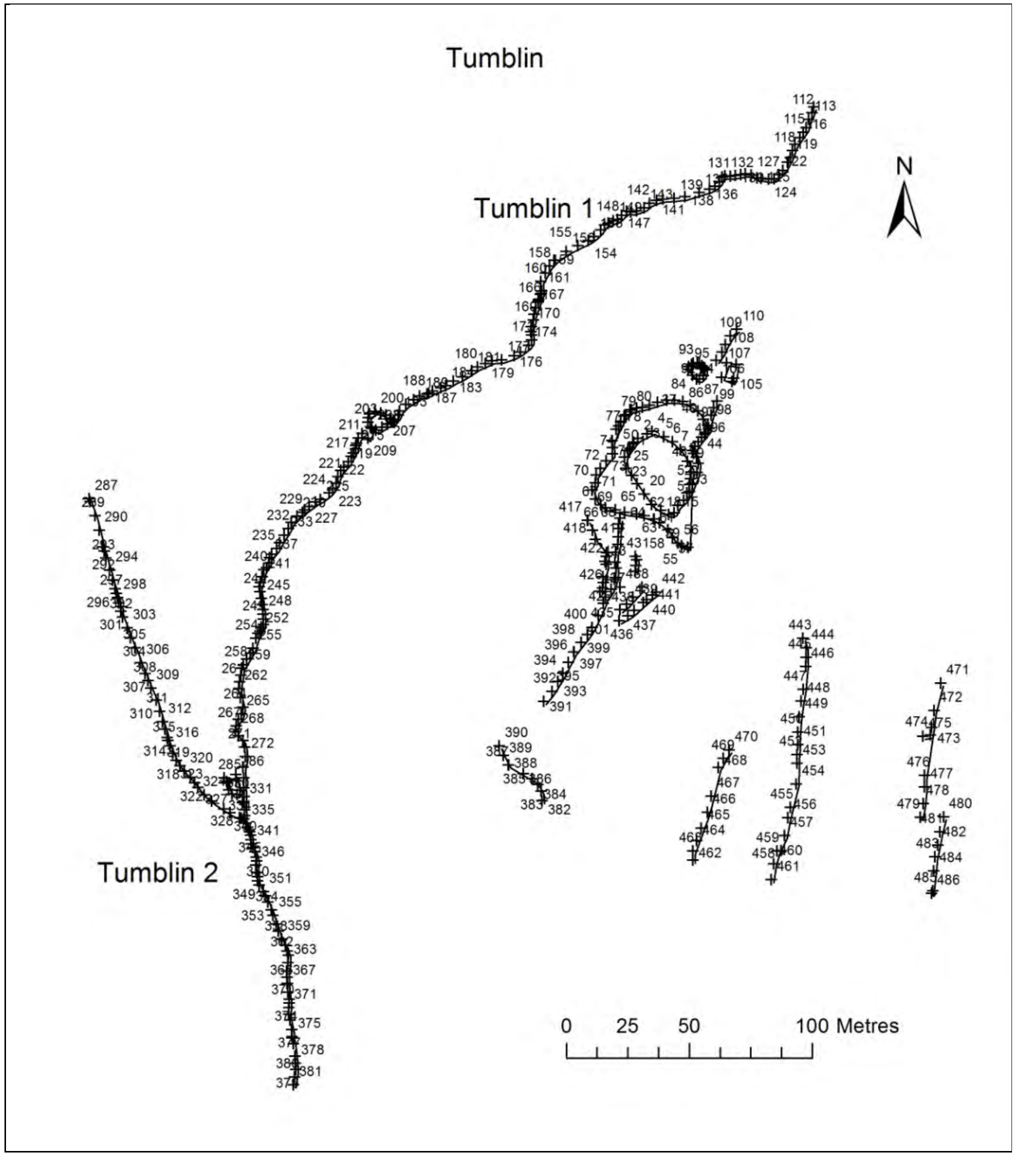
Tumblin
Tumblin 1
Tumblin 2
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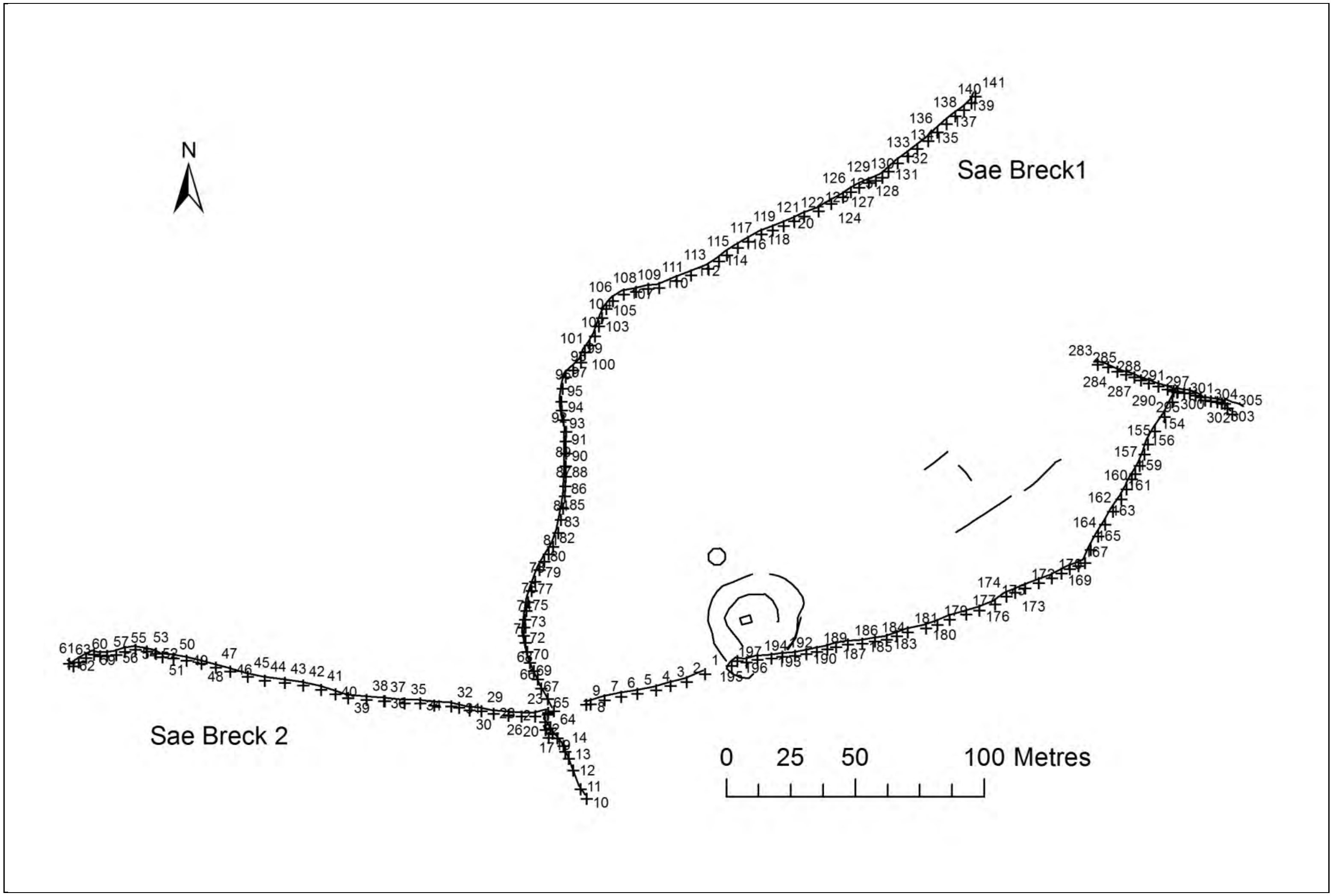
N
Sae Breck1
Sae Breck 2
0 25 50 100 Metres


Belmont
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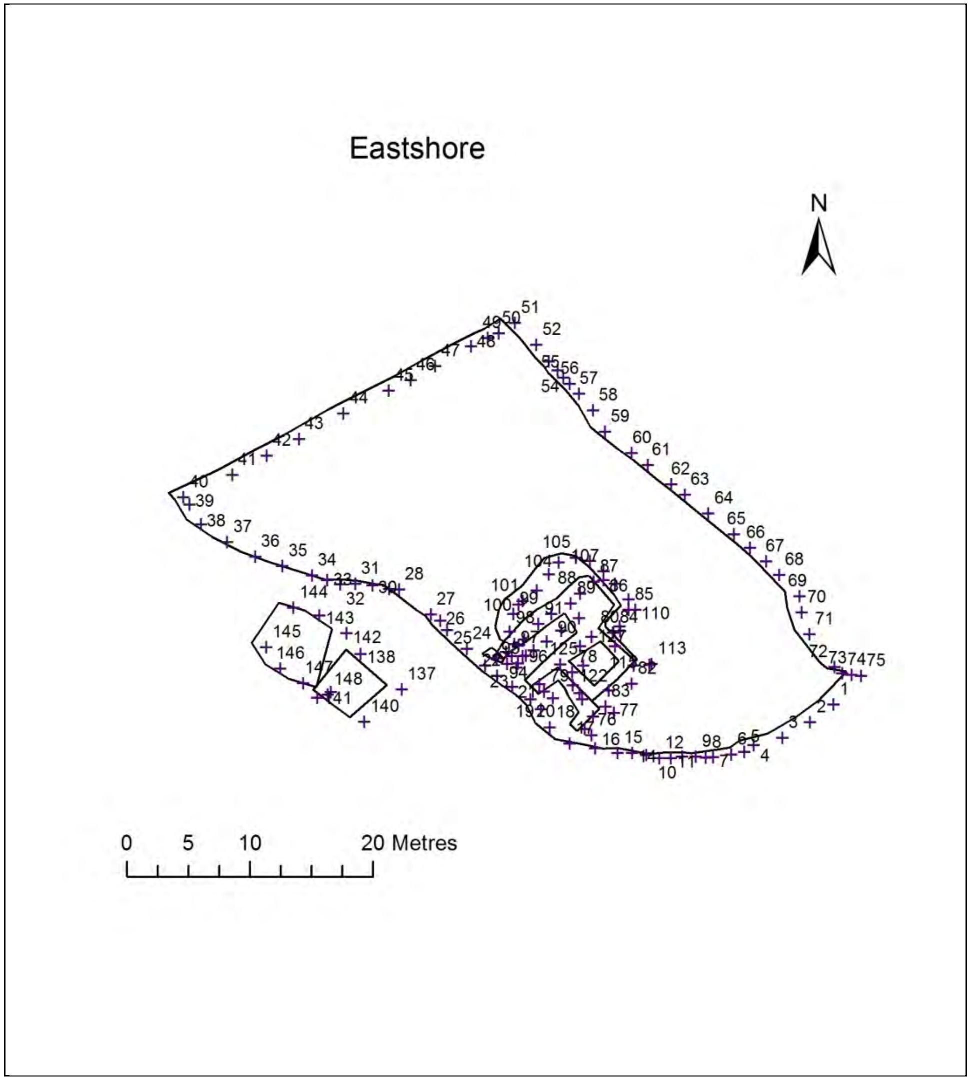
25
50
100 Meters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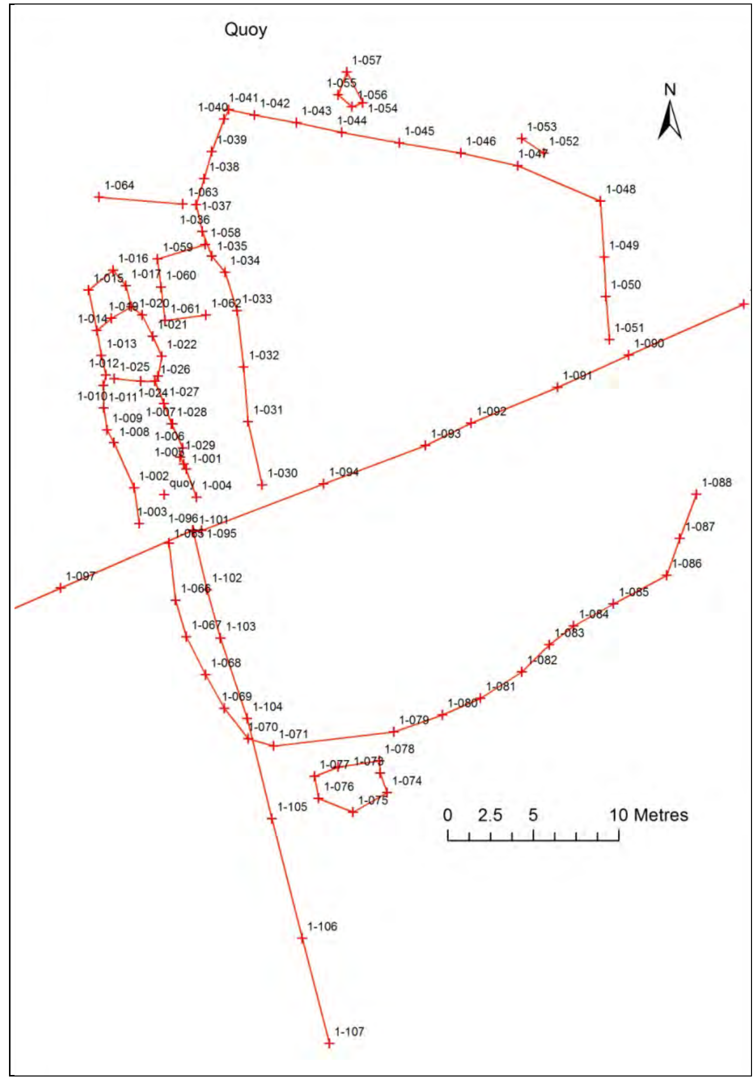
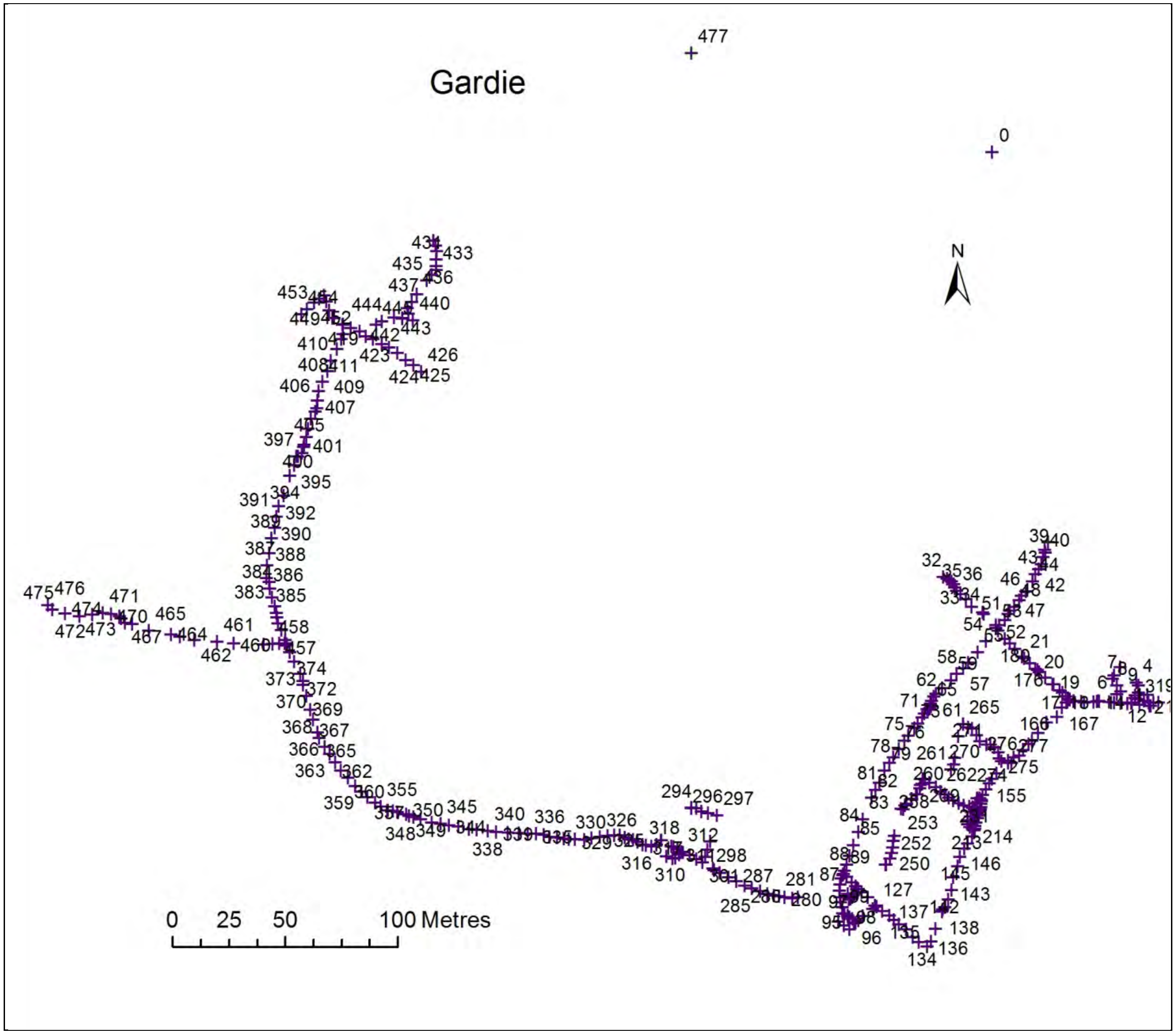
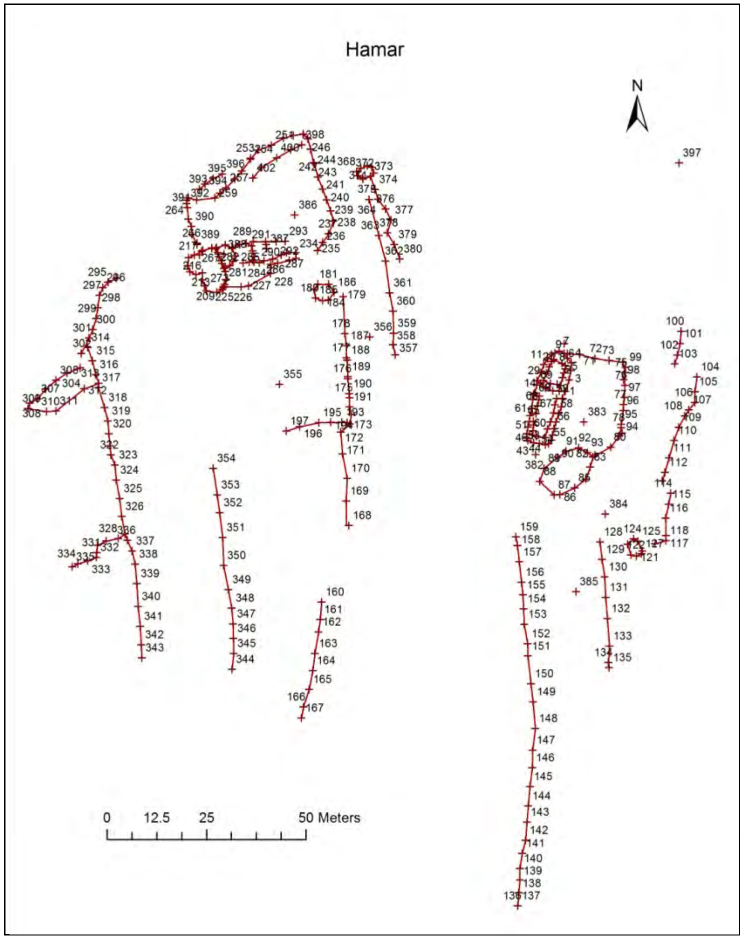
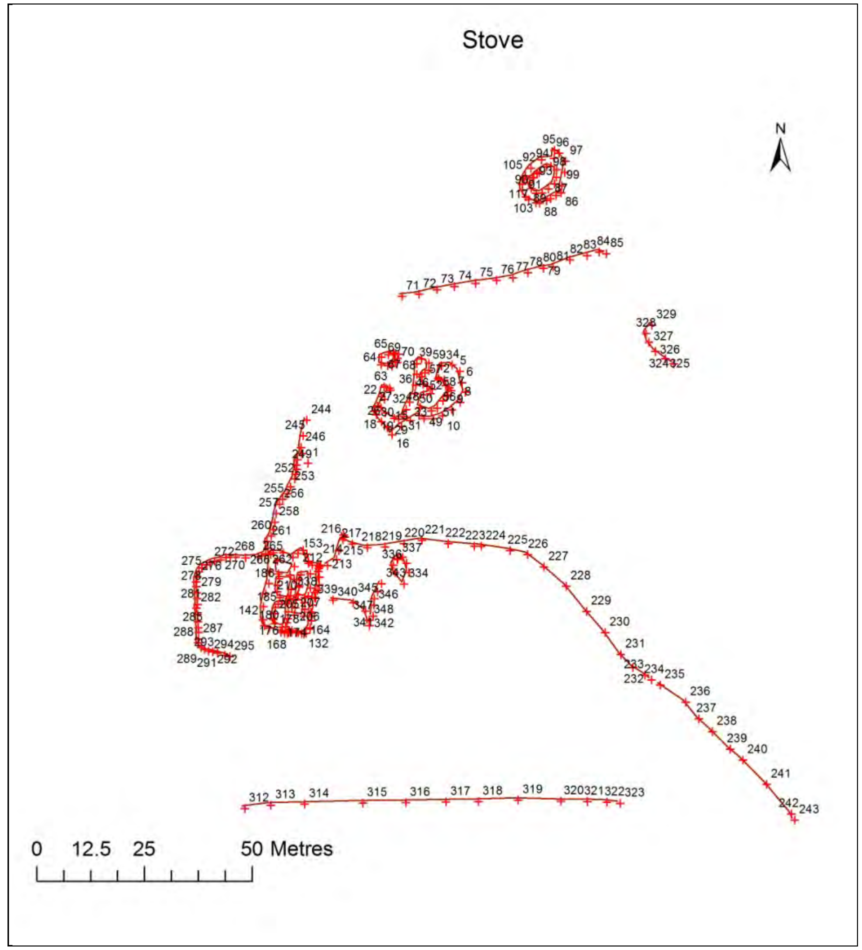
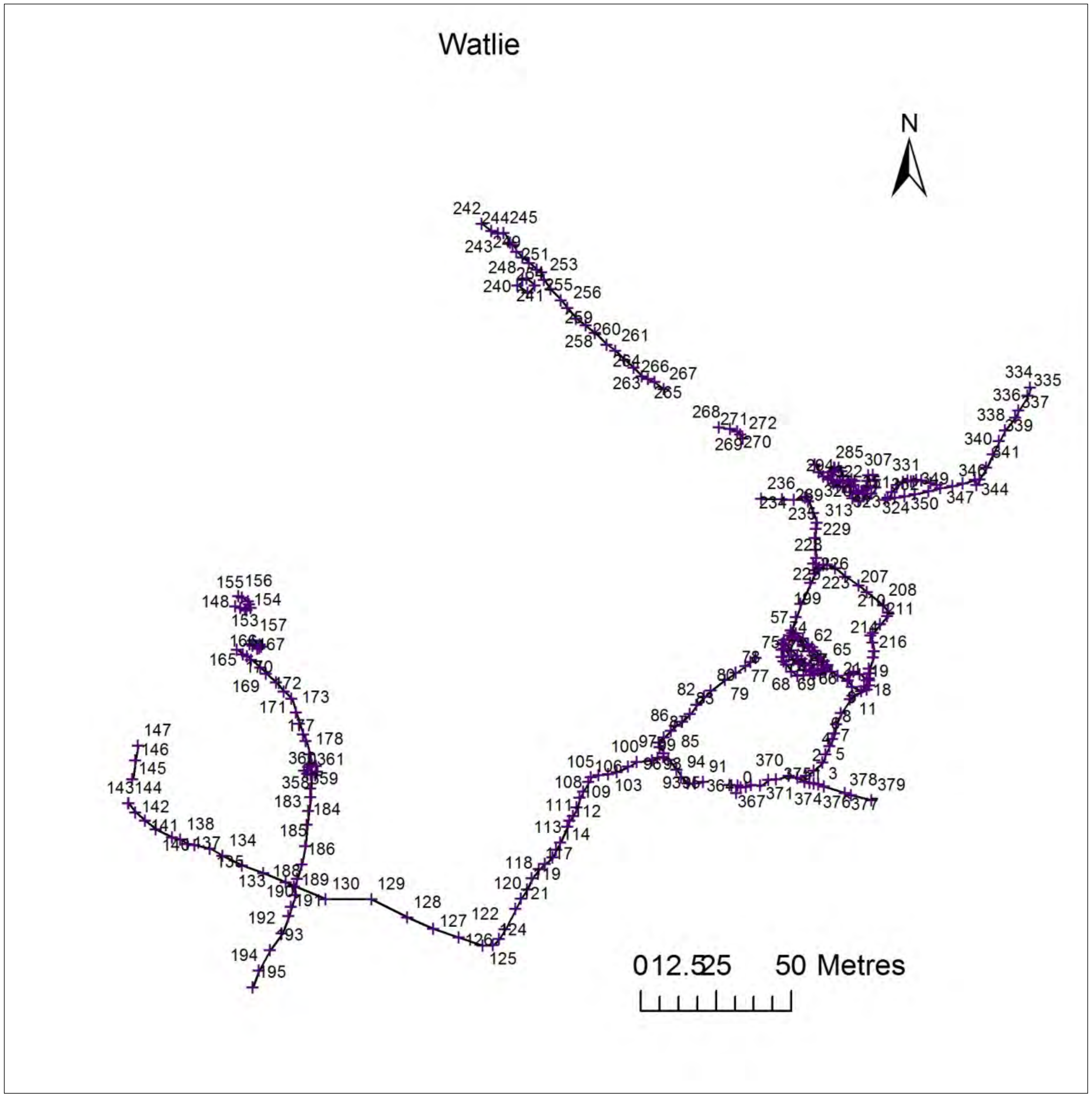

Quoy
N
0 2.5 5 10 Metres


Gardie
N
0 25 50 100 Metres


Hamar
N
0 12.5 25 50 Meters


Stove
N
0 12.5 25 50 Metres


Watlie
N
012.525 50 Metres

Appendix C: Survey Data

Appendix C.1 Croag Lea Homestead Enclosure

POINT_ID	EASTINGS	NORTHINGS	HEIGHT	TYPE	SLOPE	F HT IN	F HT OUT	ST SIZE	MIN ST	All max	MAX ST	ST DENSE	face	dir face	WIDTH	width
1	433821.309	1149740.379	40.310	D	45	C	C	A	0.30	0.30		C	T		0.6	B
2	433822.550	1149741.875	40.090	D	45	C	C	A	0.30	0.30		C	T		0.6	B
3	433824.054	1149743.623	39.882	D	45	C	C	A	0.30	0.30		C	T		0.6	B
4	433825.822	1149745.451	39.520	D	45	C	C	A	0.30	0.70	0.70	C	T	N	0.6	B
5	433827.828	1149746.795	39.338	D	45	C	C	A	0.30	0.30		C	T	N	0.6	B
6	433830.019	1149747.916	39.121	D	45	C	C	A	0.30	0.30		C	T	N	0.6	B
7	433831.944	1149748.242	39.063	D	45	C	C	A	0.30	0.30		C	T	N	0.6	B
8	433834.123	1149748.267	39.043	D	45	B	B	A	0.30	0.30		N	Q		0.6	B
9	433836.287	1149748.613	38.909	D	45	B	B	A	0.30	0.30		N	Q		0.6	B
10	433837.445	1149748.688	38.863	D	45	B	B	A	0.30	0.30		N	Q		0.6	B
11	433839.238	1149748.715	38.668	B	45	B	B	B	0.20	0.40	0.40	D	Q		0.9	B
12	433841.185	1149747.867	38.788	B	45	B	B	B	0.20	0.40	0.40	D	Q		0.9	B
13	433842.950	1149747.143	38.796	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
14	433844.775	1149746.542	38.626	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
15	433846.378	1149745.889	38.626	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
16	433848.158	1149744.940	38.592	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
17	433850.870	1149742.721	38.662	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
18	433851.785	1149741.760	38.681	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
19	433853.057	1149740.917	38.696	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
20	433854.189	1149739.666	38.785	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
21	433855.688	1149738.070	38.829	B	45	B	B	B	0.20	0.20		D	Q		0.9	B
22	433857.526	1149736.672	38.888	B	45	Z	B	B	0.20	0.20		D	Q			
23	433859.174	1149734.970	38.977	B	45	Z	C	E	0.80	0.80		D	T	NE	1.1	C
24	433861.331	1149732.731	39.052	B	45	Z	C	D	0.50	0.50		D	T	NE	1.1	C
25	433862.531	1149730.064	39.112	B	45	Z	C	Z	0.00	0.00		D	T	NE	1.1	C
26	433863.425	1149726.865	39.241	B	45	Z	C	D	0.60	0.60		D	T	NE	1.1	C

27	433863.723	1149724.124	39.203	B	45	Z	C	D	0.60	0.60		D	T	NE	1.1	C
28	433863.636	1149721.733	39.321	B	45	Z	C	C	0.40	0.50	0.50	C	Q		1	B
29	433863.392	1149719.967	39.378	D		Z		E	0.80	0.80		C	Q		1	B
30	433863.272	1149717.518	39.367	D		Z		C	0.40	0.50	0.50	C	Q		1	B
31	433863.110	1149716.745	39.544	D		Z		C	0.40	0.50	0.50	C	Q		1	B
32	433862.512	1149714.263	39.703	D		Z		C	0.40	0.50	0.50	C	Q			
33	433862.081	1149712.440	39.795	Y	0	Z		C	0.40	0.50	0.50	D	Q		0.5	A
34	433861.480	1149709.605	39.860	Y	0	Z		C	0.40	0.50	0.50	D	Q		0.5	A
35	433860.372	1149706.520	39.865	Y	0	Z		C	0.40	0.50	0.50	D	Q		0.5	A
36	433859.778	1149703.725	39.873	Y	0	Z		C	0.40	0.50	0.50	D	Q		0.5	A
37	433859.189	1149700.957	40.013	Y	0	Z		C	0.40	0.50	0.50	D	Q		0.5	A
38	433858.016	1149698.821	40.110	Y	0	Z		C	0.40	0.70	0.70	D	Q		0.5	A
39	433856.640	1149697.262	40.244	B	45	B	B	C	0.40	0.50	0.50	D	Q		0.6	B
40	433853.734	1149694.363	40.283	B	45	B	B	C	0.40	0.50	0.50	D	Q		0.6	B
41	433852.365	1149692.813	40.315	B	45	B	B	F	1.00	1.00		D	Q		0.6	B
42	433851.452	1149691.939	40.256	D	0	B	B	F	1.10	1.10	0.40	D	T	SE	0.5	A
43	433849.721	1149690.017	40.271	D	90	Z	B	C	0.30	0.40	0.40	D	T	SE	0.5	A
44	433848.723	1149688.487	40.246	D	90	Z	B		0.00	0.00		D	T	SE	0.5	A
45	433846.837	1149686.520	40.183	D	90	Z	B		0.00	0.00		D	Q		0.5	A
46	433845.065	1149684.428	40.280		90	Z	Z		0.00	0.00		D	Q		0.5	A
47	433843.202	1149682.652	40.259		0	Z	Z					D	Q		0.5	A
48	433841.340	1149680.680	40.235		0	Z	Z	D	0.50	0.50		D	Q		0.5	A
49	433839.540	1149678.895	40.254	D	0	Z	Z	D	0.50	0.50		D	Q		0.5	A
50	433838.108	1149677.588	40.264	D	90	Z	Z	D	0.50	0.50		D	Q		0.5	A
51	433836.915	1149676.253	40.248	D	90	Z	Z	D	0.50	0.50		D	Q		0.5	A
52	433836.005	1149675.512	40.193	D	90	Z	Z	D	0.50	0.50		D	Q		0.5	A
53	433834.367	1149674.361	40.238	D				D	0.60	0.60		C	N	N	0.8	B
54	433832.388	1149673.635	40.147	D	45	C		D	0.60	0.60		C	N	N	1.2	C
55	433829.897	1149672.696	40.300	D	45	C		D	0.60	0.60		C	N	N	1.2	C

56	433827.881	1149672.681	40.386	D	45	C		B	0.20	0.30	0.30	C	N	N	1	B
57	433825.085	1149673.164	40.292	D	45	C		D	0.50	0.50		D	N	N	0.8	B
58	433823.330	1149673.257	40.160	D	45	C		C	0.40	0.40		D	N	N	0.8	B
59	433820.730	1149673.810	40.175	D	45	C		B	0.30	0.30		D	N	N	0.8	B
60	433818.899	1149674.231	40.138	D	45	C	B	B	0.30	0.30		D	N	N	0.8	B
61	433818.819	1149674.353	40.129	B	45	C	B	B	0.30	0.30		D	N	N	0.8	B
62	433816.494	1149674.711	40.085	B	45	C	B	B	0.30	0.30		D	N	N	0.8	B
63	433814.617	1149675.299	39.978	B	45	C	B	B	0.30	0.30		D	N	N	0.8	B
64	433811.868	1149676.013	39.743	B	45	C	B	B	0.30	0.30		D	N	N	0.8	B
65	433810.817	1149679.173	39.984	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
66	433809.074	1149680.563	39.948	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
67	433807.909	1149682.000	40.004	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
68	433805.457	1149684.782	39.965	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
69	433803.963	1149686.989	39.982	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
70	433803.423	1149688.020	39.912	B	45	B	C		0.00	0.00		N	T	SW	1.2	C
71	433803.233	1149689.445	39.925	D	90	C	Z	B	0.30	0.70	0.70	D	T	SW	0.7	B
72	433802.588	1149691.895	40.227	D	90	C	Z	B	0.30	0.70	0.70	D	T	SW	0.7	B
73	433802.854	1149693.719	40.338	B	45	C	Z		0.00	0.00		N	T	W	1.2	C
74	433802.497	1149696.612	40.558	B	45	C	Z		0.00	0.00		N	T	W	1.2	C
75	433802.329	1149698.827	40.702	D	45	C	Z	D	0.60	0.60		C	T	W	0.8	A
76	433802.391	1149700.264	40.804	D	45	C	Z	E	0.75	0.75		C	T	W	0.8	A
77	433802.954	1149702.568	41.003	D	45	C	Z	D	0.60	0.60		C	T	W	0.8	A
78	433803.992	1149704.471	41.189	B	45	Z	B	C	0.40	0.40		D	N	E	0.8	A
79	433806.663	1149707.323	41.466	B	45	Z	B	C	0.40	0.40		D	N	E	0.8	A
80	433807.212	1149708.007	41.510	D	90	D	Z	C	0.40	0.50	0.50	D	N	E		
81	433819.958	1149737.711	41.042	D	90	D	Z	C	0.40	0.50	0.50	D	N	E		
82	433820.473	1149739.388	40.723	D	90	D	Z	C	0.40	0.50	0.50	D	N	E		
83	433821.506	1149740.674	40.285	D	90	C	Z	C	0.40	0.50	0.50	D	N	E		
84	433814.275	1149721.030	42.363					D	0.60	0.60		D				

85	433815.522	1149721.875	42.372		D	0.60	0.60	D
86	433817.439	1149722.704	42.249		D	0.60	0.60	D
87	433818.357	1149722.847	41.992		D	0.60	0.60	D
180	433838.967	1149715.760	40.514					
181	433839.350	1149716.765	40.517	O	G			
182	433839.788	1149716.090	40.464		G			
183	433841.886	1149700.372	40.267	O	F			
184	433841.173	1149700.916	40.309		F			
185	433840.803	1149700.750	40.295		F			
186	433840.717	1149699.878	40.340		F			
187	433841.202	1149699.725	40.370		F			
188	433841.795	1149699.737	40.266	S	F			
189	433866.353	1149659.723	41.024		F			
190	433866.774	1149658.983	41.046		F			
191	433866.023	1149658.146	41.130		F			
192	433865.203	1149658.322	41.128		F			
193	433865.116	1149658.909	41.173		F			
194	433866.739	1149657.488	41.146		F			
195	433866.714	1149656.957	41.076					
196	433868.061	1149656.598	41.017					
197	433868.507	1149657.377	41.085					
198	433867.832	1149657.644	41.229					
199	433866.853	1149657.621	41.147					
200	433871.218	1149656.309	41.093					
201	433871.720	1149657.870	41.031					
202	433872.449	1149657.033	41.144					
203	433872.355	1149656.412	41.302					
204	433872.294	1149659.528	41.018					
205	433871.136	1149659.401	41.058					

206	433871.037	1149660.292	41.103	
207	433871.520	1149660.812	41.054	
208	433872.118	1149660.763	40.961	
209	433872.592	1149660.211	40.987	
210	433804.277	1149723.117	44.079	M
211	433804.527	1149724.786	44.184	
212	433805.884	1149725.737	44.170	
213	433807.278	1149725.605	44.228	
214	433808.437	1149723.763	44.090	
215	433807.487	1149722.268	44.127	
216	433805.405	1149722.401	44.168	
217	433804.502	1149722.737	44.069	
ref	433805.320	1149728.207	44.039	

Appendix C.2 Exnaboe Homestead Enclosure

POINT_ID	EASTINGS	NORTHINGS	HEIGHT	TYPE	SLOPE	F HT IN	F HT OUT	ST SIZE	MIN ST	MAX ST	ST DENSE	DIR FACE	FACE	WIDTH	width
1	440354.227	1111782.314	26.870	B	33	C	B		0.00		N	E	N	3	F
2	440356.431	1111785.376	26.871	B	33	C	B		0.00		N	E	N	3	F
3	440358.017	1111789.588	26.728	B	45	C	B		0.00		N	E	N	1.25	C
4	440358.410	1111792.001	26.802	B	45	C	B		0.00		N	E	N	1.25	C
5	440360.020	1111794.377	26.809	B	45	C	B		0.00		N	E	N	1.25	C
6	440363.179	1111797.084	26.813	B	33	C	C		0.00		N		Q	2.5	E
7	440365.406	1111798.484	26.730	B	33	C	C		0.00		N		Q	2.5	E
8	440368.988	1111799.671	26.543	B	33	C	C		0.00		N		Q	2.5	E
9	440372.017	1111800.304	26.330	B	33	C	B		0.00		N	S	N	3	F
10	440376.167	1111799.711	26.090	B	33	B	B		0.00		N		Q	3	F
11	440378.644	1111799.058	25.857	B	33	B	B		0.00		N		Q	3	F
12	440381.587	1111798.622	25.742	B	45	B	B		0.00		N		Q	2	D
13	440385.051	1111796.941	25.572	B	33	C	C		0.00		N		Q	2	D
14	440387.814	1111795.396	25.330	B	33	C	C		0.00		N		Q	2	D
15	440389.930	1111793.643	25.095	B	33	C	A		0.00		N	SW	N	1.5	C
16	440391.943	1111792.135	24.757	B	33	C	A		0.00		N	SW	N	1.5	C
17	440394.328	1111789.691	24.180	B	33	B	A		0.00		N	SW	N	2	D
18	440396.593	1111787.553	23.775	B	33	A	A		0.00		N		Q	2	D
19	440398.400	1111784.975	23.330	B	0	Z	Z		0.00		N		Q	0	
20	440401.174	1111782.656	22.944	B	33	A	C	S	0.20		L	E	T	1	B
21	440401.720	1111781.563	22.967	B	33	C	A		0.00		N	W	N	2	B
22	440401.721	1111780.580	22.902	B	33	C	A		0.00		N	W	N	2	B
23	440400.019	1111778.144	22.940	B	33	C	B		0.00		N	W	N	2	B
24	440397.667	1111774.830	23.084	B	33	C	B		0.00		N	W	N	2	B
25	440395.950	1111772.269	23.046	B	33	C	B		0.00		N	W	N	2	B
26	440394.067	1111768.986	23.026	B	33	C	C		0.00		N		Q	2.5	D
27	440392.581	1111766.073	23.186	B	33	C	B		0.00		N	W	N	2	B

28	440390.915	1111763.067	23.155	B	45	C	B		0.00	N	W	N	1.25	C
29	440389.334	1111760.788	23.127	B	45	C	B		0.00	N	W	N	1.25	C
30	440386.078	1111758.675	23.231	B	45	C	B	S	0.20	L	NW	N	1.25	C
31	440382.161	1111755.988	23.319	B	33	B	A		0.00	N	NW	N	1.25	C
32	440378.183	1111753.408	23.560	B	33	B	B		0.00	N		Q	1.25	C
33	440374.514	1111751.555	23.816	B	33	B	A		0.00	N	N	N	1.25	C
34	440372.022	1111750.159	23.830	B	33	C	A	S	0.20	L	N	N	1.25	C
35	440371.009	1111749.938	23.872	B	33	C	A		0.00	N	N	N	1.25	C
36	440367.014	1111748.305	23.933	B	33	C	Z		0.00	N	N	N	1.25	C
37	440363.381	1111748.823	24.166	B	33	C	Z		0.00	N	N	N	0.9	B
38	440360.176	1111749.541	24.362	B	33	B	Z		0.00	N	N	N	0.9	B
39	440357.946	1111751.357	24.501	B	33	A	A		0.00	N		Q	0.9	B
40	440355.013	1111754.679	24.859	B	33	A	A		0.00	N		Q	0.9	B
41	440352.812	1111757.876	25.384	B	33	A	A		0.00	N		Q	0.9	B
42	440351.985	1111760.618	25.669	B	33	A	A		0.00	N		Q	0.9	B
43	440351.405	1111764.271	25.987	B	33	A	B		0.00	N	W	T	2	D
44	440350.562	1111768.911	26.364	B	33	B	C		0.00	N	W	T	2	D
45	440350.622	1111773.579	26.675	B	33	A	C		0.00	N	W	T	2	D
46	440352.011	1111777.353	26.895	B	33	B	D		0.00	N	W	T	4	I
47	440354.401	1111782.134	26.891	B	33	B	D		0.00	N	W	T	4	I
48	440365.280	1111778.962	25.919	B	33	B	D		0.00	N			5	J

Appendix C.3 Hill of the Taing Homestead Enclosure

POINT_ID	EASTINGS	NORTHINGS	HEIGHT	Type	Slope	F Ht In	F Ht Out	St Size	Min St	All Max	Max St	Dense	Dir face	Face	Width no	Width
1	446327.765	1151628.920	22.744	D	0.00	0.00	0.00	L	0.00	0.00	0.00	D	0.00			
2	446330.100	1151629.202	22.761	D				L				D				
3	446332.496	1151628.925	22.669	D				L				D				
4	446336.400	1151631.213	22.922	D				L				D				
5	446340.812	1151633.093	23.377	D				L				D				
6	446340.762	1151634.565	23.701	D				L				D				
53	446108.577	1151614.444	37.607	D	90.00	Z	Z	L	0.60	0.60		C				
54	446109.425	1151614.586	37.435	D	90.00	Z	Z	L	0.60	0.60		C				
55	446109.547	1151616.192	37.616	D	90.00	Z	Z	L	0.60	0.60		C				
56	446109.219	1151616.536	37.690	D	90.00	Z	Z	L	0.60	0.60		C				
57	446108.402	1151616.541	37.877	D	90.00	Z	Z	L	0.60	0.60		C				
58	446092.818	1151622.132	39.086	D	90.00	Z	Z	L	0.60	0.60		C			0.75	B
59	446091.326	1151621.114	39.083	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
60	446089.942	1151620.223	38.938	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
61	446088.394	1151618.634	38.790	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
62	446087.721	1151616.999	38.563	D	90.00	Z	Z	L	0.50	0.90	0.90	C			1.00	B
63	446087.206	1151615.981	38.553	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
64	446086.337	1151615.052	38.413	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
65	446085.925	1151612.804	38.063	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
66	446085.685	1151610.661	37.771	D	90.00	Z	Z	L	0.50	0.90	0.90	C			0.75	B
67	446085.465	1151608.041	37.324	D		Z	C					N			1.75	D
68	446085.025	1151607.570	37.304	D		Z	C					N			1.75	D
69	446084.440	1151604.694	37.076	D		Z	C					N			1.75	D
70	446096.844	1151589.639	35.318	B		B	C	M	0.30	0.30		L	T	S	0.75	B
71	446094.871	1151589.818	35.519	B		B	B	M	0.30	0.30		L	Q			
72	446091.629	1151591.132	35.747	B		B	B	M	0.30	0.30		N	Q			
73	446089.024	1151594.485	35.975	B		A	B					N	T	SW	1.00	B

74	446086.729	1151596.299	36.272	B	A	B					N	T	SW	1.00	B
75	446085.345	1151598.166	36.383	B	A	B					N	T	SW	1.00	B
76	446084.803	1151599.160	36.539	B	A	B					N	T	W	1.00	B
77	446084.558	1151601.746	36.743	B	A	B					N	T	W	1.00	B
78	446084.416	1151604.529	37.065	B	A	B					N	T	W	1.00	B
79	446096.857	1151589.577	35.300	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
80	446098.106	1151590.182	35.270	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
81	446099.639	1151591.351	35.640	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
82	446100.734	1151592.051	35.705	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
83	446102.031	1151594.119	36.176	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
84	446103.070	1151595.614	36.469	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
85	446105.361	1151596.853	36.584	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
86	446107.203	1151597.739	36.677	Y	Z	Z	M	0.40	0.50	0.50	D			0.50	A
87	446109.517	1151598.244	36.481	Y	Z	Z	M	0.40	0.50	0.50	C			0.40	A
88	446111.456	1151598.376	36.562	Y	Z	Z	M	0.40	0.50	0.50	C			0.40	A
89	446112.718	1151598.187	36.231	Y	Z	Z	M	0.40	0.50	0.50	C			0.40	A
90	446113.288	1151598.155	36.179	Y	Z	Z	L	0.50	0.50	0.50	D				
91	446115.758	1151597.207	35.869	Y	Z	Z	L	0.50	0.50	0.50	D				
92	446118.615	1151596.204	35.038	Y	Z	Z	L				N				
93	446119.899	1151596.254	34.496	Y	Z	Z	L				N				
94	446122.033	1151595.370	34.137	D	Z	Z	L	0.50	0.50	0.50	C			0.40	A
95	446124.606	1151594.626	33.775	D	Z	Z	L	0.50	0.50	0.50	C			0.40	A
96	446127.146	1151592.880	32.809	Y	Z	Z	S	0.20	0.30	0.30	L				
97	446129.501	1151591.949	32.460	Y	Z	Z	S	0.20	0.30	0.30	L				
98	446130.921	1151592.432	32.416	Y	Z	Z	S	0.20	0.30	0.30	L				
99	446131.972	1151592.357	32.261	Y	Z	Z	S	0.20	0.30	0.30	L				
100	446132.810	1151592.502	32.128	Y	Z	Z	S	0.20	0.30	0.30	L				
101	446134.113	1151593.420	32.033	Y	Z	Z	S				L				
102	446134.999	1151595.027	32.133	O	Z	Z					O				

103	446137.075	1151597.866	31.544	Y		Z	Z	M	0.40	0.50	0.50	O				
104	446138.139	1151599.895	31.672	Y		Z	Z	S	0.20	0.20		D			0.60	B
105	446139.756	1151601.635	31.576	Y		Z	Z	M	0.40	0.50	0.50	D			0.60	B
106	446140.558	1151603.474	31.681	D	33.00	Z	C	X	0.20	0.75	0.75	C	T	E	1.10	C
107	446140.382	1151604.873	31.898	D	33.00	Z	C	M	0.40	0.40		C	T	E	1.00	B
108	446141.671	1151606.451	31.763	Y	33.00	Z	D	M	0.40	0.50	0.50	D	T	E	1.20	C
109	446141.940	1151606.808	31.772	Y	33.00	Z	C	M	0.30	0.30		D	T	E		
110	446142.302	1151607.516	31.948	Y	33.00	Z	C	M	0.40	0.75	0.75	D	T	E		
111	446143.206	1151609.603	32.079	Y		Z	B	S	0.20	0.20		D	T	E		
112	446144.187	1151611.821	32.160	Y		Z	Z	M	0.30	0.40	0.40	D				
113	446143.202	1151613.019	32.522			Z	Z	M	0.30	0.40	0.40					
114	446142.756	1151613.886	32.615			Z	Z	M	0.30	0.40	0.40					
115	446143.304	1151615.207	32.739			Z	Z	M	0.30	0.40	0.40					
116	446144.187	1151616.618	32.866			Z	Z	M	0.30	0.40	0.40	D				
117	446145.730	1151616.822	32.691			Z	Z	M	0.30	0.40	0.40	D				
118	446146.862	1151615.660	32.300			Z	Z	M	0.30	0.40	0.40					
119	446147.725	1151613.732	31.956			Z	Z	M	0.30	0.40	0.40					
120	446147.301	1151612.736	31.812			Z	Z	M	0.30	0.40	0.40					
121	446145.905	1151612.334	31.947			Z	Z	M	0.30	0.40	0.40					
122	446144.602	1151611.872	32.181			Z	Z	M	0.30	0.40	0.40					
123	446144.695	1151611.825	32.165			Z	Z	M	0.30	0.30					0.50	A
124	446144.187	1151613.343	32.443	Y		Z	Z	M	0.30	0.30		D			0.50	A
125	446144.201	1151614.384	32.571	Y		Z	Z	M	0.30	0.30		D			0.50	A
126	446144.302	1151616.294	32.812	Y		Z	Z	S	0.20	0.20		D			1.10	C
127	446144.720	1151617.726	32.958	Y				M	0.30	0.30		D			1.10	C
128	446145.249	1151619.647	33.205	Y				M	0.30	0.30		D			1.10	C
129	446144.920	1151620.928	33.617	Y				L	0.50	0.50		D			1.10	C
130	446144.323	1151622.413	34.355	D	33.00	D	C	M	0.20	0.40	0.40	C	N	S	1.40	C
131	446143.000	1151622.924	34.523	D	33.00	D	C	M	0.20	0.40	0.40	C	N	S	2.00	D

132	446142.939	1151622.854	34.522	D	33.00	D	B	M	0.20	0.40	0.40	C	N	S	1.00	B
133	446141.296	1151623.202	34.671	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	0.70	B
134	446139.481	1151623.850	35.039	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	0.70	B
135	446137.773	1151624.579	35.341	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	0.70	B
136	446136.637	1151625.139	35.745	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	0.70	B
137	446134.490	1151624.976	35.846	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	0.70	B
138	446132.345	1151625.148	36.124	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	1.00	B
139	446129.492	1151627.169	37.269	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	1.60	D
140	446127.131	1151627.486	37.440	L	33.00	C	Z	M	0.20	0.50	0.50	D	N	S	1.30	C
141	446124.902	1151627.507	37.722	L	33.00	D	Z	M	0.20	0.50	0.50	D	N	S	1.00	B
142	446123.092	1151627.761	38.061	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
143	446120.931	1151627.801	38.293	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
144	446119.740	1151628.112	38.418	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
145	446117.751	1151628.318	38.684	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
146	446114.570	1151628.670	38.971	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
147	446111.849	1151628.922	39.449	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
148	446109.635	1151628.303	39.377	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
149	446107.506	1151628.114	39.612	L	33.00	D	Z	M	0.20	0.40	0.40	D	N	S	1.00	B
150	446105.353	1151627.146	39.675	L	90.00	C	Z	M	0.20	0.40	0.40	N	N	S	0.50	A
151	446102.750	1151626.480	39.873	L				M	0.20	0.40	0.40	N				
152	446100.267	1151625.554	39.794	L				M	0.20	0.40	0.40	N				
153	446098.560	1151625.005	39.661	L				M	0.20	0.40	0.40	N				
154	446096.188	1151624.182	39.259	L				M	0.20	0.40	0.40	N				
155	446096.059	1151624.191	39.262	O				L	0.60	0.60		N				
156	446093.765	1151622.813	39.115	O				L	0.60	0.60		N				
157	446092.392	1151622.118	39.098	O				L	0.50	0.50		N				
158	446091.077	1151621.145	39.100					L	0.50	0.50		N				
160	446163.351	1151591.691	26.286					L	0.30	0.60	0.60	C				
161	446164.713	1151590.872	25.828					L	0.30	0.60	0.60	C				

162	446166.576	1151590.537	25.449		L	0.30	0.60	0.60	C
163	446171.898	1151590.857	24.931		L	0.30	0.60	0.60	C
164	446174.489	1151591.579	24.866		L	0.30	0.60	0.60	C
165	446176.165	1151591.225	24.533		L	0.30	0.60	0.60	C
166	446176.664	1151591.163	24.503		L	0.30	0.60	0.60	C
167	446177.128	1151592.698	24.696		L	0.30	0.60	0.60	C
168	446177.810	1151594.633	24.982		L	0.40	0.50	0.50	D
169	446179.141	1151598.222	25.593		L	0.40	0.50	0.50	D
170	446179.908	1151600.794	25.907		L	0.40	0.50	0.50	D
171	446180.914	1151603.811	26.498		L	0.40	0.80	0.80	D
172	446182.524	1151608.576	27.443		L	0.40	0.50	0.50	D
173	446183.050	1151611.435	28.101		L	0.40	0.50	0.50	D
174	446183.997	1151613.283	28.535		L	0.40	0.50	0.50	D
175	446185.137	1151615.721	28.767		L	0.40	0.50	0.50	D
176	446184.358	1151616.944	28.971		L	0.40	0.50	0.50	D
177	446184.056	1151618.449	29.363		L	0.40	0.50	0.50	D
178	446181.868	1151620.777	29.678		L	0.40	0.50	0.50	D
181	446167.034	1151614.272	29.259	D					N
182	446166.961	1151610.978	28.835						N
183	446166.982	1151609.090	28.638						N
184	446167.001	1151606.063	28.066						N
185	446166.696	1151603.648	27.732						N
186	446164.898	1151601.566	27.714						N
187	446164.021	1151600.383	27.662						N
188	446162.660	1151598.728	27.552						N
189	446161.793	1151597.201	27.307						N
190	446160.620	1151596.492	27.402						N
	446064.602	1151717.057	66.144						

Appendix C.4 Houlland Homestead Enclosure

POINT ID	EASTINGS	NORTHINGS	HEIGHT	TYPE	SLOPE	F HT IN	F HT OUT	ST SIZE	MIN ST	All max	MAX ST	ST DENSE	FACE	DIR FACE	WIDTH	width
1	446388.912	1154451.825	23.780	D		B	B	M	0.3	0.3		C	Q		1.30	C
2	446391.337	1154451.560	23.757	D		B	B	M	0.3	0.3		C	Q		1.30	C
3	446394.164	1154452.120	23.658	D		B	B	M	0.3	0.3		C	Q		1.30	C
4	446396.718	1154452.010	23.535	D		B	B	M	0.3	0.3		C	Q		1.30	C
5	446398.646	1154452.426	23.678	B		B	A	M	0.3	0.5	0.5	D	N	W		
6	446398.307	1154451.727	23.714	B		B	A	M	0.3	0.5	0.5	D	N	W		
7	446399.011	1154448.995	23.622	B		B	A	M	0.3	0.5	0.5	D	N	W		
8	446398.918	1154445.798	23.566	B		B	A	M	0.3	0.5	0.5	D	N	W		
9	446399.403	1154442.037	23.609	B		B	A	M	0.3	0.6	0.6	D	N	W		
10	446398.912	1154436.257	23.610	B		B	A	L	0.3	0.6	0.6	D	N	W		
11	446398.659	1154430.290	23.611	B		B	B	L	0.3	0.3		D	Q			
12	446398.368	1154426.296	23.820	B		B	B	M	0.3	0.3		D	Q			
13	446396.243	1154421.430	24.169	B		B	B	M	0	0		N	Q			
14	446394.191	1154417.014	24.535	B		B	B		0.3	0.3		L	Q			
15	446392.513	1154412.670	24.919	B		B	B		0.3	0.3		L	Q			
16	446391.546	1154409.030	25.159	B		B	B		0.3	0.3		L	Q			
17	446390.814	1154405.090	25.484	B		B	B		0.3	0.3		L	Q			
18	446389.915	1154401.100	25.774	B		C			0	0		N	N	W		
19	446388.400	1154396.650	26.054	B		C		L	0.3	0.6	0.6	D	N	W		
20	446386.309	1154394.414	26.250	B		C			0.3	0.5	0.5	D	N	NW		
21	446382.016	1154393.271	26.171	B		C	A	L	0.3	0.3		D	N	N	2.00	D
22	446378.793	1154395.249	26.028	B		C	A	L	0.3	0.3		D	N	N	2.00	D
23	446376.258	1154396.994	26.128	B		C	A		0.3	0.3		L	N	N	2.00	D
24	446372.964	1154397.587	26.071	B		D	A		0.3	0.3		L	N	N	2.00	D
25	446368.445	1154398.081	25.849	B	33	B	B		0.3	0.3		L	Q		2.00	D
26	446363.649	1154399.134	25.560	B	33	B	B		0.3	0.3		L	Q		2.00	D
27	446359.918	1154400.291	25.528	B	33	B	B		0.3	0.3		L	Q		2.00	D

28	446359.898	1154400.326	25.513	B	33	B	B		0.3	0.3		L	Q		2.00	D
29	446356.046	1154401.712	25.121	B	33	B	B		0.3	0.3		L	Q		2.00	D
30	446351.944	1154403.419	24.817	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
31	446348.503	1154404.823	24.685	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
32	446346.162	1154407.679	24.561	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
33	446346.017	1154412.180	24.583	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
34	446345.871	1154415.695	24.590	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
35	446345.562	1154419.537	24.607	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
36	446345.309	1154423.264	24.551	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
37	446345.574	1154426.023	24.675	B	33	B	B	M	0.3	0.3		D	Q		1.00	B
38	446345.864	1154427.723	24.651	O		B	B	X	0.3	0.3		D	Q		2.00	D
39	446347.133	1154432.185	24.629	B	33	B	B	M	0.5	0.5		D	Q		1.00	B
40	446348.661	1154436.422	24.508	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
41	446350.002	1154441.524	24.342	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
42	446352.657	1154449.089	24.252	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
43	446354.980	1154454.812	24.343	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
44	446356.816	1154460.163	24.361	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
45	446357.270	1154461.824	24.442	B	90	B	B	L	0.5	0.5		C	Q		0.75	B
46	446357.779	1154462.121	24.331	B	33	B	B	L	0.5	0.8	0.8	C	Q		0.75	B
47	446356.988	1154462.481	24.304	B	33	B	B	L	0.5	0.5		C	Q		0.75	B
48	446357.226	1154463.719	24.454	B	33	B	B	L	0.5	0.5		C	Q		0.75	B
49	446358.415	1154466.225	24.563	B	33	B	B	L	0.5	0.5		C	Q		0.75	B
50	446358.991	1154467.931	24.618	B	33	B	B	L	0.5	0.5		C			0.75	B
53	446358.459	1154470.995	24.498	S				M	0.3	0.3		D				
54	446358.207	1154471.344	24.499	S				M	0.3	0.3		D				
55	446357.910	1154471.612	24.486	S				M	0.3	0.3		D				
56	446357.652	1154471.784	24.495	S				M	0.3	0.3		D				
57	446357.235	1154471.381	24.430	S				M	0.3	0.3		D				
96	446348.595	1154435.557	24.565	B	33	C	B	S	0.2	0.4	0.4	D	N	E	1.30	C

97	446349.004	1154436.185	24.443	B	33	C	B	S	0.2	0.4	0.4	D	N	SE	1.30	C
98	446351.508	1154439.036	24.330	B	33	C	B	S	0.2	0.4	0.4	D	N	SE	1.30	C
99	446355.242	1154442.265	24.457	B	33	C	B	S	0.2	0.4	0.4	D	N	SE	1.30	C
100	446358.291	1154444.580	24.366	B	33	C	B	L	0.2	0.5	0.5	D	N	SE	1.30	C
101	446362.242	1154447.457	24.143	B	33	C	B	S	0.2	0.2		D	N	SE	1.30	C
102	446366.224	1154449.321	24.084	L	90	C	Z	M	0.3	0.3		D	N	S		
103	446369.286	1154450.219	24.121	L	90	C	Z	M	0.3	0.3		D	N	S		
104	446373.272	1154450.788	23.982	L	90	C	Z	M	0.3	0.3		D	N	S		
105	446379.452	1154451.266	23.881	L	90	C	Z	M	0.3	0.3		D	N	S		
106	446381.362	1154451.411	23.767	L	90	C	Z	M	0.3	0.3		D	N	S		
107	446383.181	1154451.691	23.874	L	90	C	Z	M	0.3	0.3		D	N	S		
108	446385.290	1154452.207	23.792	L	90	C	Z	M	0.3	0.3		D	N	S		
109	446385.782	1154452.298	23.821	L	90	C	Z	M	0.3	0.3		D	N	S		

Appendix C.5 South Newing Homestead Enclosure

Point Id	Eastings	Northings	Height	TYPE	SLOPE	F HT IN	F HT OUT	ST SIZE	MIN ST	allmax	MAX ST	ST DENSE	DIR FACE	face	WIDTH	width
1	446665.893	1155954.944	41.230	Y				L	0.2	0.6	0.6	D				
2	446664.238	1155957.704	42.179	Y				L	0.2	0.6	0.6	D				
3	446662.617	1155959.292	42.692	Y				L	0.2	0.6	0.6	D				
4	446661.199	1155961.994	43.306	D				M	0.3	0.3		C			1.00	B
5	446660.451	1155964.594	43.965	D				V	0.3	0.8	0.8	C			1.00	B
6	446660.356	1155967.670	44.322	D				V	0.3	0.5	0.5	C			1.00	B
7	446660.236	1155970.315	44.926	L	90	B	Z	V	0.3	0.8	0.8	C	N	E	1.00	B
8	446660.944	1155973.594	45.306	L	90	B	Z	V	0.3	0.6	0.6	C	N	E	1.00	B
9	446662.321	1155976.659	45.755	L	90	C	Z	V	0.4	0.6	0.6	C	N	E	1.00	B
10	446664.690	1155978.979	46.460	L	90	D	Z	V	0.4	0.4		C	N	SE	1.00	B
11	446667.244	1155979.422	46.662	L	90	D	Z	L	0.4	0.4		C	N	S	0.75	B
12	446671.434	1155978.808	46.351	L	90	D	Z	L	0.2	0.5	0.5	C	N	S	0.75	B
13	446676.510	1155977.328	45.848	L	90	D	Z	L	0.2	0.75	0.75	C	N	S	0.75	B
14	446680.443	1155976.292	45.649	L	90	D	Z	L	0.2	0.5	0.5	C	N	S	0.75	B
15	446683.853	1155975.658	45.624	L	90	D	Z	L	0.2	0.5	0.5	C	N	S	0.75	B
16	446689.596	1155974.619	45.121	L	90	D	Z	L	0.2	0.5	0.5	C	N	S	0.75	B
17	446691.860	1155973.032	44.363	L	90	D	Z	L	0.2	0.5	0.5	C	N	SW	1.50	C
18	446694.512	1155970.041	43.534	L	90	D	Z	M	0.3	0.7	0.7	C	N	SW	1.50	C
19	446696.331	1155967.525	43.051	L	90	D	Z	M	0.3	0.7	0.7	C	N	SW	1.50	C
20	446698.094	1155963.711	41.419			D	Z	X	0.2	1	1				1.50	C
21	446693.790	1155961.738	40.888			D	Z	X		1	1				1.50	C
22	446694.404	1155960.585	40.521	H												
23	446689.505	1155949.792	39.017	H												
24	446689.316	1155948.172	38.798	H												
25	446688.739	1155947.490	38.713	H												
26	446687.685	1155947.608	38.773	H												

27	446686.811	1155945.790	38.507	H												
28	446685.212	1155945.449	38.624	H												
29	446683.745	1155945.503	38.527	H												
30	446683.346	1155947.392	38.952	H												
31	446683.037	1155949.842	39.420	H												
32	446683.121	1155951.363	39.577	H												
33	446684.081	1155951.991	39.686	H												
34	446685.403	1155951.887	39.644	H												
35	446686.979	1155952.324	39.593	H												
36	446687.956	1155952.158	39.508	H												
37	446689.519	1155951.587	39.212	H												
38	446689.558	1155949.667	39.005	H												
39	446689.309	1155947.790	38.638	H												
40	446697.908	1155966.643	42.540	O		F	A	X	1.1	1.1		L	N	S		
41	446697.960	1155966.634	42.541	L	33	E	Z	L	0.6	0.6		L	N	S	1.50	C
42	446701.023	1155967.551	42.721	L	33	E	Z	L	0.6	0.6		L	N	S	1.50	C
43	446703.855	1155966.957	42.142	L	33	E	Z	L	0.6	0.6		L	N	S	1.50	C
44	446705.129	1155965.326	41.598	L	90	D	Z	M	0.4	0.4		D	N	S	0.30	A
45	446707.535	1155964.181	41.275	L	90	D	Z	M	0.4	0.4		D	N	S	0.30	A
46	446707.458	1155964.214	41.257	L	90	D	Z	M	0.4	0.4		D	N	S	0.30	A
47	446707.504	1155964.158	41.262	L	90	D	Z	M	0.4	0.4		D	N	S	0.30	A
48	446709.798	1155962.728	40.828	L	90	D	Z	M	0.4	0.4		D	N	S	0.30	A
49	446698.032	1155963.150	41.085	L	90	D	Z	M	0.4	0.4		D			0.30	A
50	446700.837	1155963.064	40.859	L	90	D	Z	M	0.4	0.4		D			0.30	A
51	446703.287	1155963.060	40.771	L	90	D	Z	M	0.4	0.4		D			0.30	A
52	446705.788	1155963.026	40.612	L	90	D	Z	M	0.4	0.4		D			0.30	A
53	446705.721	1155963.016	40.608	L	90	D	Z	M	0.4	0.4		D	O	NE	0.30	A
54	446709.722	1155962.603	40.754	B		Z		M	0.3	0.4	0.4	D	O	NE	1.30	C
55	446711.152	1155961.397	40.353	B		Z		M	0.3	0.4	0.4	D	O	NE	1.30	C

56	446712.506	1155959.202	39.636	B		Z		M	0.3	0.4	0.4	D	O	NE	1.30	C
57	446712.004	1155955.869	38.795	L	45	Z	F	M				D	O	E	1.30	C
58	446711.956	1155951.807	38.033	L	45	Z	E	M	1.1	1.1		D	O	E	1.30	C
59	446712.553	1155947.802	37.200	L	45	Z	E		1	1		L	O	E	1.30	C
60	446712.151	1155943.518	36.482	L	45	Z	E		0	0		N	O	E	1.30	C
61	446709.185	1155938.965	35.816	L	45	Z	E		0	0		N	O	E	1.30	C
62	446705.505	1155936.670	35.777	L	45	Z	E		0	0		N	O	SE	1.30	C
63	446705.501	1155936.656	35.763	L	45	Z	E		0	0		N	O	SE	1.30	C
64	446702.625	1155936.213	36.078	L	45	Z	E		0	0		N	O	S	1.30	C
65	446699.657	1155936.153	36.172	L	45	Z	E		0	0		N	O	S	1.30	C
66	446695.113	1155934.811	36.506	L	45	Z	E		0	0		N	O	S	1.30	C
67	446692.158	1155933.698	36.366	L	45	Z	E		0.4	0.4		D	O	S	1.30	C
68	446688.185	1155932.265	36.227	L	45	Z	E	M	0.3	0.4	0.4	L	O	S		
69	446685.516	1155931.766	36.313	L	45	Z	F	M	0.3	0.4	0.4	D	O	S		
70	446682.876	1155932.399	36.471	L	45	Z	F	M	0.3	0.4	0.4	D	O	S		
71	446679.750	1155934.128	36.791	L	45	Z	D	M	0.3	0.4	0.4	D	O	S		
72	446678.008	1155934.733	36.921	L	45	Z	C	L	0.2	0.6	0.6	D	O	SW		
73	446676.510	1155937.331	37.170	L	45	Z	C	M	0.3	0.4	0.4	D	O	SW		
74	446675.748	1155940.053	37.382	C												
75	446676.375	1155937.547	37.190	C												
76	446676.994	1155933.730	36.599	C												
77	446674.067	1155933.406	36.661	C												
78	446672.021	1155933.343	36.619	C												
79	446670.027	1155933.292	36.710	C												
80	446669.689	1155934.788	37.025	C												
81	446669.743	1155935.148	37.078	C												
82	446668.868	1155937.811	37.403	C												
83	446669.286	1155939.227	37.681	C												
84	446671.948	1155939.440	37.628	C												

85	446673.946	1155939.829	37.524	C						
86	446675.784	1155940.176	37.377	C						
87	446672.485	1155939.471	37.593	Y	L	0.5	0.5	D	0.30	A
88	446671.618	1155941.551	37.945	Y	L	0.5	0.5	D	0.30	A
89	446683.501	1155973.041	43.831							
90	446682.054	1155971.275	43.661							
91	446679.698	1155969.402	43.368							
92	446676.801	1155967.204	43.155							
93	446673.307	1155964.315	42.926							
94	446669.720	1155962.935	42.836							
95	446664.564	1155959.461	42.550							
96	446661.553	1155958.660	42.505							
97	446660.459	1155956.659	42.216							
98	446659.346	1155953.669	41.592							
99	446658.333	1155950.561	40.941							
100	446654.306	1155945.843	40.144							
101	446651.705	1155943.312	39.850							
102	446649.132	1155939.215	39.397							
103	446645.454	1155935.118	38.950							
104	446642.726	1155933.310	38.994							
105	446638.733	1155929.794	38.715							
106	446636.467	1155928.095	38.775							
107	446635.157	1155928.113	38.931							
108	446632.996	1155924.931	38.850							
109	446631.179	1155923.306	38.427							
110	446628.196	1155918.611	38.372							
111	446624.771	1155915.422	38.648							
112	446620.600	1155910.641	38.306							
113	446617.982	1155906.061	38.219							

114	446616.088	1155903.143	38.194
115	446615.630	1155901.658	37.841
116	446614.345	1155900.475	37.672
117	446611.440	1155896.631	38.141
118	446609.608	1155894.485	38.255
119	446610.962	1155889.055	38.033
120	446608.193	1155894.034	38.134
121	446604.760	1155893.823	38.580
122	446601.848	1155895.706	38.834
123	446605.355	1155890.725	38.528
124	446604.438	1155888.734	38.426
125	446599.872	1155887.894	39.495
126	446598.730	1155887.178	39.687
127	446594.387	1155886.073	40.392
128	446590.143	1155884.183	40.533
129	446585.473	1155879.519	40.941
130	446583.948	1155877.897	41.038
131	446711.596	1155956.443	39.128
132	446713.973	1155957.669	39.046
133	446719.088	1155958.803	38.900
134	446720.958	1155960.058	38.817
135	446722.569	1155962.861	39.422
136	446726.605	1155965.180	39.622
ref	446538.916	1155897.462	46.598

Appendix C.6 Vassa Homestead Enclosure

POINT ID	EASTINGS	NORTHINGS	HEIGHT	TYPE	SLOPE	F HT IN	F HT OUT	ST SIZE	MIN ST	allmax	MAX ST	ST DENSE	DIR FACE	face	WIDTH	width
49	446197.533	1152774.230	12.263	D	33.00	C	B	M	0.30	0.40	0.40	D	N	S	1.10	C
50	446194.465	1152773.059	11.805	D	33.00	C	B	M	0.30	0.40	0.40	D	N	S	1.10	C
51	446191.916	1152773.390	11.646	D	33.00	C	B	M	0.30	0.30		D	N	S	1.10	C
52	446189.999	1152772.155	11.185	D	33.00	C	B	M	0.30	0.60	0.60	D	N	SE	1.10	C
53	446187.057	1152769.734	10.820	D	33.00	B	A	M	0.30	0.30		C	N	SE	1.30	C
54	446182.930	1152765.756	10.021	D	33.00	B	A	M	0.30	0.30		C	N	E	1.30	C
55	446180.244	1152762.342	9.544	D	33.00	B	A	M	0.30	0.30		C	N	E	1.30	C
56	446179.139	1152760.576	9.377	D	33.00	B	A	M	0.30	0.30		C	N	E	1.30	C
57	446178.024	1152758.576	9.074	D	33.00	B	A	M	0.30	0.30		D	N	E	1.30	C
58	446176.795	1152755.752	8.925	D	33.00	B	A	M	0.30	0.30		D	N	E	1.30	C
62	446181.388	1152730.246	8.469	D		Z	Z	S	0.20	0.30	0.30	D			1.30	C
63	446183.185	1152728.027	8.931	D		Z	Z	S	0.20	0.30	0.30	D			1.30	C
64	446185.236	1152725.400	9.051	D		Z	Z	S	0.20	0.30	0.30	D			1.30	C
65	446187.881	1152721.957	9.221	L	90.00	Z	B	S	0.20	0.30	0.30	D	T	SW	1.10	C
66	446189.302	1152719.857	9.201	L	90.00	Z	B	S	0.20	0.30	0.30	D	T	S	1.10	C
67	446191.726	1152717.883	9.299	L	90.00	Z	B	S	0.20	0.30	0.30	D	T	S	1.10	C
68	446192.720	1152717.375	9.352	L	90.00	Z	B	S	0.20	0.30	0.30	D	T	S	1.10	C
69	446194.184	1152716.372	9.213	L				M	0.50	0.50		D			1.00	B
70	446195.954	1152715.249	9.367	B	33.00	B	B	M	0.50	0.50		D	Q		1.00	B
71	446198.063	1152714.507	9.357	B	33.00	C	B	S	0.20	0.40	0.40	F	N	N	1.00	B
72	446201.182	1152713.885	9.475	B	33.00	C	B	S	0.20	0.40	0.40	F	N	N	1.00	B
73	446203.887	1152714.353	9.621	B	33.00	C	B	S	0.20	0.40	0.40	F	N	N	1.00	B
74	446208.013	1152715.015	9.948	D	33.00	Z	Z	S	0.20	0.20		D			0.80	B
75	446211.182	1152716.540	10.169	D	33.00	Z	Z	S	0.20	0.20		D			0.80	B
76	446214.308	1152718.805	10.401	D	33.00	Z	Z	S	0.20	0.20		D			0.80	B
77	446217.070	1152720.652	10.640	D	33.00	Z	Z	S	0.20	0.20		D			0.80	B
78	446220.040	1152721.660	11.159	L	33.00	C	Z	S	0.20	0.20		D	N	NW	1.00	B

79	446221.808	1152723.588	11.355	L	33.00	C	Z	S	0.20	0.20		D	N	NW	1.00	B
81	446224.740	1152726.491	11.357	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
82	446226.358	1152728.749	11.604	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
83	446227.718	1152731.521	11.887	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
84	446229.095	1152735.124	12.122	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
85	446230.372	1152739.495	12.497	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
86	446230.927	1152744.362	12.786	B	33.00	B	B	S	0.20	0.20		D	Q		0.60	B
87	446231.475	1152748.848	13.142	B	33.00	B	B	S	0.20	0.60	0.60	C	Q		0.60	B
88	446230.557	1152751.888	13.193	B	33.00	B	B	M	0.40	0.40		D	Q		0.60	B
89	446229.828	1152754.534	13.363	B	33.00	B	B	M	0.30	0.30		D	Q		0.60	B

Appendix C.7 Scord of Brouster Multiple Field System

Point ID	EASTINGS	NORTHINGS	HEIGHT	Type	Slope	F HT IN	F HT OUT	Min Stone	Max Stone	Ht In	Ht Out	Min Stone	All max	Max Stone	Stone Dense	Face 2	Dir Face	Width
1	425515.026	1151577.846	40.315	L	33	D	Z	M	o	0.6	0	0.3	0.4	0.4	C	N	SE	1.10
2	425512.411	1151576.266	40.626	L	33	D	Z	M		0.6		0.3	0.4	0.4	C	N	SE	1.10
3	425508.449	1151574.936	40.596	L	33	D	Z	M		0.6		0.3	0.4	0.4	C	N	S	1.10
4	425507.435	1151574.233	40.583	L	33	D	Z	M		0.6		0.3	0.4	0.4	C	N	SE	1.10
5	425506.697	1151573.159	40.606	L	33	D	Z	M		0.6		0.3	0.4	0.4	C	N	SE	1.10
6	425505.961	1151570.957	40.494	L	33	D	Z	M		0.5		0.3	0.4	0.4	C	N	E	1.10
7	425505.965	1151568.657	40.523	L	90	C	Z	VS		0.4		0.3	0.9	0.9	C	N	E	1.10
8	425505.974	1151567.127	40.625	L	90	C	Z	M		0.4		0.3	0.4	0.4	C	N	E	0.60
9	425506.832	1151565.466	40.529	L	90	C	Z	M		0.4		0.3	0.4	0.4	C	N	E	0.60
10	425507.968	1151563.806	40.512	L	90	C	Z	M		0.4		0.3	0.4	0.4	C	N	E	0.60
11	425509.526	1151562.380	40.367	L	45	D	Z	L		0.6		0.5	0.5		C	N	E	1.60
12	425509.522	1151562.434	40.368	L	45	E	Z	M		0.8		0.3	0.3		C	N	E	1.60
13	425511.379	1151560.004	39.954	L	45	F	Z	M		1		0.4	0.4		C	N	E	1.60
14	425513.478	1151557.816	39.346	L	45	F	Z	L		1		0.5	0.5		C	N	E	1.60
15	425514.477	1151555.102	39.204	L	45	E	Z	L		0.8		0.5	0.5		C	N	E	1.60
16	425515.382	1151551.780	38.974	L	33	D	Z	L		0.6		0.5	0.5		C	N	E	1.60
17	425515.689	1151550.100	38.802	L	33	A	Z	M	L	0.1		0.4	0.4		C	N	E	1.60
18	425515.715	1151548.508	38.671	L	33	A	Z	M		0.1		0.4	0.4		C	N	E	1.60
19	425515.606	1151546.149	38.562	L	33	A	Z	M		0.1		0.4	0.4		C	N	E	1.60
20	425516.487	1151544.233	38.286	L	33	E	Z	M		0.8		0.4	0.4		C	N	E	1.60
21	425519.256	1151542.834	37.885	L	33	D	Z	M	L	0.6		0.4	0.5	0.5	C	N	NE	1.60
22	425520.885	1151541.492	37.762	L	33	D	Z	M	L	0.6		0.4	0.5	0.5	C	N	NE	1.60
23	425522.714	1151540.087	37.438	L	33	D	Z	M	L	0.5		0.4	0.5	0.5	C	N	N	1.60
24	425526.095	1151539.435	37.036	L	33	C	Z	M	L	0.4		0.4	0.5	0.5	C	N	N	0.90
25	425529.409	1151538.899	36.604	L	33	C	Z	M	L	0.4		0.4	0.5	0.5	C	N	N	0.90
26	425531.619	1151538.112	36.252	L	33	C	Z	M	L	0.4		0.4	0.5	0.5	C	N	N	0.90

27	425533.930	1151538.399	35.902	B	33	C	A	M		0.3		0.3	0.4	0.4	C	N	N	0.60
28	425537.255	1151538.852	35.534	B	33	C	A	M		0.3	0.1	0.3	0.4	0.4	C	N	N	0.60
29	425541.009	1151539.559	34.938	B	33	B	A	M		0.2		0.3	0.4	0.4	C	N	N	0.60
30	425543.597	1151540.271	34.519	B	33	B	A	M	L	0.2	0.2	0.3	0.4	0.4	C	N	W	0.60
31	425546.131	1151541.062	34.173	B	33	C	A	M		0.2	0.2	0.3	0.4	0.4	C	N	W	0.60
32	425547.318	1151541.451	34.080	B	33	C	A	M		0.2		0.3	0.4	0.4	C	N	W	0.60
33	425547.441	1151542.469	34.014	L	33	Z	E	M	L			0.3	0.4	0.4	C	O	E	1.80
34	425546.927	1151544.439	33.991	L	33	Z	F	M	L		0.9	0.3	0.6	0.6	C	O	E	1.80
35	425546.326	1151546.580	34.291	L	33	Z	F	M	L		1	0.3	0.6	0.6	C	O	E	2.00
36	425545.710	1151549.270	34.710	L	33	Z	F	M	L		1.1	0.3	0.6	0.6	C	O	E	2.00
37	425545.733	1151551.414	34.898	L	33	Z	F	M	L		1.1	0.3	0.6	0.6	C	O	E	2.00
38	425546.047	1151553.722	35.147	L	33	Z	F	M	L		1.1	0.3	0.6	0.6	C	O	E	2.00
39	425544.990	1151555.033	35.447	L	33	Z	E	M	L		1	0.3	0.6	0.6	C	O	E	1.50
40	425544.248	1151556.029	35.635	L	33	Z	D	M	L		0.9	0.3	0.6	0.6	C	O	E	0.90
41	425542.866	1151557.963	35.664	B	90	B	C	S			0.5	0.3	0.6	0.6	C	O	E	0.80
42	425541.647	1151559.332	35.925	B	90	B	C	S		0.3	0.3	0.2	0.3	0.3	C	O	E	0.80
43	425539.725	1151560.609	36.323	B	90	B	C	S		0.3	0.3	0.1	0.2	0.2	C	O	E	0.80
44	425537.562	1151561.177	36.742	B	90	B	C	S		0.3	0.3	0.1	0.2	0.2	C			1.00
45	425535.362	1151561.841	37.453	B	90	B	C	S		0.3	0.3	0.1	0.2	0.2	C			1.20
46	425537.296	1151561.620	36.924	M	45	F	F	M	L	F	1.2	0.1	0.2	0.2	C			
47	425536.232	1151559.333	36.513	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
48	425533.883	1151560.792	37.105	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
49	425532.601	1151562.089	37.449	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
50	425532.006	1151563.655	37.754	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
51	425531.717	1151565.225	37.943	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
52	425532.666	1151566.155	37.746	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6	C			
53	425534.600	1151566.082	37.395	M	45	F	F	M	L	F	1.2	0.3	0.6	0.6				
54	425536.231	1151564.839	36.981	M		F	F			F	1.2							
55	425538.128	1151563.439	36.580	M		F	F			F	1.2							

56	425539.104	1151562.699	36.367	M		F	F			F	1.2							
57	425531.809	1151565.271	37.904	L	33	Z	C	M	L		0.3	0.4	0.6	0.6	C	O	E	0.90
58	425530.470	1151566.954	38.066	L	33	Z	C	M	L		0.3	0.4	0.6	0.6	C	O	E	0.90
59	425529.092	1151568.458	38.318	L	33	Z	C	M	L		0.3	0.4	0.6	0.6	C	O	E	0.90
60	425528.348	1151569.815	38.365	L	33	Z	C	M	L		0.3	0.4	0.6	0.6	C	O	E	0.90
61	425527.162	1151571.271	38.637	L	33	Z	C	M	L		0.3	0.4	0.6	0.6	C	O	E	0.90
62	425525.552	1151572.922	39.062	L	33	C	B	M	L	0.4	0.2	0.4	0.6	0.6	C	N	W	0.90
63	425523.460	1151573.803	39.374	L	33	C	B	M	L	0.4	0.2	0.4	0.6	0.6	C	N	W	0.90
64	425521.510	1151575.468	39.724	L	33	C	B	M	L	0.4	0.2	0.4	0.6	0.6	C	N	W	0.90
65	425519.196	1151577.155	40.102	L	33	D	B	M	L	0.5	0.2	0.4	0.6	0.6	C	N	S	0.90
74	425513.496	1151576.987	40.478	L	33	C	Z	M		0.3		0.3			D			0.40
75	425512.621	1151577.882	40.569	L	33	C	Z			0.3								0.40
76	425511.365	1151578.556	40.560	L	33	C	Z			0.3								0.40
77	425510.270	1151577.468	40.731	L	33	C	Z			0.3								0.40
78	425510.345	1151576.354	40.649	L	33	C	Z			0.3								0.40
79	425510.588	1151575.673	40.634	L	33	C	Z			0.3								0.40
80	425511.887	1151576.212	40.685	L	33	C	Z			0.3								0.40
81	425512.933	1151576.626	40.578	L	33	C	Z			0.3								0.40
154	425512.349	1151596.847	40.779	B				S				0.1	0.3	0.3	L			
155	425512.369	1151596.833	40.788	B				S				0.1	0.3	0.3	L			
156	425512.482	1151599.386	40.658	B				S				0.1	0.3	0.3	L			
157	425513.012	1151602.405	40.553	B				S				0.1	0.3	0.3	L			
158	425514.502	1151604.157	40.550	B				S				0.1	0.3	0.3	L			
159	425516.117	1151604.245	40.438	B				S				0.1	0.3	0.3	L			
160	425517.585	1151602.957	40.360	B				S				0.1	0.3	0.3	L			
161	425517.617	1151601.910	40.379	B				S				0.1	0.3	0.3	L			
162	425516.938	1151600.330	40.533	B				S				0.1	0.3	0.3	L			
163	425515.621	1151598.650	40.689	B				S				0.1	0.3	0.3	L			
164	425514.978	1151596.155	40.553	B				S				0.1	0.3	0.3	L			

165	425512.826	1151595.765	40.759	B				S				0.1	0.3	0.3	L			
166	425511.978	1151596.975	40.743	B				S				0.1	0.3	0.3	L			
167	425517.996	1151596.782	40.028									0.1	0.3	0.3				
168	425518.408	1151598.274	40.008															
169	425519.453	1151599.611	39.911															
170	425521.215	1151600.493	39.824															
171	425523.271	1151599.848	39.616															
172	425524.689	1151598.119	39.613															
173	425524.257	1151595.930	39.635															
174	425522.781	1151594.094	39.701															
175	425521.084	1151593.501	39.776															
176	425519.165	1151594.325	39.905															
177	425518.185	1151596.024	39.999															
178	425492.817	1151593.732	41.888	L	45	B	Z	S		0.2		0.1	0.3	0.3	F	N	E	0.40
179	425492.221	1151597.045	42.087	L	45	B	Z	S		0.2		0.1	0.3	0.3	F	N	E	0.40
180	425491.219	1151600.377	42.265	L	45	B	Z	S		0.2		0.1	0.3	0.3	F	N	E	0.40
181	425490.312	1151603.905	42.491	L	90	B	Z	S		0.3		0.1	0.3	0.3	F	N	E	0.30
182	425492.202	1151606.089	42.323	L	90	B	Z	S		0.3		0.1	0.3	0.3	D	N	E	0.30
183	425491.982	1151608.861	42.457	L	33	B	Z	S		0.3		0.1	0.3	0.3	D	N	E	0.30
184	425491.670	1151612.621	42.709	L	33	B	B	S		0.3	0.2	0.1	0.3	0.3	D	Q		0.40
185	425492.360	1151614.580	42.712	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.40
186	425493.490	1151616.243	42.621	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.40
187	425496.071	1151618.815	42.446	L	33	B	A	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.40
188	425497.057	1151620.911	42.407	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.40
189	425498.422	1151623.782	42.382	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.40
190	425500.731	1151625.887	42.213	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.60
191	425503.252	1151628.189	41.807	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.60
192	425506.290	1151631.130	41.400	L	33	B	Z	S		0.3	0.2	0.1	0.3	0.3	D	N	E	0.60
193	425508.516	1151632.946	41.186	L	33	B	Z	L		0.3	0.2	0.1	0.3	0.3	D	N	E	0.60

194	425508.395	1151632.963	41.197	L	33	B	Z	L	0.3	0.2				D			0.60
195	425511.057	1151633.951	40.727	L	33	B	Z	L	0.3	0.2				D			0.60
196	425511.780	1151634.510	40.532	D	90	C	C	L	0.3	0.2				C			1.10
197	425514.138	1151635.375	40.701	D	90	C	C	L	0.4	0.4	0.5	0.6	0.6	C			1.10
198	425515.276	1151633.993	40.532	D	90	C	C	L	0.4	0.4	0.5	0.6	0.6	C			1.10
199	425517.022	1151631.469	40.251	B	45	C	A	M	0.4	0.4	0.5	0.6	0.6	C	U	N	1.10
200	425518.684	1151630.292	40.155	B	45	C	A	M	0.4	0.1	0.4	0.4		C	U	N	1.10
201	425520.800	1151630.362	40.017	B	45	C	A	M	0.4	0.1	0.4	0.4		D	U	N	1.10
202	425522.950	1151629.658	39.900	B	33	A	A	S	0.1	0.1	0.4	0.4		D	Q		1.20
203	425524.703	1151628.567	39.772	B	33	A	A	S	0.1	0.1	0.1	0.3	0.3	F	Q		1.20
204	425527.945	1151626.250	39.316	B	33	A	A	S	0.1	0.1	0.1	0.3	0.3	F	Q		1.20
205	425530.302	1151623.508	39.181	B	33	A	A	S	0.1	0.1	0.1	0.3	0.3	F	Q		1.20
206	425532.572	1151621.511	38.931	D	45	Z	C	S		0.3	0.1	0.3	0.3	D	D	S	2.00
207	425534.301	1151619.172	38.815	D	45	Z	C	S		0.3	0.1	0.3	0.3	D	D	S	2.00
208	425536.635	1151618.212	38.545	D	45	Z	C	S		0.4	0.1	0.3	0.3	D	D	S	2.00
209	425540.650	1151617.524	38.151	D	33	Z	C	S		0.3	0.1	0.3	0.3	D	D	S	2.00
210	425544.544	1151616.310	37.371	D	33	Z	C	S		0.3	0.1	0.3	0.3	D	D	S	2.00
211	425549.019	1151615.002	36.827	D	33	Z	D	S		0.6	0.1	0.3	0.3	D	D	S	2.00
212	425551.448	1151613.841	36.477	D	33	Z	F	S		1	0.1	0.3	0.3	D	D	S	1.00
213	425554.183	1151613.631	35.996	D	33	B	C	S	0.2	0.4	0.1	0.3	0.3	F	D	S	2.00
214	425557.761	1151615.548	35.564	D	33	Z	C	S		0.4	0.1	0.3	0.3	C	D	S	2.00
215	425559.672	1151616.880	35.350	D	33	Z	C	S		0.3	0.1	0.3	0.3	C	D	E	0.60
216	425560.675	1151619.437	35.096	L	90	Z	D	M		0.5	0.4	0.4		F	D	E	0.50
217	425561.388	1151622.721	35.229	L	45	Z	D	M		0.5	0.4	0.4		F	D	E	0.50
218	425562.989	1151625.647	35.269	L	33	Z	D	M		0.5	0.4	0.4		F	D	E	1.10
219	425564.077	1151627.916	35.251	L	33	Z	D	M		0.5	0.4	0.4		C	D	E	1.10
220	425565.022	1151629.028	35.133	L	33	Z	D	M		0.5	0.4	0.4		C	D	SE	1.10
221	425565.140	1151629.910	35.210	L	33	Z	D	V		0.6	0.4	0.4		C	D	SE	2.60
222	425567.043	1151631.134	35.193	L	33	Z	D	V		0.6	0.1	0.6	0.6	C	D	SE	2.60

223	425569.018	1151632.602	35.076	L	33	Z	D	V	0.6	0.1	0.6	0.6	C	D	SE	2.60
224	425571.430	1151634.402	35.076	L	33	Z	D	V	0.6	0.1	0.6	0.6	C	D	SE	2.60
225	425573.719	1151636.767	34.904	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
226	425575.673	1151638.470	34.942	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
227	425577.559	1151640.789	35.000	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
228	425579.338	1151643.983	35.282	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
229	425580.508	1151646.890	35.553	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
230	425582.809	1151650.193	35.545	L	33	Z	F	V	1	0.1	0.6	0.6	C	D	SE	2.60
231	425584.500	1151652.902	35.416	L	45	Z	D	V	1	0.1	0.6	0.6	F	D	SE	1.80
232	425585.278	1151654.873	35.469	L	45	Z	D	V	0.5	0.1	0.6	0.6	F	D	SE	1.80
233	425587.428	1151657.979	35.359	L	45	Z	D	V	0.5	0.1	0.6	0.6	F	D	SE	1.80
234	425589.411	1151660.893	35.304	L	45	Z	D	V	0.5	0.1	0.6	0.6	F	D	SE	1.80
235	425591.960	1151663.643	35.252	L	45	Z	C	V	0.5	0.1	0.6	0.6	F	D	SE	1.80
236	425594.330	1151665.783	35.072	L	45	Z		V	0.4	0.1	0.6	0.6	F	D	SE	1.80
237	425596.745	1151666.974	34.945	L	45	Z		V		0.1	0.6	0.6	F	D	SE	1.50
238	425598.975	1151668.463	34.812	L	45	Z		V		0.1	0.6	0.6	F	D	SE	1.50
239	425599.528	1151670.139	35.023	L	45	Z		V		0.1	0.6	0.6	F	D	E	1.10
240	425599.459	1151673.988	35.245	L	45	Z		V		0.1	0.6	0.6	C	D	E	1.10
241	425597.576	1151674.475	35.581	L	33	Z	C			0.1	0.6	0.6	N	D	E	1.10
242	425595.367	1151675.801	36.150	L	33	Z	C		0.4				N	N	S	4.00
243	425593.001	1151677.970	36.602	L	33	Z	C		0.4				N	N	S	4.00
244	425589.682	1151680.636	37.195	L	33	Z	C		0.4				N	N	S	4.00
245	425586.539	1151682.453	37.436	L	33	Z	C		0.4				N	N	S	4.00
246	425584.127	1151683.239	37.607	L	33	Z	C	L	0.4				D	N	S	4.00
247	425584.070	1151683.123	37.595	L	45	Z	C	S	0.4	0.6	0.6		C	N	S	4.00
248	425582.749	1151683.551	37.818	L	45	Z	C	S	0.4	0.2	0.2		C	N	S	4.00
249	425579.928	1151684.443	38.271	L	45	Z	C	M	0.3	0.2	0.2		D	N	S	4.00
250	425577.126	1151684.903	38.531	Y	0	Z	Z	X		0.3	0.3		D			1.00
251	425568.342	1151685.943	39.411	Y	0	Z	Z	X		1	1		D			1.00

252	425563.909	1151685.967	39.963	L	90	Z	B	M		0.2	1.4	1.4	D	N	S	1.00
253	425560.885	1151684.521	40.137	L	0	Z	Z	L			0.3	0.3	C			1.00
254	425557.339	1151681.801	40.424	L	0	Z	Z	X			0.5	0.5	C			1.00
255	425556.436	1151680.312	40.361	L	0	Z	Z	M			1.2	1.2	C			0.95
256	425554.900	1151677.232	40.199	L	0	Z	Z	M		0.6	0.3	0.3	C			0.95
257	425555.274	1151675.127	40.082	L	33	B	B	L	0.2	0.2	0.3	0.3	D	A	E	0.30
258	425555.723	1151671.049	39.789	L	33	B	B	M	0.2	0.2	0.5	0.5	D	A	E	0.30
259	425555.755	1151669.280	39.655	L	33	B	B	M	0.2	0.2	0.3	0.3	D	A	E	0.30
302	425563.006	1151653.447	38.262	L	33	Z	C	M			0.3	0.3	D	A	E	1.00
303	425563.157	1151651.369	38.066	L	33	Z	C	S	0.3	0.3	0.2	0.2	D	A	E	1.00
304	425562.978	1151649.019	37.925	L	33	Z	C	S	0.3	0.2	0.2	0.2	D	A	E	1.00
305	425562.938	1151647.058	37.693	L	45	Z	C	M	0.3	0.2	0.3	0.3	D	A	E	1.00
306	425562.978	1151644.203	37.380	L	45	Z	C	M	0.4	0.3	0.3	0.3	D	A	E	1.00
307	425563.079	1151641.276	37.014	L	45	Z	C	M	0.4	0.3	0.3	0.3	D	A	E	1.00
308	425563.394	1151638.297	36.601	L	33	Z	C	M	0.4	0.3	0.3	0.3	D	A	E	1.00
309	425563.943	1151635.381	36.143	L	33	Z	C	M	0.4	0.3	0.3	0.3	C	A	E	1.00
310	425565.218	1151633.211	35.681	L	33	Z	C	S	0.4	0.3	0.2	0.2	C	A	E	1.00
311	425566.966	1151631.782	35.282	L	33	Z	C	M	0.3	0.2	0.2	0.2	C	A	E	1.00
380	425540.344	1151656.993	40.177	B	33	B	B		0.3	0.3			D	Q		1.50
381	425536.937	1151653.906	40.259	B	33	B	B		0.2	0.2			D	Q		1.50
382	425540.003	1151652.985	40.050	B	33	B	B		0.2	0.2			D	Q		1.50
383	425543.232	1151651.267	39.743	B	33	B	B		0.2	0.2			D	Q		1.50
384	425545.849	1151649.734	39.375	B	33	B	B		0.2	0.2			D	Q		1.50
385	425547.601	1151648.748	39.182	B	33	B	B		0.2	0.2			D	Q		1.50
436	425554.691	1151679.601	40.230	B	33	B	B	M	0.2	0.2	0.4	0.4	D	Q		1.70
437	425552.482	1151680.086	40.497	B	33	B	B	M	0.2	0.2	0.4	0.4	D	Q		1.70
438	425550.027	1151681.065	40.676	B	33	B	B	M	0.2	0.2	0.4	0.4	D	Q		1.70
439	425546.892	1151682.227	40.826	B	33	B	B	M	0.2	0.2	0.4	0.4	D	Q		1.70
440	425543.087	1151683.228	40.721	B	33	B	B	M	0.2	0.2	0.4	0.4	D	Q		1.00

441	425540.274	1151683.801	40.715	B	33	B	B	M	0.2	0.2	0.4	0.4		D	Q		1.00
442	425531.221	1151684.582	40.840	L	45	B	A	M	0.2	0.2	0.4	0.4		D	N	S	1.00
443	425529.181	1151684.325	41.030	L	45	B	Z	M	0.2	0.1	0.3	0.4	0.4	C	N	S	1.00
444	425527.552	1151684.351	41.246	L	45	B	Z	M	0.3		0.3	0.4	0.4	C	N	S	1.00
445	425524.991	1151683.953	41.600	L	45	B	Z	V	0.3		0.3	0.4	0.4	C	N	S	1.00
446	425522.962	1151682.662	41.810	L	33	D	Z	M	0.4		0.3	0.4	0.4	C	N	SE	1.00
447	425520.600	1151680.315	42.166	L	33	D	Z	M	0.5		0.3	0.4	0.4	F	N	SE	1.40
448	425517.534	1151676.047	42.453	L	33	F	Z	M	0.6		0.3	0.4	0.4	F	N	E	1.80
449	425515.275	1151671.382	42.591	L	33	F	Z	M	1		0.3	0.4	0.4	F	N	E	
450	425514.159	1151667.594	42.622	L	45	E	Z	M	1		0.3	0.4	0.4	F	N	E	1.20
451	425513.170	1151664.019	42.503	L	45	C	Z	M	0.7		0.3	0.4	0.4	D	N	E	1.20
452	425511.868	1151660.410	42.424	L	45	C	A	M	0.4		0.3	0.4	0.4	C	N	E	1.20
453	425510.537	1151656.823	42.369	L	45	C	A	M	0.3	0.1	0.3	0.4	0.4	C	N	E	1.20
454	425509.601	1151653.281	42.239	L	45	C	A	M	0.3	0.1	0.3	0.4	0.4	C	N	E	1.20
455	425510.531	1151650.589	41.878	B	33	C	A	M	0.3	0.1	0.3	0.4	0.4	D	N	E	0.90
456	425510.988	1151646.947	41.655	B	33	C	A	S	0.3	0.1	0.2	0.2		D	N	E	1.00
457	425511.046	1151643.379	41.333	B	33	C	A	S	0.3	0.1	0.2	0.2		D	N	E	1.00
458	425510.930	1151640.023	41.155	B	33	C	A	S	0.3	0.1	0.2	0.2		D	N	E	1.00
459	425511.562	1151637.232	40.874	B	33	C	A	S	0.3	0.1	0.2	0.2		D	N	E	1.00
460	425511.723	1151634.496	40.572	D	90	B	B	L	0.3	0.1	0.5	0.5		C	Q		1.10
461	425513.423	1151635.175	40.478	D	90	B	B	L	0.3	0.1	0.5	0.5		C	Q		1.10
462	425512.252	1151637.021	40.578	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		1.10
463	425511.289	1151638.379	40.705	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		1.10
464	425510.669	1151638.222	40.902	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		1.10
465	425509.569	1151635.702	40.926	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		0.70
466	425508.686	1151634.466	40.903	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		0.70
467	425508.299	1151633.269	41.077	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		0.70
468	425519.378	1151646.594	40.851	D	90	B	B	L	0.2	0.2	0.5	0.5		C	Q		0.70
483	425510.547	1151679.023	43.529	D	90	B	B	L	0.4		0.3	0.3		C	Q		0.90

484	425510.494	1151678.966	43.525	D	90	C	Z	M	0.4		0.3	0.3		C	N	S	
485	425508.226	1151679.331	44.215	D	90	C	Z	M	0.4		0.3	0.3		C	N	S	
486	425506.550	1151679.858	45.135	D	90	C	Z	M	0.4		0.3	0.3		C	N	S	
487	425504.030	1151680.247	46.113	D	90	C	Z	M	0.4		0.3	0.3		D	N	S	1.10
488	425499.538	1151680.633	46.913	D	45	B	Z	M	0.4		0.4	0.4		D	N	S	0.70
489	425495.618	1151680.759	47.233	D	45	B	Z	M	0.2		0.4	0.4		D	N	S	0.70
490	425490.786	1151680.553	47.648	D	45	B	Z	M	0.2		0.4	0.4		D	N	S	0.70
491	425487.270	1151679.337	48.052	D	45	B	Z	M	0.2		0.4	0.4		D	N	S	0.70
492	425482.529	1151677.522	48.855	D	45	B	Z	M	0.2		0.4	0.4		D	N	S	0.70
493	425478.192	1151675.865	49.329	D	45	B	Z	M	0.2		0.4	0.4		D	N	S	0.70
494	425475.643	1151672.575	49.542	D		Z	Z	M			0.4	0.4		C			1.00
495	425474.553	1151669.259	49.694	D		Z	Z	L			0.6	0.6		C			1.00
496	425475.262	1151663.309	49.839	D	45	B	Z	L	0.2		0.5	0.5		D	N	E	1.00
497	425475.908	1151658.044	50.148	D	45	B	Z		0.2					N	N	E	1.00
498	425477.334	1151655.340	50.042	D	45	B	Z		0.2					N	N	E	1.00
499	425477.232	1151653.127	50.160	D	0	Z	Z	X			0.8	0.8		D			1.00
500	425476.875	1151649.129	50.278	D	0	Z	Z	L			0.6	0.6		C			1.00
501	425477.044	1151646.006	49.894	D	45	B	Z	S	0.2		0.2	0.3	0.3	D	N	E	1.00
502	425477.298	1151644.813	49.772	D	90	B	Z	S	0.2		0.2	0.3	0.3	D	N	E	1.00
503	425477.151	1151643.158	49.864	D	90	B	Z	L	0.3		0.5	0.5		C	N	E	1.00
504	425478.047	1151639.699	49.462	D	90	B	Z	L	0.3		0.5	0.5		C	N	E	1.00
505	425480.823	1151632.047	47.904	D	45	B	Z	M	0.3		0.3	0.3		D	N	E	1.00
506	425481.909	1151629.403	46.912	D	33	Z	Z	Z						N	N	E	1.00
507	425483.108	1151627.835	46.067	D	33	Z	Z	Z						N	N	E	1.00
508	425482.452	1151625.802	46.278	D	90	C	Z	M	0.4		0.3	0.4	0.4	F	N	E	1.00
509	425482.772	1151623.044	45.921	D	45	C	Z	M	0.4		0.3	0.4	0.4	F	N	E	1.00
510	425482.499	1151621.612	45.769	D	45	C	Z	M	0.4		0.3	0.4	0.4	F	N	E	1.00
511	425483.150	1151621.333	45.524	D	45	C	Z	M	0.4		0.3	0.4	0.4	F	N	E	1.00
512	425602.062	1151680.964	35.374	L	33	Z	L	S		0.6	0.2	0.2		D	N	E	1.00

513	425602.555	1151678.484	35.164	L	33	Z	L	S		0.6	0.2	0.2		D	D	E	1.00
514	425603.749	1151675.534	34.849	L	33	Z	L	S		0.6	0.2	0.2		D	D	E	1.00
515	425605.736	1151669.784	33.725	L	33	Z	L	S		0.6	0.2	0.2		D	D	E	1.00
516	425606.598	1151666.853	33.115	L	33	Z	L	S		0.6	0.2	0.2		D	D	E	1.00
517	425606.738	1151664.311	32.627	L	33	Z	L	S		0.6	0.2	0.2		D	D	E	1.00
518	425606.799	1151661.530	32.019	L	33	Z	M	S		0.6	0.2	0.2		D	D	E	1.00
519	425607.948	1151658.211	31.266	L	33	Z	M	S		0.4	0.2	0.2		D	D	E	1.00
520	425609.452	1151653.816	30.777	L	45	Z	M	S		0.4	0.2	0.2		D	D	E	1.00
521	425610.143	1151650.157	30.192	L	45	Z	M	S		0.4	0.2	0.2		D	D	E	1.00
522	425609.746	1151647.447	29.784	L	45	Z	M	S		0.4	0.2	0.2		D	D	E	1.00
523	425610.543	1151644.498	29.170	L	45	Z	M	S		0.4	0.2	0.2		D	D	E	1.00
524	425611.141	1151638.910	28.508	L	33	Z	M	S		0.4	0.2	0.2		C	D	E	0.50
525	425611.183	1151636.749	28.330	D	33	Z	DD	M		0.5	0.3	0.3		C	D	E	0.80
526	425612.878	1151633.988	27.961	D	33	Z	D	M		0.5	0.3	0.3		C	D	E	0.50
527	425614.800	1151631.091	27.719	D	33	B	B	M		0.2	0.3	0.3		C			0.50
528	425617.891	1151629.385	27.086	D	33	Z	B	M		0.2	0.3	0.3		C	D		0.50
529	425621.368	1151629.266	26.726	D	33	Z	B	M		0.2	0.3	0.3		C	D		0.50
530	425624.515	1151629.834	26.565	D	33	Z	B	M		0.2	0.3	0.3		C	D		0.50
531	425626.969	1151629.971	26.326	D	33	Z	B	M		0.2	0.3	0.3		C	D		0.50
532	425629.121	1151629.062	26.016	D	33	Z	B	M		0.2	0.3	0.3		C	D		0.50
533	425601.828	1151680.026	35.428	L	33	Z	C	C		0.2	0.3	0.3		D	D	E	0.60
534	425600.537	1151678.169	35.465	L	33	Z	C	C		0.4	0.3	0.4	0.4	D	D	E	0.60
535	425600.113	1151675.994	35.253	L	33	Z	C	C		0.4	0.3	0.4	0.4	D	D	E	0.60
536	425599.622	1151673.392	35.209	L	33	Z	C	C		0.4	0.3	0.4	0.4	D	D	E	0.60
557	425560.951	1151616.651	35.048	L	45	Z	D	M		0.4	0.3	0.4	0.4	D	N	E	1.60
558	425563.204	1151614.340	34.719	L	33	Z	D	M		0.5	0.3	0.5	0.5	D	N	E	1.50
559	425563.662	1151611.067	34.605	L	33	Z	E	M		0.6	0.3	0.5	0.5	D	N	E	1.00
560	425564.226	1151610.166	34.442	L	33	Z	C	M		0.8	0.3	0.5	0.5	D	N	E	1.00
622	425550.342	1151604.226	37.105	B	33	C	C	S	0.3	0.4	0.2	0.5	0.5	D	Q		1.60

623	425551.873	1151605.271	36.710	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	D	Q		1.60
624	425553.634	1151606.112	36.347	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	D	Q		1.60
625	425555.262	1151606.243	36.018	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	C	Q		1.30
626	425557.229	1151606.379	35.634	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	C	Q		1.30
627	425558.957	1151607.326	35.183	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	C	Q		1.30
628	425561.298	1151608.543	34.882	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	C	Q		1.30
629	425562.892	1151609.293	34.642	B	33	C	C	S	0.3	0.3	0.2	0.3	0.3	C	Q		1.30
630	425565.443	1151610.304	34.250	B	33	C	C	S	0.4	0.4	0.2	0.3	0.3	F	Q		1.80
631	425567.984	1151610.374	34.031	B	33	C	C	S	0.4	0.4	0.2	0.3	0.3	F	Q		1.80
632	425571.599	1151610.144	33.523	B	33	C	C	S	0.4	0.4	0.2	0.3	0.3	F	Q		1.80
633	425573.690	1151610.241	33.135	B	33	C	C	S	0.4	0.4	0.2	0.2		C	Q		1.80
634	425576.500	1151609.477	32.695	B	33	C	C	S	0.4	0.4	0.2	0.2		C	Q		1.80
635	425579.328	1151608.708	32.177	B	33	C	C	S	0.4	0.4	0.2	0.2		C	Q		1.80
636	425581.930	1151608.277	31.629	B	33	B	B		0.2	0.2				N	Q		1.80
637	425585.382	1151608.282	31.078	B	33	B	B	M	0.2	0.2	0.2	0.2		N	Q		1.80
638	425588.081	1151607.786	30.678	B	33	B	B	M	0.2	0.2	0.2	0.2		D	Q		1.80
639	425590.723	1151606.970	30.254	B	33	B	B	M	0.2	0.2	0.2	0.2		N	Q		1.80
640	425591.926	1151606.711	30.090	B	33	B	B	M	0.2	0.2	0.2	0.2		N	D		1.80
641	425549.970	1151604.553	37.110	L	33	C	Z	M	0.4		0.4	0.4		C	D	S	1.00
642	425550.736	1151601.849	37.284	L	33	C		M	0.4		0.4	0.4		D	D	S	1.00
643	425551.253	1151598.725	37.166	L	33	C		M	0.4		0.4	0.4		D	D	E	1.00
644	425552.171	1151596.303	37.008	L	33	C		M	0.4		0.4	0.4		D	D	E	1.00
645	425553.973	1151593.878	36.781	L	45	D		M	0.5		0.3	0.3		F	D	E	1.50
646	425554.665	1151591.162	36.679	L	45	D		S	0.6		0.2	0.3	0.3	F	D	E	1.50
647	425553.664	1151586.621	36.470	L	33	E		S	0.7		0.2	0.3	0.3	F	D	E	1.50
648	425552.918	1151584.241	36.586	L	33	F		S	1		0.2	0.3	0.3	F	D	E	2.00
649	425552.908	1151581.750	36.382	L	33	F		S	1.4		0.2	0.3	0.3	F	D	E	2.00
650	425553.535	1151577.204	36.088	L	33	F		S	1.4		0.2	0.3	0.3	F	D	E	2.00
651	425552.808	1151572.982	35.875	L	33	F		S	1.4		0.2	0.3	0.3	F	D	E	2.00

652	425552.442	1151568.155	35.621	L	33	F		S	1.4		0.2	0.3	0.3	D	D	E	2.00
653	425552.543	1151564.451	35.313	L	33	F		S	1.4		0.2	0.3	0.3	D	D	E	2.00
654	425552.036	1151560.627	34.886	L	33	F		S	1.2		0.2	0.3	0.3	D	D	E	2.00
655	425552.532	1151555.431	34.237	L	33	F		S	1		0.2	0.3	0.3	D	D	E	2.00
656	425553.456	1151553.567	33.920	L	33	D		S	0.6		0.2	0.3	0.3	D	D	NE	2.00
657	425557.322	1151552.098	33.153	L	33	D	A	S	0.5	0.1	0.2	0.3	0.3	D	N	N	2.00
658	425559.776	1151551.548	32.669	L	33	C	B	S	0.3	0.2	0.2	0.3	0.3	D	N	N	2.00
659	425562.084	1151551.596	32.292	L	33	C	B	S	0.3	0.2	0.2	0.3	0.3	D	N	N	2.00
660	425566.359	1151550.556	31.901	L	33	C	B	S	0.3	0.2	0.2	0.3	0.3	D	N	N	2.00
661	425570.717	1151551.113	31.672	L	33	C	B		0.3	0.2	0.2	0.3	0.3	N	N	N	2.00
662	425574.402	1151553.350	31.275	L	33	A	Z		0.1					N	N	N	
663	425576.460	1151555.006	31.285	D				S						C			0.50
664	425578.604	1151554.577	30.961	D				S			0.2	0.2		C			0.50
665	425582.092	1151554.980	30.460	D				S			0.2	0.2		C			0.50
666	425568.592	1151546.786	31.451	D	0	Z	Z	M			0.2	0.2		C			0.50
667	425568.573	1151546.796	31.454	D	0	Z	Z	M			0.3	0.3		F			0.50
668	425568.603	1151546.817	31.432	D	0	Z	Z	M			0.3	0.3		F			0.50
669	425567.335	1151545.019	31.463	D	0	A	A	S	0.1	0.1	0.3	0.3		D			0.50
670	425566.670	1151543.021	31.387	D	0	A	A	S	0.1	0.1	0.2	0.2		D			0.50
671	425563.817	1151538.064	31.243	B	33	A	A	L	0.1	0.1	0.2	0.2		C			0.50
672	425561.377	1151538.341	31.599	B	33	B	A	M	0.3	0.1	0.5	0.5		C	N	N	0.50
673	425559.706	1151539.105	31.976	B	33	C	B	M	0.4	0.2	0.3	0.3		D	N	N	2.00
674	425557.661	1151540.452	32.218	B	33	D	C	S	0.5	0.3	0.5	0.5		D	N	N	2.00
675	425554.423	1151540.988	32.803	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00
676	425552.729	1151540.480	32.901	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00
677	425551.548	1151539.833	33.084	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00
678	425550.221	1151539.467	33.329	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00
679	425548.285	1151540.754	33.645	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00
680	425547.626	1151541.054	33.834	B	33	D	C	S	0.5	0.3	0.2	0.3	0.3	D	N	N	2.00

681	425511.830	1151534.525	38.610	L	33	D	Z	S	0.5	0.3	0.2	0.3	0.3	F	D	NE	1.10
682	425512.585	1151532.220	38.446	L	33	D	Z	S		0.3	0.2	0.3	0.3	F	D	NE	1.10
683	425513.611	1151530.749	38.095	L	33	D	Z	S		0.3	0.2	0.3	0.3	F	D	NE	1.10
684	425516.965	1151526.249	37.365	L	33	D	Z	S		0.3	0.2	0.2		D	D	NE	1.10
685	425518.399	1151524.772	37.033	L	33	D	Z	S		0.3	0.2	0.2		D	D	NE	1.10
686	425527.762	1151517.615	35.065	L	33	C	Z	S		0.2	0.2	0.2		D	D	E	0.80
687	425530.162	1151514.898	34.585	D	33	E	A	M		0.2	0.3	0.3		F	N	E	1.80
688	425531.979	1151512.211	34.077	D	33	F	A		0.9	0.1				N	N	E	4.00
689	425534.498	1151509.441	33.575	D	33	E	Z	M	1.2	0.1	0.2	0.4	0.4	D	N	NE	3.00
690	425537.720	1151508.215	32.847	D	33	D	Z	M	0.8	0.1	0.2	0.4	0.4	D	N	N	3.00
691	425541.607	1151507.597	32.445	D	33	C	Z	M	0.6	0.1	0.2	0.4	0.4	D	N	N	1.80
692	425543.425	1151507.079	32.164	D	33	C	Z	M	0.4		0.2	0.4	0.4	F	N	N	0.80
693	425545.891	1151506.149	31.811	D	33	C	Z	M	0.4		0.2	0.4	0.4	F	N	N	0.80
694	425547.583	1151505.818	31.750	D	33	B	Z		0.4					N			0.50
695	425548.963	1151506.766	31.562	D	0	Z	Z	M	0.2		0.3	0.3		D			0.50
696	425551.341	1151509.112	31.355	D	0	Z	Z	M			0.4	0.4		F			0.30
697	425552.737	1151511.498	31.507	D	0	Z	Z	S			0.2	0.2		F			0.30
698	425553.832	1151514.279	31.753	D	0	Z	Z	S			0.2	0.2		F			0.30
699	425554.469	1151517.707	32.033	D	0	Z	Z	S			0.2	0.2		F			0.30
700	425555.001	1151520.236	32.039	D	0	Z	Z	S			0.2	0.2		F			0.30
701	425555.527	1151522.394	31.973	D	0	Z	Z	S			0.2	0.2		F			0.30
702	425556.111	1151524.403	31.775	D	0	Z	Z	S			0.2	0.2		F			0.30
703	425556.616	1151528.686	31.761	D	0	Z	Z	S			0.2	0.2		F			0.30
704	425559.226	1151527.759	31.330	D	0	Z	Z	S			0.2	0.2		F			0.30
bref	425521.955	1151437.859	34.738														

Appendix C.8 Clevigarth Multiple Field System

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	Ht In	Ht Out	Min Stone	all max	Max Stone	Dense	Face	Dir Face	Width	width
1-004	440677.321	1112800.960	19.00	O											
1-005	440679.493	1112799.941	18.00	O											
1-006	440679.690	1112802.924	19.00	O											
1-007	440678.158	1112804.008	19.00	O											
1-008	440676.452	1112799.875	18.00	D	0.00	0.00		0.20	0.70	0.70	D			0.00	
1-009	440673.647	1112801.107	18.00	D	0.00			0.20	0.70	0.70	D			0.00	
1-010	440670.206	1112803.545	18.00	B	0.00	0.30	0.30	0.30	0.70	0.70	F	Q		0.80	B
1-011	440667.955	1112804.168	18.00	B	0.00	0.30	0.30	0.30	1.00	1.00	F	Q		1.20	C
	440663.790	1112803.958	18.00	B	0.00	0.30	0.30	0.30	0.50	0.50	F	Q		1.20	C
1-013	440663.801	1112803.984	18.00	B	0.00	0.30	0.30	0.30	0.50	0.50	F	Q		1.50	C
1-014	440660.107	1112802.623	18.00	B	0.00	0.30	0.30	0.30	0.70	0.70	F	Q		1.10	C
1-015	440655.299	1112799.695	18.00	B	0.00	0.30	0.30	0.30	0.70	0.70	F	Q		1.10	C
1-016	440651.862	1112797.724	18.00	B	0.00	0.30	0.30	0.30	0.70	0.70	F	Q		1.10	C
1-017	440649.707	1112796.231	18.00	B	0.00	0.30	0.30	0.30	0.50	0.50	F	Q		1.10	C
1-019	440645.936	1112790.043	18.00	B	33.00	0.20	0.20	0.00	0.00	0.00	N	Q		0.50	A
1-020	440645.075	1112786.081	18.00	B	33.00	0.30	0.30	0.00	0.00	0.00	N	Q		0.70	B
1-021	440644.306	1112781.810	18.00	B	33.00	0.30	0.30	0.20	0.20	0.00	N	Q		0.70	B
1-022	440642.926	1112777.929	17.00	B	33.00	0.30	0.30	0.20	0.30	0.30	D	Q		0.70	B
1-023	440642.783	1112775.668	17.00	B	33.00	0.30	0.30	0.20	0.30	0.30	D	Q		0.50	A
1-024	440641.651	1112773.354	17.00	B	33.00	0.30	0.30	0.20	0.30	0.30	D	Q		0.50	A
1-025	440642.667	1112771.080	17.00	B	33.00	0.30	0.30	0.20	0.30	0.30	D	Q		0.50	A
1-026	440642.135	1112768.302	17.00	B	33.00	0.30	0.20	0.20	0.50	0.50	D	D	W	0.80	B
1-027	440644.388	1112765.476	17.00	B	33.00	0.30	0.20	0.20	0.30	0.30	D	D	W	0.80	B
1-028	440648.495	1112763.434	17.00	B	33.00	0.30	0.20	0.20	0.40	0.40	D	D	W	0.80	B
1-029	440648.540	1112763.436	17.00	B	33.00	0.30	0.20	0.20	0.50	0.50	D	D	W	0.80	B
1-030	440649.318	1112762.610	17.00	B	33.00	0.30	0.20	0.20	0.60	0.60	D	D	W	0.80	B
1-033	440649.805	1112763.169	17.00	D				0.40	0.00	0.00	D				
1-034	440652.627	1112760.101	17.00	D				0.30	0.80	0.80	D				
1-035	440652.609	1112760.068	17.00	D				0.30	0.70	0.70	D				
1-036	440655.520	1112755.646	17.00	D				0.20	0.60	0.60	D				
1-037	440656.597	1112754.283	17.00	D				0.20	0.60	0.60	D				

1-038	440659.568	1112753.578	17.00	D			0.20	1.40	1.40	D				
1-039	440661.316	1112781.019	18.00	D			0.60	0.60		D				
1-040	440661.634	1112786.190	18.00	D			0.20	0.20		D				
1-041	440662.160	1112791.089	18.00	D			0.30	0.30		D				
1-042	440662.000	1112795.971	18.00	D			0.60	0.60		D				
1-043	440661.046	1112800.070	18.00	D			0.40	0.90	0.90	D				
1-044	440663.571	1112782.751	18.00	D			0.50	0.50		D				
1-045	440666.293	1112792.470	18.00	D			0.40	0.40		D				
1-046	440668.774	1112800.528	18.00	D			0.80	0.80		D				
1-071	440679.245	1112753.466	18.00	D			0.30	0.30		C				
1-072	440676.142	1112753.026	18.00	D			0.30	0.30		C			0.80	B
1-073	440674.012	1112752.443	18.00	D			0.30	0.30		C			1.20	C
1-074	440670.852	1112752.974	18.00	D			0.30	0.30		C			1.40	C
1-075	440668.678	1112753.497	18.00	D	0.30	0.30	0.00	0.00		N			2.00	D
1-076	440665.556	1112754.364	18.00	D	0.30	0.30	0.20	0.20		D			2.00	D
1-077	440665.799	1112755.838	18.00	D			0.20	0.20	0.20	D				
1-078	440666.351	1112758.296	18.00	D			0.20	0.20	0.20	D				
1-079	440667.521	1112761.593	18.00	D			0.20	0.20		D				
1-080	440668.527	1112763.568	18.00	D			0.30	0.30		D				
1-081	440670.021	1112765.070	18.00	D			0.30	0.30		D				
1-082	440671.797	1112766.839	18.00	D			0.30	0.30		D				
1-146	440677.370	1112801.096	19.00	D			0.30	1.20	1.20	C				
1-147	440677.525	1112797.958	18.00	D			0.50	0.70	0.70	C				
1-148	440677.313	1112795.943	18.00	D			0.40	0.70	0.70	C				
1-149	440675.710	1112793.595	18.00	B	0.20	0.20	0.30	0.30		D	Q		0.60	B
1-150	440674.826	1112790.841	18.00	B	0.20	0.20	0.30	0.30		D	Q		0.60	B
1-151	440673.533	1112787.628	18.00	B	0.20	0.20	0.00	0.00		N	Q		0.80	B
1-152	440673.133	1112784.460	18.00	B	0.20	0.20	0.30	0.40	0.40	D	Q		0.80	B
1-153	440672.758	1112782.801	18.00	B		0.20	0.20	0.20		D	D	W	0.80	B
1-154	440672.158	1112779.033	18.00	B		0.20	0.50	0.50		D	D	W	0.50	A
1-155	440671.456	1112775.987	18.00	B		0.20	0.60	0.60		D	D	W	0.50	A
1-156	440669.809	1112772.527	18.00	B		0.20	0.00	0.00		N	D	W	0.50	A
1-157	440668.734	1112770.657	18.00	B	0.20	0.20	0.00	0.00		N	D	W	0.50	A
1-158	440667.670	1112769.220	18.00	B	0.20	0.30	0.10	0.50	0.50	D	D	W	0.50	A

1-159	440666.453	1112766.989	18.00	B		0.20	0.30	0.60	0.60		D	D	W	0.80	B
1-160	440665.875	1112765.956	18.00	B		0.20	0.30	0.00			N	D	W	0.50	A
1-161	440666.526	1112765.596	18.00	B		0.20	0.20	0.00			N	Q		0.50	A
1-162	440666.064	1112763.386	18.00	B		0.20	0.20	0.00			N	Q		0.50	A
1-163	440665.769	1112761.634	18.00	B		0.20	0.20	0.00			N	Q		0.50	A
1-164	440664.645	1112755.429	18.00	B		0.30	0.10	0.20	0.30	0.30	D	D	W	0.80	B
1-165	440663.466	1112751.490	17.00	B		0.30	0.10	0.20	0.30	0.30	D	D	W	0.80	B
1-166	440662.271	1112748.493	17.00	B		0.30	0.10	0.20	0.70	0.70	D	D	W	0.80	B
1-167	440661.182	1112746.828	17.00	B		0.30	0.10	0.20	0.30	0.30	D	D	W	0.80	B
1-168	440659.380	1112743.713	17.00	B				0.30	0.30		D				
1-169	440657.469	1112739.884	17.00	B				0.60	0.60		D				
1-170	440656.393	1112736.632	17.00	B				1.60	1.60		D				
1-171	440665.488	1112775.970	18.00	D				0.70	0.70		D				
1-172	440665.887	1112772.541	18.00	D				0.80	0.80		D				
1-173	440663.822	1112769.636	18.00	D				0.70	0.70		D				
1-174	440662.836	1112766.439	18.00	D				0.20	0.20		D				
1-182	440642.144	1112746.397	17.00	B		0.30	0.20	0.20	0.20		D		N	1.50	C
1-183	440645.587	1112745.695	17.00	B		0.30	0.20	0.00			D		N	1.10	C
1-184	440649.412	1112744.862	17.00	B		0.20	0.20	0.40	0.40	0.40	D	Q		1.10	C
1-185	440653.084	1112744.324	17.00	B		0.20	0.20	0.20	0.30	0.30	L	Q		1.10	C
1-186	440655.036	1112743.194	17.00	B		0.20	0.20	0.20	0.70	0.70	L	Q		0.80	B
1-187	440658.132	1112740.814	17.00	B		0.20	0.20	0.20	1.30	1.30	L	Q		0.80	B
1-188	440659.596	1112724.142	17.00	L			0.20	0.20	0.20		D	N	S	0.40	A
1-189	440660.036	1112726.269	17.00	L			0.30	0.30	0.90	0.90	D	N	S	0.40	A
1-190	440660.443	1112727.820	17.00	L			0.50	0.20	0.20		D	N	S	0.40	A
1-191	440660.965	1112728.855	17.00	L			0.50	0.00			D	N	S	0.50	A
1-192	440662.344	1112729.278	17.00	L			0.50	0.20	0.40	0.40	D	N	S	0.50	A
1-193	440665.138	1112729.161	17.00	L	33.00		0.50	0.00			D	N	S	0.30	A
1-194	440665.245	1112727.178	17.00	L	45.00		0.20	0.20	0.20		D	N	S	0.60	B
1-195	440667.216	1112726.994	17.00	B	45.00		0.30	0.40	0.70	0.70	D	N	S	0.60	B
1-196	440668.801	1112726.172	17.00	B	45.00		0.30	0.30	0.30		D	N	S	0.60	B
1-197	440670.296	1112725.418	17.00	B	45.00		0.40	0.20	0.80	0.80	D	N	S	0.60	B
1-204	440642.718	1112723.037	16.00	Y				0.40	1.40	1.40	C				
1-205	440645.204	1112722.545	16.00	Y				0.30	1.30	1.30	C				

1-206	440647.641	1112722.799	16.00	Y			1.60	1.60		D				
1-207	440647.856	1112725.417	17.00	Y			0.20	0.60	0.60	D				
1-208	440647.167	1112728.407	17.00	Y			0.30	0.50	0.50	D				
1-209	440645.506	1112730.761	17.00	Y			0.30	0.50	0.50	D				
1-210	440644.418	1112733.800	17.00	Y			0.30	0.50	0.50	D				
1-211	440644.969	1112735.898	17.00	Y			0.80	0.80		D				
1-212	440644.659	1112737.530	17.00	Y			0.90	0.90		D				
1-213	440651.904	1112735.218	17.00	B	0.20	0.20	0.20	0.20	0.20	D			0.80	B
1-214	440649.809	1112735.474	17.00	B			0.40	1.30	1.30	C				
1-215	440648.110	1112736.460	17.00	B			0.50	1.30	1.30	C				
1-216	440646.011	1112738.412	17.00	B	0.20	0.20	0.20	0.20	0.20	D	A	N	1.20	C
1-217	440643.321	1112740.286	17.00	B	0.00	0.20	0.20	1.00	1.00	D	A	N	1.20	C
1-218	440641.270	1112741.468	17.00	B	0.00	0.20	0.20	0.60	0.60	D	A	N	1.20	C
1-219	440638.098	1112743.225	17.00	B	0.00	0.20	0.20	0.20		D	A	N	1.20	C
1-220	440636.883	1112744.834	17.00	B	0.00	0.20	0.00	0.00		D	A	N	1.20	C
1-221	440632.924	1112747.218	17.00	D	0.00	0.20	0.30	0.30		L	A	W	1.20	C
1-222	440630.512	1112744.084	17.00	D	0.20	0.30				D	A	W	1.20	C
1-223	440628.307	1112741.868	17.00	D	0.30	0.40	0.60	0.60		D	A	W	1.20	C
1-224	440626.316	1112738.726	16.00	D	0.20	0.30	0.50	0.50		D	A	W	1.00	B
1-225	440625.009	1112737.132	16.00	D	0.20	0.30	0.30	0.30		L	A	W	1.00	B
1-226	440623.759	1112734.456	16.00	D	0.20	0.30	0.50	0.50		C	A	W	1.00	B
1-227	440623.898	1112733.223	16.00	D	0.20	0.30	0.50	0.50		C	A	W	1.00	B
1-228	440621.145	1112727.685	16.00	B	0.00	0.00	0.60	0.60		D	Q			
1-229	440619.810	1112724.447	16.00	B	0.20	0.30	0.30	0.30		D	D	W	0.50	A
1-230	440618.538	1112722.292	16.00	B	0.20	0.30	0.40	0.40		D	D	W	0.50	A
1-231	440617.067	1112719.750	16.00	B	0.20	0.30	0.20	0.20		D	D	W	0.50	A
1-232	440615.963	1112716.861	16.00	B	0.20	0.30	0.40	0.40		D	D	W	0.50	A
1-233	440613.977	1112713.894	16.00	D			0.50	0.70	0.70	C				
1-234	440612.041	1112710.836	16.00	D			0.30	0.50	0.50	C				
1-235	440610.265	1112708.380	15.00	D			0.40	1.30	1.30	C				
1-236	440607.537	1112705.875	15.00	D			0.40	0.60	0.60	C				
1-237	440605.242	1112703.399	15.00	D			0.50	0.50		C				
1-249	440610.659	1112697.139	15.00	D			0.40	0.70	0.70	D				
1-250	440612.291	1112698.602	15.00	D			0.60	0.60		D				

1-251	440613.809	1112699.396	15.00	D			0.40	0.40		D				
1-252	440615.403	1112700.513	15.00	D			0.20	0.20		D				
1-253	440617.510	1112701.764	15.00	D			0.20	0.20		D				
1-254	440621.742	1112703.442	15.00	Y			0.40	0.40		D				
1-255	440623.944	1112705.635	15.00	Y			0.60	0.60		D				
1-256	440625.299	1112706.825	15.00	Y			0.50	0.80	0.80	C				
1-257	440627.691	1112709.158	16.00	Y			0.40	1.10	1.10	C				
1-258	440630.793	1112711.119	16.00	Y			0.30	0.30		D				
1-259	440632.640	1112711.888	16.00	Y			1.30	1.30		L				
1-264	440637.058	1112711.037	16.00	L		0.20	0.60	0.60		F	A	S	0.50	A
1-265	440639.642	1112708.436	16.00	L		0.30	0.50	0.50		F	A	S	1.50	C
1-266	440641.362	1112707.148	16.00	L		0.30	0.40	0.40		F	A	S	2.50	E
1-267	440643.428	1112706.134	16.00	L		0.30	0.30	0.30		F	A	S	3.50	G
1-268	440645.387	1112705.638	16.00	L		0.30	0.60	0.60		F	A	S	4.50	I
1-269	440648.819	1112705.896	16.00	L		0.30	0.40	0.40		F	A	S	5.50	K
1-270	440639.354	1112718.397	16.00	D			0.40	0.40		L	A	S		
1-271	440643.623	1112718.380	16.00	D			1.10	1.10		L	A	S		
1-272	440645.484	1112717.958	16.00	D			0.90	0.90		L	A	S		
1-273	440649.319	1112717.156	16.00	D			1.10	1.10		L	A	S		
1-274	440635.423	1112751.536	17.00	B	0.20	0.20	0.20	0.40	0.40	D	Q			
1-275	440636.472	1112753.847	17.00	B	0.20	0.20	0.40	0.70	0.70	D	Q			
1-276	440637.679	1112756.038	17.00	D			0.30	0.60	0.60	D				
1-277	440638.897	1112758.052	17.00	D			0.60	0.90	0.90	C				
1-278	440639.995	1112760.325	17.00	D			0.30	0.60	0.60	C				
1-279	440641.983	1112764.364	17.00	D			0.60	1.20	1.20	C				
1-280	440642.917	1112765.938	17.00	D			0.30	0.50	0.50	C				
1-281	440640.840	1112747.482	17.00	B	0.60		0.30	0.40	0.40	F	N	W		
1-282	440638.050	1112751.093	17.00	B			0.30	0.50	0.50	F	N	W		
1-283	440636.273	1112753.356	17.00	B			0.30	0.70	0.70	F	N	W		
1-284	440632.803	1112757.675	17.00	B	0.50	0.20	0.40	0.40		F	N	W		
1-285	440630.237	1112760.510	17.00	B	0.50	0.20	0.30	0.50	0.50	C	N	W		
1-286	440629.298	1112762.813	17.00	B	0.50	0.20	0.40	0.40		C	N	W		
1-287	440628.070	1112767.002	17.00	B	0.50	0.20	0.50	0.50		D	N	W		
1-288	440627.710	1112769.544	17.00	B	0.50	0.20	0.30	0.30		D	N	W		

1-289	440627.567	1112772.908	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-290	440626.901	1112775.754	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-291	440626.225	1112778.156	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-292	440624.950	1112782.214	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-293	440624.121	1112784.799	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-294	440622.879	1112788.040	17.00	B		0.40	0.30	0.30	0.30		D	N	W		
1-295	440621.933	1112791.237	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-296	440620.860	1112794.518	17.00	B		0.50	0.20	0.30	0.30		D	N	W		
1-297	440619.639	1112797.322	17.00	B		0.60	0.20	0.30	0.60	0.60	D	N	W		
1-298	440616.078	1112801.262	17.00	B				0.20	0.70	0.70	C				
1-299	440616.621	1112803.516	17.00	B				0.30	0.50	0.50	C				
1-300	440616.343	1112805.513	17.00	B				0.30	0.40	0.40	C				
1-301	440616.123	1112807.186	17.00	B				0.30	0.50	0.50	C				
1-302	440616.078	1112809.030	17.00	B	33.00	0.30	0.20	0.20	0.40	0.40	F	N	W		
1-303	440618.114	1112809.811	18.00	B	33.00	0.40	0.20	0.30	0.70	0.70	F	N	W		
1-304	440616.491	1112812.104	18.00	D	33.00	0.30	0.20	0.30	1.00	1.00	F	N	W		
1-305	440615.997	1112814.799	18.00	D	33.00	0.40	0.20	0.00	0.00	0.00	F	N	W		
1-306	440615.829	1112818.901	18.00	D	33.00	0.50	0.20	0.30	0.30		F	N	W		
1-307	440616.529	1112821.986	18.00	D	33.00	0.30		0.30	0.30		F	N	W		
1-308	440617.868	1112824.836	18.00	D	33.00	0.30		0.10	0.30	0.30	D	N	W		
1-309	440619.461	1112827.630	18.00	D	33.00	0.30					D	N	W		
1-310	440622.462	1112830.971	18.00	D	33.00	0.20		0.30	0.30		D	N	W		
1-311	440624.272	1112833.124	18.00	D	33.00	0.20		0.30	0.30		D	N	W		
1-312	440626.071	1112835.218	18.00	D	45.00	0.30		0.30	0.30		D	N	W		
1-313	440627.015	1112837.065	18.00	D	45.00	0.30		0.30	0.30		D	N	W		
1-314	440627.207	1112805.189	18.00	B	33.00	0.30	0.20	0.20	0.40	0.40	F	N	W	0.60	B
1-315	440629.003	1112801.034	18.00	B	33.00	0.50		0.30	0.40	0.40	L	N	W	0.80	B
1-316	440630.207	1112798.376	18.00	B	33.00	0.50		0.30	0.40	0.40	L	N	W	1.30	C
1-317	440631.953	1112796.051	18.00	B	45.00	0.40		0.30	0.60	0.60	C	N	W	0.80	B
1-318	440633.223	1112793.978	18.00	B	45.00	0.40	0.40	0.30	0.40	0.40	C	Q		0.50	A
1-319	440633.711	1112792.667	18.00	B	45.00	0.40	0.40	0.30	0.70	0.70	C	Q		0.50	A
1-320	440633.867	1112791.021	18.00	B	45.00	0.40	0.40	0.30	0.80	0.80	C	Q		0.50	A
1-321	440633.862	1112787.459	18.00	B	33.00	0.40	0.40	0.20	0.80	0.80	F	Q		0.60	B
1-322	440633.906	1112784.004	17.00	B	33.00	0.20	0.40	0.40	0.60	0.60	F	D	E	0.60	B

1-323	440639.207	1112778.781	17.00	Y	33.00			0.50	0.70	0.70	F	D	E		
1-324	440636.695	1112778.694	17.00	Y	33.00			0.80	0.80		F	D	E		
1-325	440637.751	1112775.831	17.00	Y	33.00			0.40	0.60	0.60	F	D	E		
1-326	440639.105	1112771.873	17.00	Y	33.00	0.30	0.30	0.30	0.50	0.50	F	D	E	1.30	C
1-333	440615.909	1112807.028	17.00	B		0.20	0.20	0.20	0.20		L	Q			
1-334	440611.355	1112806.665	17.00	B		0.20	0.20	0.20	0.40	0.40	L	Q			
1-335	440609.215	1112806.931	17.00	B		0.20	0.20				N	Q			
1-336	440607.864	1112806.440	17.00	B	33.00	0.20	0.20				N	Q			
1-337	440605.600	1112805.791	17.00	B	33.00	0.30	0.30	0.20	0.20		D	Q			
1-338	440599.583	1112804.123	16.00	B	33.00	0.20	0.20	0.30	0.30		D	Q			
1-339	440597.262	1112803.814	16.00	B	33.00	0.20	0.20				N	Q			
1-340	440593.962	1112803.042	16.00	B	33.00	0.30	0.30				N	Q		1.40	C
1-341	440591.313	1112802.159	15.00	B	33.00	0.40	0.20				N	N	S	1.40	C
1-342	440588.464	1112801.177	15.00	B	33.00	0.20	0.20	0.40	0.40		L	Q		0.80	B
1-343	440585.451	1112800.796	15.00	B	33.00	0.20	0.20				N	Q		0.80	B
1-344	440582.205	1112799.627	15.00	B	33.00	0.20	0.20				N	Q		0.80	B
1-345	440580.301	1112798.829	15.00	B	45.00	0.30	0.30				N	Q		0.10	A
1-346	440578.539	1112797.854	14.00	B	45.00	0.40	0.20	0.30	0.30		D	N	SE	0.80	B
1-347	440572.254	1112795.327	14.00	B	45.00	0.40	0.30	0.30	0.40	0.40	D	N	E	0.90	B
1-348	440569.782	1112793.707	14.00	B	33.00	0.20	0.20				N	Q		1.40	C
1-349	440568.143	1112792.258	14.00	B	33.00	0.30	0.30	0.20	0.80	0.80	L	Q		1.60	D
1-350	440566.151	1112790.324	14.00	B	33.00	0.40	0.40	1.00	1.00		L	Q		1.60	D
1-351	440564.122	1112788.589	14.00	B	33.00	0.40	0.40	0.30	0.30		L	Q		0.80	B
1-352	440563.345	1112786.702	14.00	B	33.00	0.40	0.40	0.30	0.30		L	Q		0.80	B
1-353	440563.276	1112786.624	14.00	B	33.00	0.40	0.40	0.20	0.50	0.50	C	Q		1.10	C
1-354	440560.878	1112784.474	14.00	B	33.00	0.40	0.40	0.20	0.60	0.60	C	Q		1.10	C
1-355	440558.833	1112781.921	13.00	B	33.00	0.20	0.20	0.30	0.30		D	Q			
1-356	440557.714	1112780.777	13.00	B	33.00	0.20	0.20	0.40	0.40		D	Q			
1-410	440747.000	1112932.385	21.00	L											
1-411	440744.000	1112933.051	21.00	L											
1-412	440741.000	1112934.000	21.00	L											
1-413	440739.000	1112934.446	21.00	L											
1-414	440738.000	1112937.466	21.00	L											
1-415	440736.000	1112938.382	20.00	L											

Appendix C.9 Gallow Hill Multiple Field System

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Ht In	Ht Out	St Size	St Size 2	Min Stone	All max	Max Stone	Dense	Dif Face	Face 2	Width
1	425641.355	1151199.360	51.631	B	0	0	0	0	0	C	o	0.30	0.40	0.40	D	o		0
2	425645.027	1151198.921	51.155	B						C		0.30	0.40	0.40	D			
3	425647.480	1151198.717	50.996	B						C		0.30	0.40	0.40	D			
4	425650.065	1151198.766	50.736	B						C		0.30	0.40	0.40	D			
5	425653.330	1151198.553	50.301	B						C		0.30	0.40	0.40	D			
6	425657.574	1151198.534	50.089	B						C		0.30	0.40	0.40	D			
7	425661.499	1151198.354	49.693	B						C		0.30	0.40	0.40	D			
8	425664.336	1151198.995	49.465	B						C		0.30	0.40	0.40	D			
9	425667.152	1151199.551	49.110	B						C		0.30	0.40	0.40	D			
10	425669.341	1151199.421	48.924	B						C		0.30	0.40	0.40	D			
11	425672.585	1151200.287	48.493	B						C		0.30	0.40	0.40	D			
12	425675.990	1151199.505	48.078	B						C		0.30	0.40	0.40	D			
13	425678.261	1151198.811	47.737	B						D		0.70	0.70		D			
14	425655.786	1151198.252	50.195	Y						D		0.70	0.70		D			
15	425656.923	1151196.396	50.160	Y						D		0.70	0.70		D			
16	425658.115	1151194.671	50.082	Y						D		0.70	0.70		D			
17	425658.506	1151193.924	50.069	Y						D		0.70	0.70		D			
18	425642.526	1151184.870	51.992	B						C		0.30	0.40	0.40				
19	425644.267	1151186.214	51.752	B						C		0.30	0.40	0.40				
20	425648.196	1151187.786	51.028	B						C		0.30	0.40	0.40				
21	425650.423	1151188.971	50.833	B						C		0.30	0.40	0.40				
22	425653.065	1151190.827	50.527	B						C		0.30	0.40	0.40				
23	425655.528	1151192.348	50.278	B						C		0.30	0.40	0.40				
24	425658.326	1151194.141	50.104	B						C		0.30	0.40	0.40				
25	425660.429	1151194.827	49.916	B						C		0.30	0.40	0.40				

26	425662.851	1151195.754	49.799	B						C		0.30	0.40	0.40				
27	425664.700	1151194.843	49.528	B						C		0.30	0.40	0.40				
28	425668.255	1151194.034	49.070	B						C		0.30	0.40	0.40				
29	425668.266	1151194.032	49.075	B						C		0.30	0.40	0.40				
30	425671.248	1151193.766	48.778	B						C		0.30	0.40	0.40				
31	425673.838	1151192.215	48.475	B						C		0.30	0.40	0.40				
32	425675.870	1151192.364	48.219	B						C		0.30	0.40	0.40				
33	425680.809	1151193.497	47.641	Y						C		0.30	0.40	0.40				
34	425682.265	1151194.021	47.466	Y						C		0.30	0.40	0.40				
35	425685.995	1151194.892	46.853	Y						C		0.30	0.40	0.40				
36	425689.990	1151194.731	46.436	Y						C		0.30	0.40	0.40				
37	425718.294	1151165.276	44.620	L	33	F	Z	1		B		0.20	0.20		C	NE	N	3
38	425715.325	1151167.942	44.562	L	45	E	Z	0.7		A	D	0.20	0.50	0.50	C	NE	N	1
39	425712.942	1151169.416	44.568	L	33	F	A	1	0.1	A	C	0.10	0.40	0.40	C	NE	N	2
40	425711.038	1151172.166	44.426	L	33	F	A	1	0.1	A	C	0.10	0.40	0.40	C	NE	N	2
41	425707.983	1151175.896	44.710	L	33	F	A	1	0.1	A	C	0.10	0.40	0.40	C	NE	N	2
42	425703.588	1151179.502	44.912	L	33	F	A	1	0.1	A	C	0.10	0.40	0.40	C	NE	N	2
43	425700.296	1151183.956	45.545	L	33	F	B	1	0.2	A	D	0.10	0.60	0.60	C	NE	N	1
44	425698.588	1151185.838	45.692	L	33	F	B	1.3	0.2	A	C	0.10	0.40	0.40	C	NE	N	1
45	425696.642	1151188.226	45.781	L	33	F	B	1.3	0.2	A	C	0.10	0.40	0.40	C	E	N	1.5
46	425696.406	1151190.665	45.703	L	33	F	Z	1		A	B	0.10	0.20	0.20	C	E	N	1
47	425695.806	1151192.896	45.790	L	33	E	Z	0.7		A	B	0.10	0.20	0.20	C	E	N	1
48	425696.164	1151194.866	45.750	L	33	D	Z	0.5		A	B	0.10	0.20	0.20	C	E	N	1
49	425696.946	1151195.698	45.609	L	33	D	Z	0.5		A	B	0.10	0.20	0.20	C	E	N	1
50	425696.902	1151195.779	45.610	B	33	C	C	0.4	0.4	C		0.20	0.30	0.30	C			3.2
51	425699.752	1151196.149	45.277	B	33	C	C	0.4	0.4	C		0.20	0.30	0.30	C			3.2
52	425702.562	1151197.240	45.067	B	33	C	C	0.4	0.4	C		0.20	0.30	0.30	C			3.2
53	425705.027	1151197.650	44.871	B	33	D	C	0.6	0.4	C		0.30	0.40	0.40	C			4
54	425708.100	1151197.973	44.509	B	33	D	C	0.6	0.4	C		0.30	0.40	0.40	C			4

55	425710.709	1151199.405	44.303	B	33	D	C	0.6	0.4	C		0.30	0.40	0.40	C			4
56	425714.109	1151202.165	43.812	B	33	C	C	0.3	0.3	C		0.30	0.40	0.40	C			1.5
57	425716.865	1151204.562	43.734	B		Z	Z			C		0.30	0.40	0.40	C			1.5
58	425720.389	1151205.569	43.574	B		Z	Z			C		0.30	0.40	0.40	C			1.5
59	425723.649	1151205.730	43.300	B		Z	C		0.4	C		0.30	0.40	0.40	C	S	O	1.5
60	425725.726	1151205.708	42.983	B	33	Z	C		0.4	C		0.30	0.40	0.40	C	S	O	1.5
61	425725.233	1151207.431	42.664	L	33	E	Z	0.75		C		0.30	0.40	0.40	C	W	U	2
62	425725.146	1151207.343	42.666	L	33	E	Z	0.75							C	W	U	1.5
63	425726.053	1151210.098	42.166	L	33	D	Z	0.5		B		0.20	0.20		D	W	U	1.5
64	425726.885	1151213.195	41.749	L	33	D	B	0.5	0.2	B		0.20	0.20		D	W	O	1.5
65	425727.519	1151216.289	41.082	L	33	Z	C		0.4	A	D	0.10	0.40	0.40	C	W	O	4
66	425727.129	1151219.219	40.604	L	33	B	F	0.2	1	B	D	0.20	0.30	0.30	D	W	O	1.5
67	425726.827	1151221.716	40.415	L	33	Z	E		0.75	B		0.20	0.20		L	W	O	1.5
68	425726.804	1151223.314	40.221	L	33	Z	D		0.5	B		0.20	0.20		L	W	O	5
69	425728.455	1151224.001	39.839	B	33	C	C	0.4	0.4	B	D	0.20	0.40	0.40	C			2
70	425730.500	1151225.158	39.447	B	33	B	B	0.2	0.2						D			1
71	425733.489	1151227.281	38.918	B	33	Z	C	0.2	0.4	C		0.30	0.40	0.40	D	NW	O	1.5
72	425736.114	1151229.255	38.285	B	33	B	D	0.2	0.5	C		0.30	0.30		D	NW	O	1.5
73	425737.293	1151231.725	38.093	B	33	B	B	0.2	0.2						N			1.5
74	425737.964	1151235.022	37.719	B	33	B	Z	0.2		C		0.30	0.30		D			1.5
75	425739.180	1151237.834	37.684	B	33	B	Z	0.2		C		0.30	0.30		D			1.5
76	425740.283	1151240.063	37.649	B	33	B	Z	0.2		C		0.30	0.30		D			1.5
77	425741.151	1151242.518	37.932	B	33	B	Z	0.2		C		0.30	0.30		D			1.5
78	425741.493	1151244.278	38.011	B	33	B	Z	0.2		D		0.40	0.50	0.50	C			1.5
79	425726.677	1151211.407	41.958	B	33	D	B	0.5	0.2	C		0.30	0.30		C	N	N	4
80	425728.029	1151210.482	42.000	B	45	D	C	0.5	0.4	C		0.30	0.30		C	N	N	2.3
81	425730.827	1151209.284	41.931	B	45	D	C	0.5	0.4	C		0.30	0.30		C	N	N	3
82	425733.241	1151208.215	41.699	B	45	Z	B		0.2	C		0.30	0.30		C	N	N	0.75
88	425725.112	1151201.434	43.095	D		Z	Z			B		0.20	0.30	0.30	D			

89	425725.890	1151198.180	43.213	D		Z	Z			B		0.20	0.30	0.30	D			
90	425726.469	1151194.977	43.296	D		Z	Z			B		0.20	0.30	0.30	D			
91	425726.573	1151192.539	43.353	D		Z	Z			B		0.20	0.30	0.30	D			
92	425727.070	1151190.197	43.183	D		Z	Z			C		0.30	0.40	0.40	C			0.9
93	425727.121	1151190.165	43.185	D		Z	Z			C		0.30	0.40	0.40	C			0.9
94	425727.829	1151187.892	42.947	D		Z	Z			C		0.30	0.40	0.40	C			0.9
95	425728.845	1151184.056	42.792	D		Z	Z			C	D	0.30	0.50	0.50	C			0.9
96	425729.367	1151181.656	42.337	D		Z	Z			C	D	0.30	0.50	0.50	C			0.9
97	425728.009	1151178.510	42.489	D		Z	Z			C		0.30	0.40	0.40	C			0.9
98	425727.225	1151174.663	42.607	D		Z	Z			C		0.30	0.30		C			0.9
99	425725.426	1151170.915	43.077	D		B	B	0.2		C		0.30	0.30		D			0.7
100	425723.165	1151169.366	43.310	D		B	B	0.2		C		0.30	0.30		D			0.7
101	425721.495	1151168.642	43.544	D		Z	Z			C		0.30	0.30		D			0.7
155	425695.923	1151195.727	45.745	D	33	D	A			B		0.10	0.20	0.20	C	NE	N	2
156	425694.002	1151196.907	46.096	D	33	D	A	0.6	0.1	B		0.10	0.20	0.20	C	NE	N	2
157	425692.237	1151198.627	46.230	D	33	E	A	0.6	0.1	A	D	0.10	0.50	0.50	C	NE	N	2
158	425690.821	1151200.190	46.429	D	33	E	A	0.75	0.1	A	D	0.10	0.50	0.50	C	NE	N	2
159	425688.453	1151202.593	46.558	L	33	D	A	0.75	0.1	C		0.30	0.40	0.40	D	NE	N	2
160	425686.045	1151204.879	46.651	L	33	D	Z	0.6	0.1	C		0.30	0.40	0.40	D	NE	N	1.5
161	425683.818	1151207.344	46.755	L	33	D	Z	0.6	0.1	C		0.30	0.40	0.40	D	NE	N	0.75
162	425681.346	1151209.236	46.719	L	33	Z	Z	0.6	0.1	C		0.30	0.40	0.40	D	NE	N	0.75
163	425678.101	1151211.454	46.940	L	33	Z	Z			C		0.30	0.40	0.40	D	NE	N	0.75
164	425675.880	1151212.545	47.105	L	33	Z	Z			C		0.30	0.40	0.40	D	N	N	0.75
165	425672.533	1151213.111	47.547	L	33	G	Z			C		0.30	0.30		C	N	N	3
166	425669.875	1151213.986	47.777	L	33	G	Z	2		C		0.30	0.30		C	N	N	0.9
167	425669.806	1151213.915	47.776	L	33	G	Z	1.5		C		0.30	0.30		C	N	N	0.9
168	425667.458	1151215.429	48.047	L	33	D	Z	1.5		C		0.30	0.30		D	NE	N	0.9
169	425666.156	1151217.145	47.994	L	33	C	Z	0.5		C		0.30	0.30		D	NE	N	0.9
170	425664.195	1151218.291	48.036	D	33	Z	Z	0.4		C		0.30	0.30		D	N	N	0.9

171	425661.756	1151219.849	48.084	D	33	Z	Z			C	0.30	0.30	D	N	N	0.9
172	425659.421	1151221.754	48.124	D	33	Z	Z			C	0.30	0.30	D	NE	N	0.9
173	425657.523	1151223.334	48.052	D	33	Z	Z			C	0.30	0.30	D	NE	N	0.4
174	425656.031	1151227.023	48.044	D	33	Z	Z			C	0.30	0.30	D	E	N	0.4
175	425655.126	1151230.777	47.825	D	33	Z	Z			C	0.30	0.30	D	E	N	0.4
176	425654.991	1151235.251	47.065	D	33	Z	Z			C	0.30	0.30	D	E	N	0.4
177	425654.781	1151236.497	46.954	D	33	Z	Z			C	0.30	0.30	D	E	N	0.4
178	425659.404	1151239.014	45.489	B	33	C	C			C	0.30	0.30	C			2.2
179	425659.360	1151239.079	45.479	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
180	425661.103	1151240.171	44.964	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
181	425663.145	1151241.619	44.406	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
182	425665.071	1151243.143	43.933	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
183	425666.899	1151245.283	43.358	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
184	425668.371	1151247.397	42.693	B	33	C	C	0.4	0.4	C	0.30	0.30	C			2.2
235	425676.543	1151274.606	43.932	D						C	0.30	0.30	C			0.9
236	425679.333	1151275.427	43.650	D						C	0.30	0.30	C			0.9
237	425681.731	1151275.323	43.391	D						E	0.70	0.70	C			0.9
238	425685.780	1151274.956	42.954	D						E	0.90	0.90	C			0.9
239	425686.930	1151274.955	42.884	D						F	1.10	1.10	C	S	N	0.9
240	425686.954	1151274.945	42.880	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
241	425689.007	1151275.986	42.675	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
242	425691.531	1151276.729	42.358	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
243	425693.776	1151277.389	42.190	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
244	425696.111	1151277.593	41.959	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
245	425699.123	1151277.320	41.604	L	33	A	Z	0.1		B	0.20	0.20	D	S	N	0.5
246	425701.402	1151276.219	41.490	L	33	A	Z	0.1		B	0.20	0.20	D	SW	N	0.5
247	425703.782	1151274.289	41.186	L	33	A	Z	0.1		B	0.20	0.20	D	SW	N	0.5
248	425706.291	1151272.388	40.980	B	33	B	C	0.1		B	0.20	0.20	D	NE	O	3
249	425708.388	1151269.970	40.834	B	33	B	C	0.2	0.4	B	0.20	0.20	D	NE	O	3

250	425709.642	1151267.252	40.627	B	33	B	C	0.2	0.4	B		0.20	0.20		D	NE	O	2
251	425711.021	1151264.654	40.399	B	33	B	C	0.2	0.4	B		0.20	0.20		D	E	O	1.5
252	425711.779	1151262.561	40.234	L	33	Z	C	0.2	0.4	B		0.20	0.20		D	E	O	1.5
253	425712.402	1151259.979	40.288	L	33	Z	C		0.3	B		0.20	0.20		D	E	O	1.5
254	425712.857	1151256.096	40.131	L	33	Z	C		0.4	B		0.20	0.20		D	E	O	1.5
255	425712.348	1151254.754	40.185	L	33	Z	C		0.4	B		0.20	0.20		D	E	O	1
256	425711.936	1151249.062	40.016	L		Z	Z		0.4	B		0.20	0.20		D	W	N	0.5
257	425711.547	1151247.084	40.209	L		A	Z			N						W	N	
258	425710.745	1151245.146	40.353	L	45	A	Z	0.1		B		0.20	0.20		D	W	N	1
259	425709.726	1151242.502	40.774	L	45	C	Z	0.1		B		0.20	0.20		C	W	N	2
260	425708.637	1151239.871	41.023	L	33	D	B	0.4		B		0.20	0.20		C	W	D	3
261	425710.815	1151239.313	41.141	L	33	D	B	0.6	0.2	B		0.20	0.20		C	SW	D	3
262	425712.492	1151238.434	41.098	B	33	E	B	0.6	0.2	B		0.20	0.20		D	SW	D	3
263	425715.371	1151236.313	40.941	B	33	E	B	0.8								SW	D	3
264	425718.264	1151233.886	40.744	B	33	E	B	0.8								SW	D	3
265	425721.746	1151229.849	40.551	B	33	F	B	1	0.3	B		0.20	0.20		D	SW	D	3
266	425723.870	1151227.783	40.324	B	33	F	B	1.5	0.3	B		0.20	0.20		C	SW	D	4
267	425725.521	1151225.628	40.083	B	33	F	B	1.5	0.3	B	C	0.20	0.20	0.40	C	SW	D	5
268	425727.352	1151224.019	39.978	B	33	D	B	0.5	0.3	B	C	0.20	0.20	0.40	C	SW	D	5
277	425692.996	1151253.744	40.844	M						B		0.20	0.20					
278	425690.932	1151253.883	40.881	M						B		0.20	0.20					
279	425688.348	1151254.185	41.011	M						B		0.20	0.20					
280	425686.406	1151254.524	41.153	M						B		0.20	0.20					
281	425684.729	1151255.901	41.225	M						B		0.20	0.20					
282	425684.211	1151257.223	41.169	M						B		0.20	0.20					
283	425684.438	1151257.687	41.128	M						B		0.20	0.20					
284	425685.733	1151256.983	41.117	M						B		0.20	0.20					
285	425687.703	1151257.261	40.982	M						B		0.20	0.20					
286	425689.290	1151257.079	41.015	M						B		0.20	0.20					

287	425691.062	1151256.455	40.883	M					B		0.20	0.20					
288	425692.486	1151255.242	40.862	M					B		0.20	0.20					
289	425693.303	1151254.043	40.853	M					B		0.20	0.20					
290	425680.660	1151210.298	46.748	M					B		0.20	0.20					
336	425686.505	1151225.404	44.198	L	45	A	Z	0.2	C		0.40	0.40		D	SE	N	0.5
337	425687.275	1151227.579	43.850	L	45	A	Z	0.2						N	SE	N	0.5
338	425688.765	1151230.668	43.388	L	45	A	Z	0.2						N	SE	N	0.5
339	425689.295	1151231.978	43.135	L	45	A	Z	0.2	C		0.40	0.40		D	SE	N	0.5
340	425691.604	1151236.529	42.366	D	90	A	Z	0.1	C		0.30	0.30	0.40	F	SE	N	0.4
341	425692.304	1151238.600	42.011	D	90	A	Z	0.1	C		0.30	0.30	0.40	F	SE	N	0.4
342	425693.494	1151241.879	41.365	D	90	A	Z	0.1	C		0.30	0.30	0.40	F	SE	N	0.4
343	425694.521	1151243.548	40.962	D	90	A	Z	0.1	C		0.30	0.30	0.40	F	SE	N	0.4
344	425696.146	1151246.341	40.688	D	90	A	Z	0.1	C		0.30	0.30	0.40	F	SE	N	0.4
414	425718.826	1151164.428	44.681	L	45	C	Z	0.4	C		0.40	0.40		D	SW	D	0.75
415	425720.699	1151162.107	44.532	L	45	C	Z	0.4	C		0.40	0.40		D	SW	D	0.75
416	425723.893	1151159.175	44.279	L	45	D	Z	0.5	C		0.40	0.40		D	SW	D	0.75
417	425725.934	1151157.150	44.087	L	45	D	Z	0.5	C		0.40	0.40		D	SW	D	0.75
418	425727.546	1151154.952	44.003	L	45	D	Z	0.5	C		0.40	0.40		D	SW	D	0.75
419	425729.548	1151151.742	43.728	L	45	D	Z	0.5	C		0.40	0.40		D	SW	D	0.75
420	425730.850	1151150.077	43.503	L	45	C	Z	0.3	D		0.50	0.50		D	SW	D	0.75
421	425733.415	1151147.520	43.304	L	45	B	Z	0.2	D		0.50	0.50		D	SW	D	0.75
422	425735.060	1151145.896	43.396	L	45	B	Z	0.2	F		1.35	1.35		C	SW	D	1.2
423	425739.450	1151142.530	42.985	L	45	B	Z	0.2	C		0.30	0.30		D	SW	D	1.2
424	425743.015	1151140.543	42.491	L	45	C	Z	0.4						N	SW	D	1
425	425746.034	1151138.262	41.854	L	45	C	Z	0.4						N	SW	D	1
426	425750.214	1151135.159	40.840	L	45	C	Z	0.4						N	SW	D	1
427	425754.662	1151131.946	40.219	L	33	C	Z	0.3	C		0.30	0.30		D	SW	D	1
428	425758.836	1151129.164	40.021	L	33	B	Z	0.2	B	D	0.20	0.20	0.50	F	SW	D	1
429	425763.392	1151125.692	40.162	L	33	A	Z	0.1	C	D	0.30	0.30	0.50	F	SW	D	1

430	425767.385	1151121.045	40.464	L	33	A	Z	0.1		C		0.30	0.30		D	SW	D	1
431	425771.928	1151115.556	40.555	L	33	A	Z	0.1		C		0.40	0.40		D	SW	D	1
432	425774.103	1151114.364	40.201	L	90	B	Z	0.2		C		0.30	0.30		D	SE	D	1
433	425775.457	1151117.730	39.901	L	90	B	Z	0.2		C		0.30	0.30		D	SE	D	1
434	425774.661	1151119.434	40.007	D		Z	Z			B	D	0.20	0.20	0.50	F			0.75
435	425772.522	1151122.631	40.102	D	90	Z	B		0.2	C		0.40	0.40		C	SE	O	0.5
436	425773.893	1151124.755	39.789	D	90	Z	B		0.3	C		0.40	0.40		C	SE	O	0.5
437	425775.547	1151126.537	39.458	L	0	Z	Z			C		0.30	0.30		D			0.5
438	425777.176	1151128.258	39.183	L	0	Z	Z			B		0.30	0.30		D			0.5
439	425779.165	1151130.209	38.922	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
440	425780.565	1151131.193	38.651	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
441	425783.601	1151135.774	37.912	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
442	425785.391	1151138.434	37.183	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
443	425784.944	1151141.844	36.391	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
444	425783.350	1151146.760	35.995	L	0	Z	Z			B		0.20	0.20	0.30	D			0.5
445	425782.043	1151148.774	36.026	D	33	B	B	0.2	0.2	C		0.30	0.30		C			0.9
446	425781.539	1151149.440	36.039	D	33	B	B	0.2	0.2	C		0.30	0.30		C			1.2
447	425781.571	1151149.457	36.050	D	33	B	B	0.2	0.2	C		0.30	0.30		C			1.2
448	425782.000	1151153.445	35.931	D	33	B	B	0.2	0.2	C		0.30	0.30		C			0.9
449	425782.539	1151156.593	35.678	D	33	F	B	0.2	0.2	D		0.60	0.60		C			1.5
450	425783.211	1151159.463	35.711	D	33	C	B	0.2	0.2	D		0.50	0.50		C			2
451	425782.483	1151163.133	35.947	D	33			0.2	0.2	D		0.60	0.60		C			2
452	425781.399	1151166.414	36.781	D	33			0.2	0.2	D		0.50	0.50		C			1
453	425779.615	1151168.494	37.471	D	45			1.5	0.2	D		0.50	0.50		C			0.8
454	425776.093	1151169.968	37.826	D	45			0.3	0.2	E		0.80	0.80		C			1.5
455	425774.377	1151171.578	38.274	D						E		0.80	0.80		C			1
456	425772.978	1151173.144	38.316	D						D		0.50	0.50		C			0.6
457	425773.003	1151176.182	38.375	D						D		0.50	0.50		C			0.6
458	425772.644	1151179.243	38.499	D						D		0.50	0.50		C			0.6

459	425773.077	1151182.383	38.415	D						D		0.50	0.50		C			1
460	425773.036	1151186.020	38.352	D						D		0.50	0.50		C			1
461	425772.669	1151190.215	37.955	D						F		1.00	1.00		C			1.2
462	425772.563	1151194.347	37.604	D						F		1.20	1.20		C			1.2
463	425769.305	1151198.628	37.700	D						E		0.75	0.75		C			1.2
464	425766.776	1151201.391	37.643	D						D		0.60	0.60		C			1
465	425764.659	1151205.327	37.601	D						C	D	0.30	0.30	0.50	C			1
466	425763.404	1151207.678	37.585	D						C	D	0.30	0.30	0.50	C			
467	425759.906	1151211.251	37.274	D						D		0.50	0.50		C			0.6
468	425758.502	1151212.603	37.260	D						D		0.50	0.50		C			0.5
469	425756.985	1151214.962	36.902	D						D		0.50	0.50		C			0.5
470	425755.190	1151216.997	36.854	D	45		D		0.6	D		0.50	0.50		D		D	0.8
471	425752.542	1151219.440	36.675	D	45		E		0.75	E		1.00	1.00		D		D	0.8
472	425750.421	1151224.142	36.057	D	0		Z			C		0.40	0.40		D			0.8
473	425749.499	1151228.182	36.080	D	0		Z			C		0.40	0.40		D			0.5
474	425748.437	1151232.282	36.159	D	0		Z			C		0.30	0.30		D			0.5
475	425748.084	1151235.057	36.492	D	45	D	Z	0.6		C		0.40	0.40		C	SW	N	1
476	425745.167	1151237.771	37.116	D	45	D	Z	0.6		C		0.30	0.30		C	SW	N	1
477	425740.965	1151239.036	37.399	D	45	C	Z	0.3		C		0.30	0.30		D	SW	N	1
493	425733.522	1151147.299	43.297	D	0	Z	Z			C		0.30	0.40	0.40	C			1.2
494	425736.484	1151150.931	42.934	D	0	Z	Z			C		0.30	0.40	0.40	C			1.2
495	425738.697	1151153.733	42.401	D	0	Z	Z			C		0.30	0.40	0.40	C			1.2
496	425740.898	1151156.360	41.991	D	0	Z	Z			C		0.30	0.40	0.40	C			1.2
497	425743.065	1151158.634	41.509	D	0	Z	Z			D		0.95	0.95		D			1.2
498	425743.728	1151159.826	41.391	D	0	Z	Z			C		0.30	0.40	0.40	C			1.2
499	425746.028	1151161.515	40.754	D	0	Z	C		0.3	C		0.30	0.40	0.40	D			0.8
500	425749.272	1151162.903	40.432	D	45	C	Z	0.3		C		0.30	0.40	0.40	C			0.8
501	425753.462	1151164.656	39.884	D	45	C	Z	0.3		C		0.30	0.40	0.40	C			0.8
502	425756.709	1151165.593	39.448	D	45	C	Z	0.3		C		0.30	0.40	0.40	C			0.8

503	425760.700	1151166.984	39.117	D	45	D	Z	0.5		C	0.30	0.40	0.40	C			1
504	425763.522	1151168.874	38.811	D	45	D	Z	0.5		D	0.60	0.60		C			1
505	425766.562	1151170.379	38.431	D	45	D	Z	0.5		D	0.60	0.60		C			1
506	425769.903	1151171.886	38.491	D	0	Z	Z			E	0.80	0.80		C			0.9
507	425773.846	1151173.022	38.292	D	0					E	0.90	0.90		C			0.9
516	425782.726	1151174.677	37.331	D						C	0.30	0.30		C			
517	425785.038	1151174.458	36.735	D						C	0.30	0.30		C			
518	425787.727	1151173.872	36.124	D						C	0.30	0.30		C			
519	425788.665	1151173.502	35.885	D						C	0.30	0.30		C			
520	425776.855	1151180.939	38.156	D						C	0.30	0.30		C			
521	425779.060	1151179.566	37.934	D						C	0.30	0.30		C			
522	425781.264	1151178.939	37.677	D						C	0.30	0.30		C			
548	425718.972	1151279.922	39.906	D	0	Z	Z			D	0.50	0.50		C			
549	425722.705	1151279.163	39.495	D	0	Z	Z			D	0.50	0.50		D			
550	425725.105	1151278.532	39.211	L	45	C	Z	0.3		B	0.30	0.30		C	S	N	0.5
551	425728.111	1151278.303	39.027	L	45	C	Z	0.3		B	0.30	0.30		C	S	N	0.5
552	425732.300	1151277.114	38.530	L	45	C	Z	0.3		B	0.30	0.30		C	S	N	0.5
553	425736.761	1151275.687	38.044	L	45	C	Z	0.3		B	0.30	0.30		C	S	N	0.5
554	425740.658	1151273.247	37.478	L	45	Z	C		0.3	B	0.30	0.30		C	SW	D	1
555	425742.998	1151270.067	37.118	L	45	Z	C		0.3	B	0.30	0.30		C	SW	D	1
556	425744.684	1151266.023	36.765	L	45	Z	C		0.3	B	0.30	0.30		C	W	D	1
557	425745.254	1151262.784	36.864	L	45	Z	C		0.3	B	0.30	0.30		C	W	D	0.5
558	425745.432	1151260.044	36.992	L	45	Z	C		0.3	B	0.30	0.30		C	W	D	0.5
559	425745.107	1151256.366	37.147	L	45	Z	C		0.3	B	0.30	0.30		C	W	D	0.5
560	425746.372	1151250.623	37.043	B	45		A		0.4	B	0.30	0.30		D	W	D	4
561	425746.674	1151249.241	37.277	B										D			
562	425746.719	1151247.619	37.266	B										D			
563	425747.175	1151244.155	37.203	B										D			
564	425747.819	1151242.934	36.992	B										D			

565	425747.991	1151240.565	36.773	B	D
566	425749.822	1151241.537	36.627	B	D
567	425751.951	1151242.756	36.394	B	D
568	425753.611	1151242.680	35.996	B	D

Appendix C.10 Ness of Gruting Multiple Field System

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max st	St Dense	Dir face	Width	width
35	427798.198	1148343.444	32.632	L	33		D				N	D	1.00	B
36	427798.965	1148341.171	32.430	L	33		D				N	D	1.00	B
37	427796.979	1148337.744	32.232	L	33		D				N	D	1.50	C
38	427792.117	1148337.005	32.446	L	33		E				N	D	2.00	
39	427788.606	1148336.164	32.476	L	33		E				N	D	1.50	C
40	427785.680	1148334.726	32.315	L	33		D	0.20	0.20		L	D	1.00	B
41	427782.430	1148333.294	32.123	L	33		B	0.20	0.20		L	D	1.00	B
42	427780.990	1148332.245	31.927	L	33		B	0.20	0.20		L	D	1.00	B
43	427778.087	1148335.418	32.415	L	45		C				N	D	0.75	B
44	427773.858	1148335.632	32.498	L	45		C	0.20	0.20		L	D	0.75	B
45	427769.503	1148335.763	32.461	L	33		C	0.20	0.20		L	D	0.75	B
46	427765.789	1148335.786	32.265	L	33		C	0.20	0.20		L	D	0.75	B
54	427761.300	1148329.355	30.962	L	33		D				N	D	1.00	B
55	427758.846	1148327.742	30.868	L	33		E				N	D	1.00	B
56	427754.408	1148326.069	30.927	L	33		E				N	D	1.00	B
57	427750.885	1148324.651	30.995	L	33		E				N	D	1.00	B
58	427745.766	1148323.261	30.946	L	33		E				N	D	1.00	B
59	427739.345	1148320.041	30.835	L	33		F	0.20	0.30	0.30	F	D	2.00	D
60	427736.937	1148320.203	31.024	L	33		F	0.20	0.30	0.30	F	D	2.00	D
61	427734.843	1148319.309	31.002	L	33		F	0.20	0.30	0.30	F	D	2.00	D
62	427735.468	1148316.543	30.299	L	33		F	0.20	0.30	0.30	F	D	2.00	D
63	427738.140	1148316.242	30.165	L	33		F	0.20	0.30	0.30	F	D	2.00	D
64	427739.968	1148318.937	30.594	L	33	Z	C				N	D	0.50	A
65	427735.816	1148319.404	31.030	L	33	Z	C				N	D	0.50	A
66	427733.334	1148320.219	31.108	L	33	Z	B				N	D	0.50	A
67	427728.857	1148322.452	31.268	L	33	Z	B				N	D	0.50	A
68	427726.086	1148324.817	31.405	L	33	Z	B				N	D	0.50	A
69	427722.566	1148330.031	31.442	L	33	Z	B				N	D	0.50	A
70	427719.741	1148333.388	31.380	L	33	Z	B				N	A	0.30	A
71	427720.781	1148335.554	31.544	L	33	Z	B				N	A	0.30	A
72	427723.856	1148337.197	31.592	L	33	Z	B				N	A	0.30	A

73	427727.719	1148338.322	31.653	L	33	Z	B				N	A	0.30	A
121	427713.280	1148338.967	31.202	B	45	B	B				N		0.90	B
122	427715.807	1148337.611	31.073	B	45	B	B				N		0.90	B
123	427717.559	1148315.013	31.097	S										
124	427717.425	1148312.424	30.907	S										
125	427716.316	1148310.503	30.557	S										
126	427714.260	1148310.482	30.736	S										
127	427712.640	1148311.529	31.117	Y				0.20	0.20		F		0.40	A
128	427715.148	1148313.773	31.243	Y				0.20	0.40	0.40	F		0.40	A
129	427711.492	1148312.236	31.222	Y				0.20	0.40	0.40	F		0.40	A
130	427711.262	1148312.259	31.340	Y				0.30	0.60	0.60	F	D	2.00	D
131	427708.057	1148311.096	31.284	Y				0.30	0.60	0.60	F		2.00	D
132	427709.213	1148307.729	30.525	Y				0.30	0.60	0.60	F		2.00	D
133	427711.780	1148309.742	30.874	Y				0.30	0.60	0.60	F		2.00	D
134	427709.879	1148313.541	31.575	Y				0.20	0.20		D		0.30	A
135	427706.290	1148314.132	31.618	Y				0.20	0.20		D		0.30	A
136	427702.837	1148314.686	31.522	Y				0.40	0.40		D		0.30	A
137	427699.524	1148315.431	31.290	Y				0.20	0.30	0.30	D		0.30	A
138	427695.292	1148317.274	30.996	Y				0.20	0.30	0.30	D		0.30	A
139	427693.615	1148318.379	30.798	Y				0.20	0.30	0.30	D		0.30	A
140	427690.894	1148320.503	30.398	Y				0.20	0.30	0.30	D		0.30	A
141	427686.966	1148323.436	29.858	Y				0.20	0.30	0.30	D		0.30	A
142	427694.909	1148325.711	30.497	B	45	E	C				N	A	2.50	E
143	427692.079	1148328.690	30.108	B	45	D	C				N	A	1.75	D
144	427686.991	1148333.984	28.921	B	45	D	C				N	A	1.50	C
151	427703.143	1148381.340	30.240	B	33	B	B				N		1.25	C
152	427706.286	1148384.876	30.372	B	33	B	B				N		1.25	C
153	427707.556	1148387.012	30.525	B	33	B	B	0.10	0.20	0.20	C		1.25	C
154	427708.643	1148389.636	30.621	B	33	B	B	0.10	0.20	0.20	C		1.25	C
155	427708.324	1148392.599	30.484	S										
156	427710.158	1148395.080	30.706	S										
157	427714.744	1148398.166	31.457	S										
178	427746.157	1148409.797	35.019	Y				0.60	0.60		D		0.50	A
179	427749.665	1148409.766	35.443	Y				0.40	0.40		D		0.50	A

180	427751.478	1148409.621	35.598	Y				0.40	0.40		D		0.50	A
181	427756.529	1148409.244	35.835	Y		C	C				N		0.50	A
182	427783.910	1148395.943	36.074	B	33	D					N	D	0.60	B
183	427779.418	1148396.751	36.083	L	33	D					N	D	0.60	B
184	427770.019	1148396.756	35.332	L	33	D		0.40	0.40		D	D	0.60	B
185	427763.298	1148397.285	35.090	L	33	D		0.60	0.60		D	D	0.60	B
186	427756.334	1148395.862	34.273	L	33	D					N	D	0.60	B
187	427752.114	1148394.840	33.936	L	33	D					N	D	0.50	A
188	427749.756	1148393.209	33.876	B	33	B	B				N		0.50	A
189	427746.136	1148391.548	33.524	B	33	B	B				N		0.50	A
190	427742.788	1148390.301	33.411	B	33	B	B				N		0.50	A
191	427739.522	1148388.318	33.247	B	33	B	B	0.50	0.50		D		1.00	B
192	427736.510	1148386.122	33.029	B	33	B	B				N		1.50	C
193	427732.481	1148384.635	32.811	B	33	B	B	0.20	0.20		N		2.00	D
194	427729.444	1148383.484	32.699	B	33	C	D	0.40	0.40		D		4.00	H
195	427727.943	1148381.370	32.134	B	33	C	D	0.40	0.40		D		4.00	H
196	427726.077	1148376.268	31.386	B	33	C	D	0.40	0.40		D		4.00	H
218	427772.306	1148387.267	34.768	B	33	C	B				N	N	2.00	D
219	427774.705	1148387.164	34.803	B	33	C	B				N	N	2.00	D
220	427779.166	1148384.430	34.810	B	33	C	B				N	N	2.00	D
221	427782.375	1148382.009	34.840	B	33	C	B				N	N	2.00	D
222	427785.239	1148380.795	34.912	B	33	C	B				N	N	2.00	D
223	427787.033	1148383.484	34.991	B	33	B	B	0.20	0.20		D		1.25	C
224	427785.556	1148381.063	34.911	B	33	B	B	0.20	0.20		D		1.25	C
225	427785.219	1148377.289	34.673	B	33	B	B	0.20	0.20		D		1.25	C
226	427785.314	1148371.552	34.382	B		B	B	0.20	0.20		D		1.25	C
227	427782.636	1148367.394	34.083	B		B	B	0.50	0.50		D		1.25	C
228	427782.754	1148362.421	33.964	B		B	B				D		1.25	C
229	427785.177	1148357.473	33.839	B		B	B	0.40	0.40		D		1.25	C
230	427788.129	1148353.452	33.737	B		B	B	0.20	0.20		D		1.00	B
231	427789.841	1148350.552	33.503	B		B	B				N		1.00	B
232	427790.429	1148349.167	33.312	B		B	B				N		1.00	B
233	427791.102	1148349.279	33.336	B		B	B	0.30	0.50	0.50	C		0.50	A
234	427773.691	1148359.379	33.658	B		D	C				N	D	2.50	E

235	427772.154	1148359.673	33.869	B		D	C				N	D	2.50	E
236	427769.173	1148360.078	33.602	B		C	B				N	D	2.50	E
237	427766.456	1148360.651	33.523	B		C	B				N	D	2.50	E
238	427764.449	1148361.372	33.313	B		C	B				N	D	2.50	E
253	427781.177	1148313.918	27.666	L	45	F		0.40	0.40		L	D	1.75	D
254	427776.375	1148313.086	28.052	L	45	F					N	D	1.75	D
255	427771.901	1148312.659	28.153	L	45	F		0.20	0.50	0.50	D	D	3.00	G
256	427766.032	1148310.232	28.520	L	45	F					N	D	3.00	G
257	427755.333	1148303.683	28.487	L	45	F		0.60	0.40	0.40	D	D	3.00	G
258	427750.684	1148298.968	28.184	L	45	F					N	D	2.00	E
259	427747.596	1148295.459	27.893	L	45	F		0.20	0.20		D	D	2.00	E
260	427746.353	1148291.849	27.543	L	45	D					N		1.00	B
261	427746.999	1148286.309	27.319	B	33	C	B				N		1.00	B
262	427750.592	1148283.603	26.905	B	33	C	C	0.40	0.60	0.60	D		0.50	A
263	427755.695	1148281.720	26.432	D		B	C	0.40	0.60	0.60	D	D		
264	427760.644	1148281.053	25.935	D		B	C	0.40	0.60	0.60	D	D		
265	427766.199	1148280.787	25.249	D		B	C	0.40	0.60	0.60	D	D		
266	427768.668	1148280.950	24.977	D		B	C	0.40	0.60	0.60	D	D		
267	427770.616	1148280.618	24.726	D		B	C	0.40	0.60	0.60	D	D		
268	427772.732	1148280.854	24.496	D		B	C	0.40	0.60	0.60	D	D		
269	427775.053	1148281.030	24.273	D		B	C	0.40	0.60	0.60	D	D		
270	427776.456	1148281.200	24.146	D		B	C	0.40	0.60	0.60	D	D		
271	427771.776	1148285.006	25.297	L	33		D				N	D	2.00	D
272	427775.597	1148286.193	24.990	L	33		D				N	D	2.00	D
273	427779.573	1148287.104	24.815	L	33		D				N	D	2.00	D
274	427785.171	1148289.553	24.668	L	33		F				N	D	3.00	F
275	427788.667	1148291.535	24.783	L	33		F				N	D	3.00	F
280	427792.901	1148297.127	24.829	D				0.40	0.40		D			
281	427793.127	1148299.816	25.157	D				0.40	0.40		D			
282	427792.628	1148301.988	25.345	D				0.50	0.50		D			
283	427791.782	1148304.726	25.690	B	33	B	B	0.20	0.20		D		1.25	C
284	427790.895	1148307.843	26.354	B	33	B	B	0.20	0.20		D		1.25	C
285	427789.644	1148310.908	26.946	B	33	B	B	0.20	0.20		D		1.25	C
286	427788.878	1148313.846	27.507	B	33	B	B	0.20	0.20		D		1.25	C

287	427786.836	1148319.617	29.316	B	33	B	B	0.20	0.20		D		1.25	C
291	427786.778	1148321.414	29.421	L	45		F	0.20	0.30	0.30	D	D	3.00	F
292	427780.324	1148320.619	29.430	L	45		G	0.20	0.30	0.30	D	D	3.00	F
293	427782.648	1148319.588	29.421	L	45		G	0.20	0.30	0.30	D	D	3.00	F
294	427787.592	1148318.517	29.181	L	45		G	0.20	0.30	0.30	D	D	3.00	F
295	427792.977	1148318.176	29.015	L	45		G	0.20	0.30	0.30	D	D	3.00	F
296	427799.014	1148320.238	29.036	L	45		G	0.20	0.30	0.30	D	D	3.00	F
297	427804.516	1148321.554	29.004	L	45		G	0.20	0.30	0.30	D	D	3.00	F
298	427809.767	1148323.755	28.832	L	45		G	0.20	0.30	0.30	D	D	3.00	F
299	427812.407	1148325.371	28.831	L	33		B	0.20	0.20		D	E	1.25	C
300	427811.172	1148328.702	29.516	L	33		B	0.20	0.20		D	E	1.25	C
301	427810.129	1148331.881	30.027	L	33		D	0.20	0.20		D	E	2.00	D
302	427809.503	1148335.468	30.587	L	33		D	0.20	0.20		D	E	1.50	C
303	427808.063	1148338.870	31.082	L	33		C	0.20	0.20		D	E	1.00	B
304	427806.883	1148341.885	31.464	L	33	B	B	0.20	0.20		D	E	0.50	A
305	427803.266	1148344.251	32.109	L	33	B	B	0.20	0.20		D	E	0.50	A
306	427797.283	1148356.659	33.565	D		B	B				F			
307	427798.882	1148359.129	33.555	D		B	B				F			
308	427800.267	1148361.911	33.636	D		B	B				F			
309	427801.196	1148363.631	33.581	D		B	B				F			
310	427804.933	1148367.968	33.654	B	33	D	D				N	D	2.00	D
311	427808.642	1148364.700	33.696	B	33	D	D	0.20	0.20		L	D	2.00	D
312	427810.347	1148361.990	33.327	B	33	D	D				N	D	2.00	D
313	427811.366	1148358.803	32.903	B	33	B	B				N	D	2.00	D
314	427812.144	1148356.669	32.589	B	33	B	B				N	D	2.00	D
315	427812.856	1148355.050	32.052	B	33	B	B				N	D	2.00	D
316	427812.312	1148373.115	35.196	L	33	F					N	D	2.50	E
317	427815.371	1148370.238	34.872	L	33	F					N	D	2.50	E
318	427819.628	1148366.104	34.162	L	33	F					N	D	2.50	E
319	427822.726	1148362.589	33.439	L	33	F					N	D	2.50	E
320	427824.523	1148357.171	32.499	L	33	F					N	D	2.50	E
321	427825.775	1148351.917	31.455	L	33	F					N	D	2.50	E
322	427828.943	1148345.446	30.815	L	33	F					N	D	2.50	E
323	427831.389	1148340.080	30.332	L	33	F					N	D	2.50	E

324	427833.131	1148335.876	29.731	L	33	F					N	N	2.00	D
325	427834.583	1148330.599	29.114	L	33	F	B				N	N	2.00	D
326	427833.429	1148324.227	27.857	L	33	E	B				N	N	2.00	D
327	427832.186	1148319.053	26.895	L	33	D	B				N	N	2.00	D
328	427832.232	1148334.423	29.466	L	45		G	0.20	0.30	0.30	D	D	3.00	F
329	427824.668	1148332.181	29.342	L	45		G	0.20	0.30	0.30	D	D	3.00	F
330	427812.951	1148325.851	28.831	L	45		G	0.20	0.30	0.30	D	D	3.00	F
343	427796.306	1148294.824	24.893	L	45		F				N	D	2.00	D
344	427800.732	1148296.632	25.069	L	45		F				N	D	2.00	D
345	427803.744	1148297.472	25.184	L	45		F				N	D	2.00	D
346	427806.668	1148297.175	25.137	L	45		F				N	D	2.00	D
347	427809.982	1148298.343	25.272	L	45		F				N	D	2.00	D
348	427814.842	1148300.996	25.460	L	45		F				N	D	2.00	D
349	427818.586	1148303.070	25.415	L	45		F				N	D	2.00	D
350	427823.111	1148305.148	25.599	L	33		F	0.65	0.65		L	D	2.00	D
351	427824.649	1148307.306	25.762	L	33		E	0.75	0.75		L	D	1.50	C
352	427826.873	1148310.969	26.256	L	33		D				N	D	1.50	C
353	427828.963	1148313.965	26.407	L	33		D				N	D	1.50	C
392	427841.883	1148279.685	21.296	B	33	B	B				N		1.50	C
393	427837.240	1148275.775	20.866	B	33	B	B				N	D	1.00	B
394	427833.333	1148274.097	20.978	B	33	B	B	0.20	0.20		D	D	1.00	B
395	427829.497	1148270.410	20.539	B	33	B	B	0.20	0.20		D	D	1.00	B
396	427827.282	1148267.741	20.210	B	33	B	B	0.20	0.50	0.50	D	D	0.50	A
397	427823.101	1148265.377	20.199	B	33	C					D	D	0.50	A
398	427820.985	1148262.959	19.801	B	33	C					D	D	0.50	A
399	427816.523	1148262.549	19.613	B	33	B					D	D	0.50	A
400	427813.985	1148261.887	19.601	B	33	B					D	D	0.50	A
401	427810.009	1148261.263	19.686	B	33	B					D	D	0.50	A
402	427805.316	1148261.141	19.668	B	33	B					D	D	0.50	A
403	427803.069	1148260.575	19.739	B	33	B					D	D	0.50	A
404	427809.211	1148259.626	19.403	L	33		A	0.20	0.20		F	D	1.00	B
405	427807.588	1148257.698	19.097	L	33		A	0.20	0.20		F	D	1.00	B
406	427805.512	1148256.375	18.923	L	33		A	0.20	0.20		F	D	1.00	B
407	427803.801	1148255.256	18.836	L	33		A	0.20	0.20		F	D	1.00	B

408	427803.510	1148253.805	18.683	L	33		A	0.20	0.20	F	D	1.00	B
437	427829.502	1148256.922	19.119	B	33	B	B	0.20	0.20	L		4.00	H
438	427828.095	1148257.188	19.095	B	33	B	B	0.20	0.20	L		4.00	H
439	427827.570	1148258.643	19.227	B	33	B	B	0.20	0.20	L		4.00	H
440	427829.365	1148259.696	19.317	B	33	B	B	0.20	0.20	L		4.00	H
441	427830.863	1148258.960	19.341	B	33	B	B	0.20	0.20	L		4.00	H
442	427830.924	1148257.527	19.200	B	33	B	B	0.20	0.20	L		4.00	H
443	427830.546	1148255.224	18.984	B	33	B	B	0.20	0.20	L		4.00	H
444	427829.022	1148253.507	18.673	B	33	B	B	0.20	0.20	L		4.00	H
445	427828.044	1148251.869	18.484	B	33	B	B	0.20	0.20	L		4.00	H
446	427827.929	1148249.735	18.204	B	33	B	B	0.20	0.20	L		4.00	H
447	427828.714	1148246.518	17.665	B	33	B	B	0.20	0.20	L		4.00	H
448	427827.514	1148242.745	17.164	B	33	B	B	0.20	0.20	L		4.00	H
449	427826.132	1148240.447	16.904	B	33	B	B	0.20	0.20	L		4.00	H
450	427825.285	1148239.090	16.766	B	33	B	B	0.20	0.20	L		4.00	H
451	427823.896	1148240.898	16.901	B	33	B	B	0.20	0.20	L		4.00	H
452	427822.313	1148241.435	16.964	B	33	B	B	0.20	0.20	L		4.00	H
453	427823.204	1148244.751	17.315	B	33	B	B	0.20	0.20	L		4.00	H
454	427824.415	1148247.740	17.816	B	33	B	B	0.20	0.20	L		4.00	H
455	427825.299	1148250.112	18.083	B	33	B	B	0.20	0.20	L		4.00	H
456	427826.553	1148252.255	18.452	B	33	B	B	0.20	0.20	L		4.00	H
463	427800.872	1148251.516	18.712	B	33	B	B			N		4.00	H
464	427802.096	1148251.723	18.586	B	33	B	B			N		4.00	H
465	427803.712	1148250.484	18.348	B	33	B	B			N		4.00	H
466	427805.375	1148249.071	17.980	B	33	B	B			N		4.00	H
467	427807.654	1148248.093	17.846	B	33	B	B			N		4.00	H
468	427808.751	1148246.819	17.700	B	33	B	B			N		4.00	H
469	427806.736	1148246.533	17.730	B	33	B	B			N		4.00	H
470	427804.711	1148247.485	17.967	B	33	B	B			N		4.00	H
471	427803.076	1148248.637	18.214	B	33	B	B			N		4.00	H
472	427801.115	1148249.505	18.610	B	33	B	B			N		4.00	H
473	427800.398	1148250.274	18.737	B	33	B	B			N		4.00	H
487	427786.326	1148265.667	21.948	B	33	B	B			N		0.75	B
488	427783.478	1148266.885	22.403	B	33	B	B			N		0.75	B

489	427780.132	1148267.696	22.843	B	33	B	B			N	0.75	B
490	427777.446	1148268.743	23.261	B	33	B	B			N	0.75	B
491	427774.845	1148269.943	23.587	B	33	B	B			N	0.75	B
492	427772.061	1148271.265	23.871	B	33	B	B			N	0.75	B
493	427768.787	1148272.770	24.329	B	33	B	B			N	0.75	B
494	427766.331	1148273.824	24.642	B	33	B	B			N	0.75	B
495	427788.955	1148271.168	22.238	B	33	B	B			N	1.25	C
496	427787.284	1148272.638	22.506	B	33	B	B			N	1.25	C
497	427786.387	1148275.346	22.922	B	33	B	B			N	1.25	C
498	427784.925	1148277.580	23.362	B	33	B	B			N	1.25	C
499	427783.757	1148279.070	23.649	B	33	B	B			N	1.25	C
500	427782.236	1148280.605	23.723	B	33	B	B			N	1.25	C
501	427781.154	1148283.388	23.927	B	33	B	B			N		
502	427780.715	1148285.275	24.178	B	33	B	B	0.30	0.30	L	0.60	B

Appendix C.11 Pinhoulland Multiple Field System

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	St Size	St Size 2	Min St	All max	Max st	St Dense	Dir face	Width
1	426091.528	1149833.991	20.860	L	45	B		S					D	N	0.60
2	426088.060	1149833.730	21.226	L	45	B		M					D	N	0.60
3	426083.789	1149833.539	21.631	L	45	B		M					D	N	0.60
4	426081.302	1149833.165	22.022	L	45	B		M					D	N	0.60
5	426078.909	1149833.047	22.326	L	45	B								N	0.40
6	426076.764	1149833.453	22.510	L	45	B								N	0.40
7	426074.976	1149834.193	22.565	L	45	B								N	0.40
8	426073.421	1149859.992	23.911	C											
9	426071.259	1149861.530	23.876	C											
10	426070.890	1149863.176	24.190	C											
11	426071.597	1149865.943	24.013	C											
12	426072.903	1149866.941	24.015	C											
13	426075.164	1149867.600	23.938	C											
14	426076.824	1149867.037	23.942	C											
15	426078.174	1149866.213	23.888	C											
16	426078.785	1149864.737	23.959	C											
17	426078.146	1149863.083	23.930	C											
18	426075.976	1149860.690	23.847	C											
19	426074.538	1149860.113	23.821	C											
20	426074.029	1149856.639	23.357	M											
21	426070.781	1149857.835	23.418	M											
22	426068.701	1149859.701	23.488	M											
23	426067.741	1149862.972	23.574	M											
24	426068.443	1149865.814	23.612	M											
25	426070.584	1149868.512	23.696	M											
26	426072.959	1149870.224	23.766	M											
27	426076.078	1149870.181	23.761	M											
28	426080.565	1149866.436	23.737	M											
29	426081.914	1149863.585	23.702	M											
30	426081.761	1149861.296	23.546	M											

31	426080.787	1149860.091	23.426	M									
32	426079.601	1149857.870	23.286	M									
33	426078.191	1149856.852	23.264	M									
34	426075.948	1149856.130	23.264	M									
35	426073.096	1149856.544	23.315	M									
36	426076.948	1149859.618	23.931	D			L				C		1.00
37	426077.623	1149857.476	23.577	D			L				C		1.00
38	426077.383	1149854.593	23.150	D			L				C		1.00
39	426076.832	1149852.235	23.077	D			L				C		1.00
40	426075.710	1149849.903	23.131	D			L				C		1.00
41	426075.496	1149839.538	22.624	D			L	0.80	0.80		C		0.60
42	426074.621	1149838.347	22.597	D			L				C		0.60
43	426072.994	1149836.988	22.646	D			L				C		0.60
44	426071.279	1149836.721	22.898	D			L				C		0.60
45	426069.854	1149836.392	22.935	D			L				C		0.50
46	426068.197	1149836.711	23.063	D			L				C		0.50
47	426067.133	1149836.726	23.200	D			L	0.30	0.50	0.50	FC		0.50
48	426066.089	1149837.578	23.329	D			L	0.30	0.50	0.50	FC		0.80
49	426063.657	1149837.211	23.586	D			L	0.30	0.50	0.50	FC		0.80
50	426061.315	1149836.976	23.925	D			L	0.30	0.50	0.50	FC		0.80
51	426059.608	1149836.718	24.196	D			L	0.30	0.50	0.50	FC		0.80
52	426057.823	1149836.218	24.374	L	33	B	L	0.30	0.50	0.50	FC	N	1.00
53	426056.057	1149836.253	24.485	L	33	D	L	0.30	0.50	0.50	FC	N	1.00
54	426054.349	1149835.920	24.715	L	33	D	L	0.30	0.50	0.50	FC	N	1.00
55	426052.509	1149835.294	24.855	L	33	D	L	0.30	0.50	0.50	FC	N	1.25
56	426050.387	1149834.375	25.463	L	33	D	L	0.30	0.50	0.50	FC	N	1.25
57	426048.523	1149833.627	25.655	L	33	D	L	0.30	0.50	0.50	FC	N	1.25
58	426046.779	1149833.048	25.823	L	33	D	L	0.30	0.50	0.50	FC	N	1.25
59	426043.325	1149833.219	26.483	L	33	B	L	0.30	0.50	0.50	FC	N	1.25
60	426041.500	1149832.464	26.440	L	33	B	L	0.30	0.50	0.50	FC	N	1.25
61	426038.742	1149832.847	26.601	L	33	A	L	0.30	0.50	0.50	FC	N	1.25
62	426035.942	1149832.011	26.911	L	33	A	L	0.30	0.50	0.50	FC	N	1.25
63	426032.294	1149831.827	27.132	L	33	A	L	0.30	0.40	0.40	FC	N	0.80
64	426029.772	1149831.978	27.200	L	33	A	L	0.30	0.40	0.40	FC	N	0.80

65	426026.747	1149833.189	27.171	L	33	A	L	0.30	0.40	0.40	FC	N	0.80
66	426024.841	1149833.635	27.200	L	33	A	L	0.30	0.40	0.40	FC	N	0.80
67	426021.287	1149835.281	27.204	L	33	A	L	0.30	0.40	0.40	FC	N	0.80
68	426017.400	1149838.314	27.006	L	33	A	S				L	N	0.80
69	426015.656	1149839.549	26.970	L	33	A	S				L	N	0.80
70	426012.966	1149840.730	26.959	L	33	A	S				L	N	0.80
71	426011.377	1149840.990	26.996	L	33	A	S				L	N	0.80
72	426009.423	1149841.650	27.045	L	33	A	S				L	N	0.80
73	426007.271	1149841.833	27.188	L	33	A	S				L	N	0.80
74	426006.224	1149842.235	27.266	L	33	A	S				L	N	0.80
75	426045.261	1149838.003	25.550	CC									
76	426043.519	1149837.332	25.715	CC									
77	426042.479	1149838.041	25.762	CC									
78	426042.350	1149839.470	25.576	CC									
79	426043.463	1149840.751	25.254	CC									
80	426045.159	1149841.050	25.046	CC									
81	426046.976	1149840.037	24.964	CC									
82	426046.320	1149838.292	25.262	CC									
83	426044.800	1149837.105	25.646	CC									
84	426043.013	1149837.568	25.802	CC									
85	426038.973	1149836.416	26.103	CC									
86	426037.386	1149835.550	26.434	CC									
87	426035.694	1149836.809	26.527	CC									
88	426034.630	1149838.871	26.205	CC									
89	426036.202	1149839.879	25.848	CC									
90	426037.824	1149839.682	25.718	CC									
91	426038.887	1149837.902	25.907	CC									
92	426038.534	1149835.846	26.213	CC									
93	426037.313	1149835.547	26.434	CC									
94	426031.060	1149849.180	24.956	CC									
95	426031.068	1149849.173	24.952	CC									
96	426029.646	1149850.553	24.837	CC									
97	426030.173	1149852.186	24.688	CC									
98	426031.381	1149853.345	24.606	CC									

99	426033.021	1149853.842	24.570	CC
100	426034.089	1149852.693	24.550	CC
101	426034.255	1149850.895	24.628	CC
102	426033.725	1149848.996	24.758	CC
103	426031.632	1149848.473	24.990	CC
104	426029.766	1149850.279	24.862	CC
105	426040.830	1149854.752	24.401	CC
106	426040.110	1149856.132	24.408	CC
107	426040.698	1149857.264	24.315	CC
108	426042.244	1149857.011	24.259	CC
109	426042.798	1149855.893	24.252	CC
110	426041.806	1149854.637	24.414	CC
111	426051.998	1149850.140	24.206	CC
112	426053.264	1149851.125	24.100	CC
113	426054.866	1149850.703	24.120	CC
114	426055.583	1149849.153	24.101	CC
115	426054.368	1149848.347	24.082	CC
116	426052.843	1149848.734	24.165	CC
117	426052.397	1149850.391	24.210	CC
118	426050.578	1149859.792	24.042	CC
119	426050.007	1149861.101	23.988	CC
120	426050.258	1149862.600	23.943	CC
121	426051.463	1149863.354	23.809	CC
122	426052.547	1149862.535	23.757	CC
123	426052.988	1149860.846	23.869	CC
124	426051.983	1149859.704	24.020	CC
125	426050.433	1149860.177	24.047	CC
126	426058.201	1149870.037	23.574	CC
127	426059.297	1149871.179	23.502	CC
128	426060.781	1149870.813	23.443	CC
129	426062.068	1149869.606	23.487	CC
130	426062.115	1149867.777	23.555	CC
131	426060.448	1149866.810	23.621	CC
132	426058.844	1149868.043	23.675	CC

133	426058.054	1149869.934	23.567	CC
134	426072.565	1149874.280	23.603	M
135	426073.637	1149876.155	23.581	M
136	426075.264	1149877.082	23.524	M
137	426077.192	1149877.161	23.494	M
138	426078.336	1149876.427	23.637	M
139	426079.348	1149874.550	23.832	M
140	426080.881	1149873.314	23.809	M
141	426080.557	1149872.512	23.837	M
142	426079.654	1149872.709	23.852	M
143	426079.075	1149873.634	23.887	M
144	426077.751	1149873.071	23.875	M
145	426076.038	1149872.889	23.882	M
146	426074.127	1149873.018	23.779	M
147	426072.730	1149874.003	23.644	M
148	426071.895	1149880.881	23.430	H
149	426071.465	1149883.094	23.421	H
150	426071.930	1149885.390	23.287	H
151	426072.930	1149886.832	22.974	H
152	426075.510	1149886.177	23.116	H
153	426078.453	1149884.985	23.217	H
154	426079.703	1149883.500	23.313	H
155	426079.724	1149882.500	23.401	H
156	426078.609	1149882.022	23.375	H
157	426077.932	1149881.595	23.392	H
158	426076.910	1149880.729	23.395	H
159	426074.616	1149880.007	23.431	H
160	426071.552	1149881.190	23.386	H
161	426077.835	1149887.802	22.932	H
162	426073.576	1149888.489	22.777	H
163	426072.646	1149889.678	22.504	H
164	426074.314	1149890.954	22.428	H
165	426075.838	1149890.573	22.531	H
166	426077.240	1149889.683	22.738	H

167	426078.648	1149888.491	22.864	H								
168	426077.577	1149887.717	22.932	H								
169	426082.523	1149889.200	22.837	CC								
170	426082.076	1149890.889	22.683	CC								
171	426083.484	1149892.534	22.391	CC								
172	426085.377	1149892.670	22.159	CC								
173	426085.909	1149891.230	22.277	CC								
174	426084.957	1149889.987	22.640	CC								
175	426083.338	1149889.082	22.889	CC								
176	426081.923	1149890.183	22.710	CC								
177	426096.625	1149877.982	22.407	CC								
178	426095.661	1149876.385	22.665	CC								
179	426094.930	1149876.072	22.869	CC								
180	426093.542	1149876.715	23.081	CC								
181	426093.364	1149878.956	22.889	CC								
182	426094.752	1149880.016	22.518	CC								
183	426096.812	1149879.270	22.319	CC								
184	426085.706	1149861.165	23.328	L	33	C	V				D	0.40
185	426089.306	1149861.174	23.229	L	33	C	V				D	0.40
186	426093.331	1149861.348	22.812	L	33	C	V				D	0.40
187	426096.752	1149861.662	22.155	L	33	C	V				D	0.40
188	426099.817	1149863.403	21.907	L	45	C		0.40	0.40	FC	D	0.50
189	426102.041	1149863.976	21.487	L	45	C		0.40	0.40	FC	D	0.50
190	426104.357	1149863.862	20.888	L	45	C		0.40	0.40	FC	D	0.50
191	426106.629	1149862.864	20.429	L	45	C		0.40	0.40	FC	D	0.50
192	426109.132	1149861.642	19.885	L	45	C		0.40	0.40	FC	D	0.50
193	426112.163	1149860.153	19.408	L	45	C		0.40	0.40	FC	D	0.50
194	426102.468	1149881.976	21.698	CC								
195	426102.012	1149883.523	21.679	CC								
196	426103.009	1149884.093	21.423	CC								
197	426104.454	1149883.997	20.916	CC								
198	426105.288	1149882.778	20.705	CC								
199	426104.771	1149881.549	21.079	CC								
200	426103.276	1149881.790	21.564	CC								

201	426102.038	1149882.664	21.779	CC			
202	426102.260	1149884.895	21.486	L	M	L	D
203	426100.430	1149887.842	21.510	L	M	L	D
204	426098.516	1149889.996	21.487	L	M	L	D
205	426096.297	1149892.440	21.354	L	M	L	D
206	426094.816	1149893.883	21.338	L	M	L	D
207	426092.227	1149894.888	21.446	L	M	L	D
208	426090.482	1149895.863	21.501	L	M	L	D
209	426101.470	1149901.209	19.601	R	M	L	
210	426105.566	1149899.771	19.327	R	M	L	
211	426109.071	1149899.169	18.960	R	M	L	
212	426111.157	1149896.209	18.941	R	M	L	
213	426113.517	1149891.804	18.890	R	M	L	
214	426115.676	1149888.606	18.890	R	M	L	
215	426117.385	1149884.904	18.690	R	M	L	
216	426118.936	1149881.512	18.538	R	M	L	
217	426153.793	1149953.113	7.716	CC			
218	426152.629	1149954.111	7.786	CC			
219	426152.464	1149955.295	7.772	CC			
220	426153.921	1149955.266	7.747	CC			
221	426145.328	1149959.550	7.506	CC			
222	426143.532	1149958.280	7.829	CC			
223	426142.186	1149959.329	7.757	CC			
224	426140.234	1149959.918	7.899	CC			
225	426140.308	1149959.998	7.901	CC			
226	426139.151	1149956.246	8.297	CC			
227	426138.346	1149956.167	8.311	CC			
228	426139.303	1149956.559	8.269	CC			
229	426127.288	1149963.716	8.623	CC			
230	426061.952	1149912.064	18.553	Z			
231	426063.341	1149906.865	19.145	Z			
232	426064.380	1149903.875	19.583	Z			
233	426066.299	1149899.386	20.513	Z			
234	426068.312	1149895.456	21.463	Z			

235	426069.356	1149892.611	22.017	Z							
236	426069.791	1149891.592	22.234	Z							
237	426070.943	1149884.196	23.503	L	45	E	Z	X	D	D	0.75
238	426067.367	1149884.444	23.206	L	45	E	Z		N	D	0.75
239	426062.047	1149884.235	23.041	L	45	E	Z			D	0.75
240	426058.957	1149884.391	22.967	L	45	D	Z			D	0.75
241	426056.535	1149884.116	22.972	L	45	D	Z	L	C	D	0.75
242	426053.564	1149882.633	23.103	L	33	D	Z	L	C	D	0.75
243	426051.693	1149880.208	23.268	L	33	F	Z	L	L	D	0.75
244	426049.973	1149879.214	23.296	L	33	F	Z	L	L	D	0.75
245	426047.912	1149876.380	23.498	L	33	F	Z	L	L	D	0.75
246	426045.795	1149874.452	23.687	L	33	D	Z	L	L	D	0.75
247	426042.221	1149872.267	23.742	L	33	D	Z	L	L	D	0.75
248	426040.077	1149870.589	23.812	L	33	C	Z	L	L	D	0.75
249	426037.526	1149868.755	23.962	L	33	C	Z	L	L	D	0.75
250	426035.143	1149867.113	23.991	L	33	C	Z	L	L	D	0.75
251	426031.629	1149866.094	24.105	L	33	B	Z	L	L	D	0.75
252	426028.696	1149865.320	24.175	L	33	B	Z	L	L	D	0.75
253	426025.562	1149865.157	24.150	L	33	Z	Z	L	L	D	0.75
254	426022.407	1149865.661	24.275	L	33	Z	Z	L	L	D	0.75
255	426010.837	1149852.444	26.235	H							
256	426009.891	1149849.980	26.417	H							
257	426008.049	1149847.816	26.658	H							
258	426006.218	1149846.734	27.009	H							
259	426004.655	1149848.464	26.795	H							
260	426003.014	1149849.541	26.501	H							
261	426002.076	1149852.102	26.384	H							
262	426001.452	1149854.850	26.151	H							
263	426001.538	1149858.359	25.742	H							
264	426002.572	1149860.614	25.489	H							
265	426005.036	1149859.701	25.474	H							
266	426007.886	1149858.930	25.508	H							
267	426010.351	1149857.891	25.189	H							
268	426012.009	1149857.317	25.200	H							

269	426012.897	1149856.519	25.418	H									
270	426029.083	1149866.226	24.048	B	33	B	A		0.50	0.50	D	N	2.00
271	426029.069	1149866.208	24.050	B	33	B	A		0.50	0.50	D	N	2.00
272	426026.001	1149867.796	23.934	B	33	B	A		0.50	0.50	D	N	2.00
273	426023.549	1149870.297	23.913	B	33	D	B		0.30	0.30	D	N	2.00
274	426021.662	1149873.705	23.690	B	33	D	B		0.30	0.30	D	N	2.00
275	426019.935	1149876.678	23.488	B	33	C	B		0.30	0.30	D	N	2.00
276	426019.390	1149880.011	23.242	B	33	C	B		0.30	0.30	D	N	2.00
277	426018.370	1149884.473	22.947	B	33	B	B		0.30	0.30	D	N	2.00
278	426018.000	1149889.345	22.611	B	33	B	B		0.30	0.30	D	N	2.00
279	426017.647	1149894.679	22.232	B	33	B	B		0.30	0.30	D	N	2.00
280	426017.716	1149899.911	21.763	B	33	B	B		0.30	0.30	D	N	2.00
281	426039.112	1149894.964	21.326	M									
282	426041.716	1149895.673	21.132	M									
283	426043.991	1149894.540	21.321	M									
284	426043.974	1149892.553	21.741	M									
285	426041.727	1149891.056	22.049	M									
286	426039.496	1149891.299	22.129	M									
287	426038.488	1149893.293	21.666	M									
288	426039.786	1149895.510	21.260	M									
289	426042.123	1149895.864	21.053	M									
290	426044.079	1149894.287	21.386	M									
291	426060.416	1149911.264	18.649	M									
292	426061.265	1149909.874	18.820	M									
293	426060.011	1149908.509	19.025	M									
294	426058.779	1149909.056	19.009	M									
295	426058.921	1149910.837	18.797	M									
296	426060.442	1149911.065	18.707	M									
297	426062.087	1149911.880	18.615	D				V			C		0.80
298	426063.194	1149909.072	18.975	D				V			C		0.80
299	426063.649	1149906.103	19.431	D				V			C		0.80
300	426064.184	1149903.463	19.738	D				V			C		2.00
301	426066.857	1149898.209	20.840	D				V			C		2.00
302	426068.281	1149894.938	21.523	D				V			C		1.00

303	426070.155	1149891.604	22.278	D				V	C		1.00
304	426035.624	1149884.052	22.779	M							
305	426034.118	1149882.929	22.957	M							
306	426033.035	1149883.562	22.776	M							
307	426032.523	1149884.907	22.622	M							
308	426033.521	1149885.908	22.504	M							
309	426035.309	1149885.442	22.549	M							
310	426035.003	1149883.549	22.826	M							
311	426033.977	1149882.736	22.895	M							
312	426008.194	1149859.112	25.450	L	33	Z	D	S	L	T	1.50
313	426007.849	1149862.427	25.293	L	33	Z	D	S	L	T	1.50
314	426006.555	1149866.493	25.097	L	33	Z	D	S	L	T	1.50
315	426005.591	1149870.492	24.948	L	33	Z	D	S	L	T	1.50
316	426003.650	1149874.801	24.697	L	33	Z	D	S	L	T	1.50
317	426001.920	1149878.485	24.581	L	33	Z	D	S	L	T	1.50
318	425999.736	1149882.128	24.478	L	33	Z	D	S	L	T	1.50
319	425997.438	1149885.611	24.281	L	33	Z	D	S	L	T	1.50
320	425995.912	1149889.451	24.093	L	33	Z	D	S	L	T	1.50
321	425995.392	1149890.960	24.043	L	33	Z	D	S	L	T	1.50
322	425994.988	1149892.146	24.070	L	33	Z	D	S	L	T	1.50
323	425993.930	1149894.704	24.034	L	33	Z	D	S	L	T	1.50
324	425993.476	1149896.559	24.069	L	33	Z	D	S	L	T	1.50
325	425992.553	1149899.935	23.971	L	33	Z	D	S	L	T	1.00
326	425991.797	1149903.363	23.775	L	33	Z	D	S	L	T	1.00
327	425991.242	1149904.746	23.872	L	33	Z	D	S	L	T	1.00
328	425991.074	1149905.931	24.032	L	33	Z	D	S	L	T	1.00
329	425991.696	1149909.801	23.765	B	33	D	D	M	L		1.00
330	425992.104	1149912.624	23.407	B	33	D	D	M	L		1.00
331	425992.073	1149916.105	23.297	B	33	D	D	M	L		1.00
332	425991.934	1149919.218	23.166	B	33	D	D	M	L		1.50
333	425992.557	1149922.445	22.772	B	33	D	D	M	L		1.50
334	425993.327	1149925.165	22.521	B	33	D	D	M	L		1.50
335	425994.039	1149928.743	22.173	B	33	D	D	M	L		1.50
336	425995.641	1149935.449	21.547	B	33	D	D	M	L		1.50

337	425995.657	1149935.404	21.547	B	33	D	D	M			L	1.50
338	425997.674	1149942.605	21.109	Y				M	0.30	0.30	D	1.50
339	425993.993	1149943.863	21.879	Y				M	0.60	0.60	D	1.50
340	425987.396	1149943.917	22.907	Y				M	0.20	0.20	D	1.50
341	425982.192	1149943.256	23.406	Y				M	0.30	0.30	D	1.50
342	425976.296	1149942.942	24.394	Y				M	0.30	0.30	D	1.50
343	425976.447	1149942.932	24.386	Y				M	0.30	0.30	D	1.50
344	425971.634	1149942.105	25.184	Y				M			D	1.50
345	425966.201	1149941.069	25.757	Y				M			D	1.50
346	425961.312	1149939.683	26.308	Y				M			D	1.50
347	425957.891	1149938.738	26.460	Y				M			D	1.50
348	425955.395	1149938.078	26.707	Y				M			D	1.50
349	425948.720	1149937.199	27.487	Y				M			D	1.50
350	425945.207	1149936.835	27.812	Y				M			D	1.50
351	425941.109	1149936.130	28.027	Y				M			D	1.50
352	425938.102	1149934.759	28.225	Y				M			D	1.50
353	425934.669	1149933.563	28.342	Y				M			D	1.50
354	425932.318	1149932.471	28.256	Y				M			D	1.50
355	425931.984	1149932.173	28.223	Y				M			D	1.50
356	425929.439	1149932.806	28.519	Y				M			D	1.50
357	425925.153	1149931.564	28.898	Y				M			D	1.50
358	425923.217	1149930.670	29.302	Y				M			D	1.50
359	425934.329	1149922.262	27.957	M								
360	425936.070	1149922.215	27.685	M								
361	425936.690	1149921.273	27.551	M								
362	425935.346	1149920.044	27.719	M								
363	425934.141	1149920.016	27.788	M								
364	425933.599	1149921.666	27.956	M								
365	425934.461	1149922.501	27.936	M								
366	425928.218	1149919.285	28.379	M								
367	425927.666	1149917.378	28.418	M								
368	425925.909	1149916.396	28.464	M								
369	425924.918	1149917.781	28.772	M								
370	425925.246	1149919.646	28.781	M								

371	425926.751	1149919.881	28.494	M										
372	426018.113	1149917.389	20.037	D					0.30	0.40	0.40	FC		1.00
373	426018.041	1149913.806	20.209	D					0.20	0.30	0.30	FC		1.00
374	426018.120	1149910.353	20.671	D					0.20	0.30	0.30	FC		1.00
375	426019.486	1149907.424	20.930	D					0.20	0.30	0.30	FC		1.00
376	426019.760	1149906.609	20.764	D	45	B			0.30	0.30		C	N	0.60
377	426022.047	1149906.196	20.495	D	45	B			0.30	0.30		C	N	0.60
378	426024.533	1149905.370	20.324	D	45	B			0.30	0.30		C	N	0.60
379	426025.175	1149906.052	20.265	D	45	B			0.30	0.30		C	N	0.60
380	426029.536	1149907.773	20.071	D	45	B			0.30	0.30		C	N	0.60
381	426033.167	1149911.082	19.754	D	45	A			0.30	0.30		C	N	0.40
382	426035.038	1149913.113	19.557	D	45	A			0.30	0.30		C	N	0.40
383	426036.566	1149915.331	19.416	D	45	A			0.30	0.30		C	N	0.40
384	426037.944	1149918.718	19.271	D	45	A			0.30	0.30		C	N	0.40
385	426038.441	1149920.185	19.263	D	45	A			0.30	0.30		C	N	0.40
386	426047.056	1149929.614	18.742	D					0.30	0.40	0.40	C		0.50
387	426049.946	1149932.952	18.639	D					0.30	0.40	0.40	C		0.50
388	426053.101	1149934.786	18.500	D		B			0.30	0.40	0.40	C	N	0.50
389	426055.680	1149938.152	18.363	D		B	B		0.30	0.40	0.40	C		0.50
390	426056.275	1149941.098	18.241	D		B	B					N		0.50
391	426056.110	1149944.240	18.149	D		B	B							0.50
392	426055.318	1149946.782	17.857	D	33	Z	D		0.50	0.50		C	T	0.80
393	426052.389	1149950.736	18.095	D	33	Z	C		0.30	0.40	0.40	C	T	0.80
394	426048.673	1149954.365	18.180	D		Z	Z		0.30	0.40	0.40	C		0.50
395	426044.209	1149955.377	18.160	D	33	B	Z					N	N	0.50
396	426038.832	1149957.276	18.707	D	33	B	Z					N		0.50
397	426037.161	1149953.477	18.920	D	33	B	Z					N	N	0.50
398	425991.184	1149886.089	24.409	B	90	D	D	M				L		2.00
399	425989.243	1149884.011	24.589	B	90	D	D	M				L		2.00
400	425985.769	1149882.734	24.828	B	90	D	D	M				L		2.00
401	425982.698	1149882.290	25.053	B	90	D	D	M				L		2.00
402	425980.368	1149881.793	25.200	B	90	D	D	M				L		2.00
403	425978.365	1149880.897	25.306	B	90	D	D	M				L		2.00
404	425975.823	1149880.334	25.448	B	90	D	D	M				L		2.00

405	425973.308	1149878.965	25.554	B	90	D	D	M	L	2.00
406	425970.405	1149878.313	25.704	B	90	D	D	M	L	2.00
407	425967.512	1149877.088	25.975	B	90	D	D	M	L	2.00
408	425963.895	1149875.962	26.251	B	90	D	D	M	L	2.00
409	425961.868	1149876.485	26.330	B	90	D	D	M	L	2.00
410	425959.254	1149877.739	26.397	B	90	D	D	M	L	2.00
411	425956.621	1149878.069	26.602	B	90	D	D	M	L	2.00
412	425953.137	1149879.211	26.788	B	90	D	D	M	L	2.00
413	425949.092	1149880.896	27.034	B	90	D	D	M	L	2.00
414	425943.331	1149883.581	27.336	B	90	D	D	M	L	2.00
415	425941.890	1149884.911	27.301	B	90	D	D	M	L	2.00
416	425942.681	1149885.472	27.036	B	90	D	D	M	L	2.00
417	425944.549	1149884.873	26.984	B	90	D	D	M	L	2.00
418	425946.072	1149883.981	26.939	B	90	D	D	M	L	2.00
419	425948.386	1149883.038	26.797	B	90	D	D	M	L	2.00
420	425950.677	1149882.716	26.679	B	90	D	D	M	L	2.00
421	425952.676	1149881.829	26.567	B	90	D	D	M	L	2.00
422	425953.293	1149880.777	26.599	B	90	D	D	M	L	2.00
423	425957.226	1149879.595	26.446	B	90	D	D	M	L	2.00
424	425959.471	1149878.699	26.281	B	90	D	D	M	L	2.00
425	425961.840	1149879.013	26.171	B	90	D	D	M	L	2.00
426	425964.571	1149879.099	26.069	B	90	D	D	M	L	2.00
427	425967.155	1149879.390	25.949	B	90	D	D	M	L	2.00
428	425969.541	1149880.369	25.744	B	90	D	D	M	L	2.00
429	425971.832	1149882.093	25.518	B	90	D	D	M	L	2.00
430	425974.883	1149882.599	25.439	B	90	D	D	M	L	2.00
431	425978.515	1149884.180	25.165	B	90	D	D	M	L	2.00
432	425981.538	1149884.789	24.902	B	90	D	D	M	L	2.00
433	425982.537	1149884.646	24.810	B	90	D	D	M	L	2.00
434	425985.009	1149885.137	24.686	B	90	D	D	M	L	2.00
435	425986.407	1149885.624	24.636	B	90	D	D	M	L	2.00
436	425987.406	1149886.203	24.517	B	90	D	D	M	L	2.00
437	425988.668	1149887.514	24.344	B	90	D	D	M	L	2.00
438	425990.130	1149887.500	24.285	B	90	D	D	M	L	2.00

439	425991.084	1149886.552	24.347	B	90	D	D	M			L	2.00
440	425992.203	1149899.601	23.976	Z								
441	425991.965	1149901.491	23.913	Z								
442	425991.812	1149903.438	23.795	Z								
443	425990.993	1149904.825	24.001	Z								
444	425991.467	1149907.390	23.884	Z								
445	425991.795	1149910.345	23.483	Z								
446	425992.059	1149912.461	23.382	Z								
447	425991.910	1149916.343	23.281	Z								
448	425991.938	1149916.510	23.280	Z								
449	425991.674	1149919.323	23.158	Z								
450	425992.397	1149922.263	22.785	Z								
451	425993.956	1149929.025	22.130	Z								
452	425994.375	1149930.293	21.980	Z								
453	425994.934	1149934.755	21.854	Z								
454	425995.128	1149936.068	21.825	Z								
455	425993.026	1149943.624	22.258	Z								
456	425978.653	1149924.556	23.673	M								
457	425980.416	1149925.441	23.629	M								
458	425981.868	1149927.119	23.134	M								
459	425981.316	1149929.643	23.727	M								
460	425978.812	1149925.386	23.966	M								
461	425977.281	1149926.532	24.107	M								
462	425977.101	1149928.184	23.759	M								
463	425978.608	1149929.451	23.506	M								
464	425980.589	1149930.383	23.315	M								
465	425980.332	1149930.333	23.435	M								
466	425981.610	1149929.637	23.381	M								
467	425981.592	1149929.620	23.429	M								
468	425976.277	1149926.398	23.848	M					0.40	0.40	C	1.50
469	425973.391	1149925.468	24.006	D					0.60	0.60	C	1.50
470	425971.042	1149924.879	24.222	D								
471	425970.608	1149923.238	24.261	D								
472	425970.603	1149923.281	24.272	D								

473	425970.599	1149923.274	24.257	D				0.50	0.50		C		2.00
474	425970.595	1149923.307	24.262	D									
475	425968.092	1149921.711	24.557	D									
476	425965.509	1149922.096	24.740	D									
477	425964.049	1149923.724	24.876	D									
478	425964.292	1149924.635	24.865	D				0.50	0.50		C		0.80
479	425960.849	1149923.242	24.956	D				0.50	0.50		C		0.80
480	425959.430	1149922.256	25.133	D				0.50	0.50		C		0.80
481	425960.016	1149919.735	25.129	D	33	E	D	0.20	0.30	0.30	FC	N	
482	425956.912	1149918.676	25.615	D	33	E	D	0.20	0.30	0.30	FC	N	
483	425953.787	1149918.090	25.879	D	33	E	D	0.20	0.30	0.30	FC	N	
484	425951.025	1149917.570	26.075	D	33	E	D	0.20	0.30	0.30	FC	N	
485	425948.040	1149916.000	26.325	D	33	E	C					N	
486	425945.197	1149913.765	26.467	D	33	E	C					N	
487	425945.137	1149913.713	26.462	D	33	F	C					N	
488	425943.669	1149911.445	26.500	D	33	F	C					N	
489	425941.199	1149909.182	26.557	D	33	D	B					N	
490	425941.194	1149909.223	26.599	D	33	D	B					N	
491	425939.683	1149908.803	26.718	D	33	D	B					N	
492	425938.107	1149906.624	26.934	D	33	D	B					N	
493	425940.235	1149904.763	26.853	D	33	D	B					N	
494	425942.170	1149905.421	26.664	D	33	D	B					N	
495	425944.739	1149904.796	26.524	D	45	F	D					N	
496	425946.281	1149902.262	26.643	D	45	F	D					N	
497	425948.272	1149900.029	26.808	D	45	F	D					N	
498	425950.836	1149896.845	26.855	D	45	F	D					N	
499	425951.589	1149896.217	26.865	D	45	D	D	0.20	0.60	0.60	FC		
500	425955.358	1149896.242	26.791	D	45								
501	425957.422	1149895.752	26.719	D	45								
502	425957.201	1149894.909	26.659	D	45								
503	425954.590	1149894.484	26.615	D									
504	425951.987	1149894.637	26.605	D									
505	425947.611	1149895.575	26.872	D									
506	425946.375	1149896.297	26.914	D									

507	425945.959	1149897.515	26.959	D											
508	425944.323	1149899.324	26.939	D											
509	425942.894	1149900.455	27.013	D											
510	425941.660	1149901.491	26.980	D											
511	425940.091	1149902.744	26.976	D											
512	425938.356	1149902.876	27.041	D											
513	425936.754	1149903.663	27.031	D											
514	425936.824	1149905.428	27.186	D											
515	425937.183	1149907.127	27.088	D											
516	425938.427	1149909.204	26.987	D											
517	425940.251	1149911.913	27.100	D											
518	425942.319	1149914.525	26.946	D											
519	425943.617	1149916.633	26.843	D											
520	425945.988	1149918.669	26.620	D											
521	425950.779	1149918.971	26.157	D											
522	425953.721	1149920.591	25.923	D											
523	425957.077	1149922.244	25.390	D											
524	425959.556	1149923.530	24.983	D											
525	425961.702	1149924.503	24.870	D											
526	425964.573	1149926.007	24.741	D											
527	425964.512	1149926.010	24.739	D											
528	425964.509	1149926.014	24.731	D											
529	425967.259	1149927.189	24.627	D											
530	425969.570	1149926.416	24.614	D											
531	425969.495	1149926.147	24.545	D											
532	425978.380	1149924.449	23.769	D	33	C	C	M		0.30	0.40	0.40	C		0.50
533	425979.535	1149922.913	23.575	D	33	C	C	M		0.30	0.40	0.40	C		0.50
534	425979.450	1149920.256	23.876	D	33	B	B	M		0.30	0.40	0.40	C		0.50
535	425980.181	1149917.804	24.036	D	33	B	B	M		0.30	0.40	0.40	C		0.80
536	425980.869	1149915.201	24.205	D	33	B	B	M		0.30	0.40	0.40	C		0.80
537	425980.794	1149915.079	24.198	D	33	B	B	M		0.30	0.40	0.40	C		0.80
538	425982.672	1149914.151	24.120	D	33	Z	E	M		0.30	0.60	0.60	C		
539	425982.757	1149911.720	24.160	D	33	Z	E	M		0.30	0.60	0.60	C		
540	425981.153	1149910.005	24.386	D	33	Z	E	M		0.30	0.60	0.60	C		

541	425979.087	1149909.601	24.571	D	33	Z	E	M	0.30	0.60	0.60	C
542	425978.313	1149911.683	24.609	D	33	Z	E	M	0.30	0.60	0.60	C
543	425979.070	1149913.750	24.456	D	33	Z	E	M	0.30	0.60	0.60	C
544	425980.348	1149915.027	24.311	D	33	Z	E	M	0.30	0.60	0.60	C
545	425980.450	1149909.399	24.371	D	33	C	C	M	0.60	0.60		C
546	425980.256	1149905.190	24.532	D	33	C	C	M	0.60	0.60		C
547	425980.032	1149901.873	24.552	D	33	C	C	M	0.40	0.40		C
548	425979.418	1149896.592	24.707	M	33	C	C	L	0.40	0.40		C
549	425979.013	1149894.146	24.731	M	33	C	C	L	0.40	0.40		C
550	425976.389	1149892.803	24.994	M	33		F	L	0.60	0.60		L
551	425974.602	1149893.097	25.253	M	33		F	L	0.60	0.60		L
552	425972.858	1149892.629	25.431	M	33		F	L	0.60	0.60		L
553	425971.942	1149893.848	25.610	M	33		F	L	0.60	0.60		L
554	425973.260	1149895.049	25.607	M	33		F	L	0.60	0.60		L
555	425974.179	1149896.981	25.504	M	33		F	L	0.60	0.60		L
556	425974.895	1149898.249	25.288	M	33		F	L	0.60	0.60		L
557	425976.409	1149897.710	24.999	M	33		F	L	0.60	0.60		L
558	425978.314	1149897.663	24.751	M	33		F	L	0.60	0.60		L
559	425979.668	1149896.529	24.685	M	33		F	L	0.60	0.60		L
560	425970.689	1149887.485	25.469	O	33			X				C
561	425969.152	1149888.512	25.600	D	33			M	0.40	0.40		C
562	425966.993	1149890.596	25.883	D	33			M	0.40	0.40		C
563	425965.073	1149891.481	26.058	D	33			M	0.40	0.40		C
564	425962.680	1149892.139	26.251	D	33			M	0.40	0.40		C
565	425959.997	1149893.044	26.372	D	33			M	0.40	0.40		C
566	425959.163	1149894.487	26.590	D	33			M	0.40	0.40		C
567	425960.926	1149893.159	26.348	M	33		F	M				D
568	425963.198	1149892.492	26.187	M	33		F	M				D
569	425965.478	1149893.888	26.185	M	33		F	M				D
570	425966.756	1149895.708	26.042	M	33		F	M				D
571	425967.007	1149898.137	26.054	M	33		F	M				D
572	425965.874	1149899.480	26.176	M	33		F	M				D
573	425963.612	1149899.532	26.374	M	33		F	M				D
574	425961.703	1149899.655	26.630	M	33		F	M				D

575	425960.653	1149897.707	26.844	M	33		F	M	D
576	425958.991	1149898.034	26.728	M	33		F	M	D
577	425957.233	1149898.762	26.761	M	33		F	M	D
578	425956.435	1149897.584	26.788	M	33		F	M	D
579	425958.205	1149896.291	26.767	M	33		F	M	D
580	425959.205	1149896.521	26.831	M	33		F	M	D
581	425958.986	1149895.364	26.745	M	33		F	M	D
582	425957.649	1149894.782	26.638	M	33		F	M	D
583	425955.921	1149894.259	26.596	B		E	E	V	
584	425953.524	1149894.359	26.611	B		E	E	V	
585	425951.709	1149894.598	26.603	B		E	E	V	
586	425949.439	1149894.754	26.768	B		E	E	V	
587	425947.584	1149895.499	26.848	B		E	E	V	
588	425946.220	1149897.277	26.930	B		E	E	V	
589	425944.673	1149898.921	26.919	B		E	E	V	
590	425943.043	1149900.318	26.958	B		E	E	V	
591	425941.125	1149902.000	26.978	B		E	E	V	
592	425939.233	1149903.054	26.953	B		E	E	V	
593	425937.101	1149904.033	27.049	B		E	E	V	
594	425941.528	1149905.585	26.613	B		E	E	V	
595	425944.549	1149904.851	26.479	B		E	E	V	
596	425945.960	1149903.700	26.467	B		E	E	V	
597	425946.630	1149902.042	26.656	B		E	E	V	
598	425948.704	1149899.918	26.763	B		E	E	V	
599	425950.232	1149897.332	26.873	B		E	E	V	
600	425951.850	1149896.260	26.840	B		E	E	V	
601	425954.930	1149896.345	26.801	B		E	E	V	
602	425957.090	1149896.016	26.723	B		E	E	V	
603	425957.544	1149895.330	26.736	B		E	E	V	
604	425954.479	1149899.323	26.764	M					
605	425952.648	1149899.902	26.825	M					
606	425951.355	1149901.666	26.663	M					
607	425952.256	1149903.445	26.507	M					
608	425954.425	1149904.090	26.609	M					

609	425954.682	1149903.439	26.636	M
610	425954.230	1149902.448	26.716	M
611	425954.229	1149901.260	26.769	M
612	425954.668	1149900.778	26.740	M
613	425955.194	1149900.008	26.655	M
614	425954.573	1149899.181	26.735	M
615	425958.256	1149901.723	26.781	H
616	425955.708	1149902.413	26.655	H
617	425954.524	1149904.273	26.628	H
618	425953.781	1149906.660	26.385	H
619	425954.504	1149909.553	26.257	H
620	425956.369	1149912.469	26.035	H
621	425958.848	1149914.705	25.670	H
622	425962.616	1149916.860	25.192	H
623	425965.844	1149917.589	24.832	H
624	425969.799	1149917.945	24.544	H
625	425972.133	1149918.919	24.306	H
626	425974.168	1149919.456	24.091	H
627	425974.971	1149916.755	24.311	H
628	425974.913	1149915.075	24.559	H
629	425974.924	1149912.889	24.798	H
630	425976.140	1149910.451	24.841	H
631	425978.027	1149909.420	24.710	H
632	425979.265	1149907.777	24.563	H
633	425979.496	1149905.273	24.756	H
634	425976.741	1149899.729	24.983	H
635	425973.505	1149899.675	25.542	H
636	425970.754	1149899.307	25.831	H
637	425969.416	1149901.907	26.122	H
638	425967.393	1149902.602	26.297	H
639	425965.204	1149902.917	26.473	H
640	425963.335	1149903.583	26.597	H
641	425962.963	1149902.112	26.594	H
642	425961.538	1149901.537	26.668	H

643	425959.709	1149901.854	26.810	H										
644	425958.057	1149901.539	26.762	H										
645	425933.777	1149905.105	27.611	B	33	F		M	0.30	0.30		D	D	8.00
646	425931.109	1149903.597	27.867	B	33	F		M	0.40	0.40		FC	D	8.00
647	425929.733	1149902.124	27.974	B	33	F		M	0.40	0.50	0.50	FC	D	6.00
648	425929.443	1149900.009	27.959	B	33	F		M	0.30	0.70	0.70	FC	D	5.00
649	425927.172	1149895.489	28.383	B	33	F		M	0.30	0.70	0.70	FC	D	5.00
650	425926.131	1149893.332	28.537	B	33	F		M	0.30	0.70	0.70	FC	D	5.00
651	425924.725	1149890.278	28.782	B	33	F		M	0.30	0.70	0.70	FC	D	5.00
652	425922.361	1149890.694	29.342	B	33		B	M	0.30	0.70	0.70	FC	D	5.00
653	425922.843	1149892.750	29.426	B	33		B	M						
654	425923.995	1149894.270	29.290	B			B	M						
655	425924.734	1149898.946	29.161	B			B	M						
656	425926.357	1149902.660	28.659	B			B	M						
657	425931.463	1149909.539	27.665	B			D	M						
658	425931.532	1149909.551	27.704	B			E	M						
659	425934.086	1149910.011	27.366	B			E	M						
660	425937.628	1149908.147	27.193	B			B	M						
661	425894.721	1149908.917	33.462	B	33	B	C		0.20	0.40	0.40	L	N	1.50
662	425894.946	1149907.054	33.315	B	33	B	C		0.30	0.30		L	N	1.50
663	425894.449	1149904.838	33.235	B	45	C	D						N	2.50
664	425894.695	1149900.650	33.655	B	45	C	D						N	3.50
665	425897.352	1149898.366	33.333	B	45	C	D						N	3.50
666	425900.797	1149896.429	32.870	B	45	B	C						N	3.00
667	425904.610	1149894.020	32.449	B	33	B	B		0.20	0.60	0.60	C		1.50
668	425908.023	1149893.237	32.219	B	33	B	B		0.20	0.60	0.60	FC		1.50
669	425910.604	1149891.669	31.912	B					0.30	0.80	0.80	FC		1.50
670	425913.226	1149889.874	31.534	B					0.30	0.80	0.80	FC		1.50
671	425913.395	1149886.900	31.349	B	90		B		0.30	0.40	0.40	D	D	
672	425914.146	1149881.505	31.227	B	45		D		0.30	0.40	0.40	D	D	
673	425914.809	1149878.345	31.229	B	45		D		0.30	0.40	0.40	D	D	
674	425916.053	1149871.706	31.237	B	45		D		0.30	0.40	0.40	D	D	
675	425919.002	1149866.740	31.465	B					0.40	0.80	0.80	D		
676	425919.869	1149862.763	31.449	B					0.60	0.60		D		

677	425918.996	1149857.856	31.558	B		0.60	0.60		D
678	425921.693	1149854.057	31.300	B		0.60	0.60		D
679	425921.737	1149853.928	31.293	M					
680	425921.699	1149852.221	31.361	M					
681	425922.395	1149851.466	31.392	M					
682	425923.441	1149851.724	31.342	M					
683	425924.259	1149852.392	31.183	M					
684	425923.986	1149853.663	31.088	M					
685	425922.964	1149853.978	31.231	M					
686	425918.913	1149858.377	31.558	M					
687	425916.974	1149856.948	31.698	M					
688	425914.501	1149856.877	31.954	M					
689	425911.736	1149858.288	32.234	M					
690	425908.424	1149862.793	32.400	M					
691	425908.015	1149866.278	32.257	M					
692	425911.345	1149869.911	31.929	M					
693	425914.442	1149870.852	31.513	M					
694	425917.263	1149869.129	31.408	M					
695	425919.205	1149866.355	31.318	M					
696	425920.002	1149862.973	31.413	M					
697	425919.196	1149858.279	31.532	M					
698	425910.389	1149894.500	32.055	M					
699	425907.469	1149895.315	32.203	M					
700	425906.596	1149898.408	32.264	M					
701	425907.696	1149901.184	32.180	M					
702	425910.512	1149902.879	32.020	M					
703	425913.506	1149903.104	31.555	M					
704	425914.808	1149903.143	31.428	M					
705	425915.879	1149902.709	31.319	M					
706	425917.252	1149901.401	31.078	M					
707	425916.961	1149899.451	31.037	M					
708	425915.822	1149897.215	31.153	M					
709	425914.429	1149893.342	31.410	M					
710	425913.930	1149891.890	31.472	M					

711	425913.840	1149890.170	31.458	M
712	425925.766	1149859.193	30.644	CC
713	425926.085	1149860.801	30.397	CC
714	425927.153	1149861.102	30.075	CC
715	425928.135	1149860.181	30.021	CC
716	425927.656	1149858.612	30.235	CC
717	425926.531	1149858.557	30.547	CC
718	425930.315	1149856.367	30.501	CC
719	425930.598	1149857.496	30.199	CC
720	425931.750	1149858.306	30.009	CC
721	425932.662	1149857.295	30.067	CC
722	425932.515	1149855.782	30.382	CC
723	425931.452	1149855.093	30.633	CC
724	425930.424	1149855.451	30.604	CC
725	425935.575	1149855.053	30.388	CC
726	425936.125	1149856.461	30.154	CC
727	425937.479	1149856.624	30.056	CC
728	425938.125	1149855.417	30.236	CC
729	425937.377	1149854.491	30.412	CC
730	425936.148	1149854.081	30.575	CC
731	425935.631	1149854.828	30.489	CC
732	425934.077	1149862.822	29.244	CC
733	425933.247	1149864.198	29.101	CC
734	425933.631	1149865.820	28.803	CC
735	425935.221	1149866.233	28.739	CC
736	425936.484	1149865.250	28.800	CC
737	425936.045	1149863.640	29.019	CC
738	425934.835	1149863.024	29.250	CC
739	425937.055	1149868.959	28.197	CC
740	425936.502	1149870.501	28.137	CC
741	425936.757	1149871.896	27.887	CC
742	425938.135	1149873.316	27.698	CC
743	425939.855	1149873.623	27.762	CC
744	425940.900	1149872.774	27.686	CC

745	425940.953	1149870.732	27.494	CC
746	425939.747	1149869.378	27.845	CC
747	425937.398	1149868.647	28.181	CC
748	425947.604	1149868.099	27.653	CC
749	425948.220	1149870.424	27.289	CC
750	425950.690	1149871.769	27.066	CC
751	425952.693	1149871.662	27.139	CC
752	425952.794	1149870.361	27.270	CC
753	425951.422	1149868.534	27.542	CC
754	425948.714	1149867.596	27.701	CC
755	425949.149	1149864.900	28.023	CC
756	425950.770	1149865.249	27.802	CC
757	425952.900	1149864.334	27.742	CC
758	425953.077	1149862.843	28.180	CC
759	425951.436	1149861.967	28.704	CC
760	425949.940	1149862.801	28.695	CC
761	425949.576	1149864.017	28.348	CC
762	425950.811	1149854.144	29.956	CC
763	425951.803	1149855.941	29.632	CC
764	425953.089	1149857.082	29.192	CC
765	425954.672	1149856.699	29.035	CC
766	425954.288	1149854.709	29.580	CC
767	425952.929	1149853.160	30.004	CC
768	425951.464	1149853.721	30.051	CC
769	425951.333	1149854.564	29.939	CC
770	425958.492	1149867.872	27.281	CC
771	425958.320	1149869.524	27.021	CC
772	425960.085	1149870.757	26.684	CC
773	425962.761	1149870.533	26.332	CC
774	425964.816	1149869.202	26.380	CC
775	425964.496	1149867.535	26.733	CC
776	425962.375	1149866.293	27.037	CC
777	425959.915	1149866.720	27.294	CC
778	425958.600	1149867.886	27.301	CC

779	425965.729	1149863.181	27.313	CC										
780	425965.670	1149863.125	27.301	CC										
781	425966.353	1149864.356	27.040	CC										
782	425968.195	1149864.460	26.836	CC										
783	425969.214	1149862.758	26.896	CC										
784	425969.176	1149861.111	27.237	CC										
785	425967.206	1149861.387	27.531	CC										
786	425966.259	1149862.352	27.419	CC										
787	425967.186	1149849.680	28.630	CC										
788	425968.876	1149850.292	28.357	CC										
789	425971.136	1149849.604	28.214	CC										
790	425972.067	1149847.579	28.220	CC										
791	425971.029	1149845.817	28.684	CC										
792	425968.784	1149845.786	29.012	CC										
793	425967.451	1149847.997	28.906	CC										
794	425968.290	1149849.475	28.607	CC										
795	425969.798	1149850.226	28.246	CC										
796	425965.375	1149869.131	26.343	CC										
797	425964.186	1149867.215	26.758	CC										
798	425962.334	1149866.282	27.025	CC										
799	425959.435	1149866.839	27.287	CC										
800	425971.084	1149874.453	26.024	CC										
801	425971.021	1149874.436	26.011	B	33	B	B		0.20	0.40	0.40	D		1.00
802	425971.576	1149872.173	26.268	B	33	C	B		0.20	0.40	0.40	D		3.00
803	425971.836	1149869.495	26.332	B	33	D	C		0.20	0.40	0.40	D		3.00
804	425972.068	1149866.903	26.593	B	45	D	B					N		2.00
805	425972.406	1149865.327	26.500	B	45	B	B					N		1.00
806	425978.844	1149861.643	26.549	L	45	F		S				N	D	0.50
807	425981.129	1149859.817	26.687	L	45	F		S				N	D	0.50
808	425982.599	1149858.961	26.459	L	45	F		S	0.50	0.50		W	D	0.50
809	425981.513	1149858.375	26.705	L	33	F		S				N	D	4.00
810	425980.232	1149857.008	26.951	L	33	F		S				N	D	4.00
811	425979.828	1149854.636	27.205	L	33	F		S				N	D	5.00
812	425979.412	1149850.807	27.613	L	33	F		S				N	D	6.00

813	425979.506	1149848.162	27.765	L	33	F		S				N	D	6.00
814	425980.104	1149846.097	27.845	L	33	F		S				N	D	6.00
815	425981.721	1149842.711	28.036	L	33	F		S				N	D	4.00
816	425983.195	1149838.063	28.300	L	33	E		S				N	D	4.00
817	425984.556	1149834.702	28.592	L	33	D		S				N	D	2.00
818	425986.551	1149832.831	28.480	L	33	D		S				N	D	1.00
819	425972.077	1149807.660	31.965	D				M	0.30	0.30		D		
820	425972.073	1149807.605	31.974					M	0.40	0.40		D		
821	425974.121	1149808.056	31.727					M	0.40	0.40		D		
822	425978.367	1149808.922	31.487					M	0.40	0.40		D		
823	425981.094	1149810.075	31.114					M	0.40	0.40		D		
824	425958.684	1149775.119	36.163	B	33	D	B	M	0.30	0.30		D		2.00
825	425959.702	1149777.146	36.061	B	33	D	B		0.30	0.30		D		3.00
826	425961.227	1149779.355	35.920	B	33	D	B		0.30	0.30		D		2.00
827	425963.314	1149782.299	35.586	D		C	B		0.30	0.60	0.60	C		
828	425965.670	1149787.294	35.056	D		C	B		0.30	0.60	0.60	C		
829	425968.372	1149791.201	34.214	D		C	B		0.30	0.60	0.60	C		
830	425971.954	1149796.153	33.294											
831	425974.876	1149799.099	32.875											
832	425977.332	1149801.809	32.484											
833	425980.627	1149806.857	31.962											
834	425982.159	1149810.427	31.220											
835	425986.199	1149815.414	30.478											
836	425988.661	1149817.668	30.064											
837	425992.699	1149822.946	29.240											
838	425996.744	1149827.718	28.599											
839	425999.371	1149831.571	28.229											
840	425999.615	1149832.000	28.171											
841	426002.857	1149836.964	27.687											
842	426005.572	1149842.646	27.217											
843	426006.304	1149846.863	27.024	L				S				L		
844	426006.059	1149848.058	27.039	H										
845	426003.286	1149849.442	26.588	H										
846	426002.047	1149852.681	26.383	H										

847	426002.113	1149855.465	26.117	H
848	426003.409	1149857.848	25.952	H
849	426006.448	1149857.910	25.777	H
850	426008.766	1149858.507	25.471	H
851	426011.372	1149857.018	25.232	H
852	426012.747	1149855.667	25.552	H
853	426010.560	1149851.846	26.309	H
854	426009.190	1149849.488	26.466	H
855	426007.377	1149847.670	26.769	H
856	426004.329	1149848.331	26.726	H
857	425994.087	1149859.684	25.686	CC
858	425994.190	1149857.691	25.788	CC
859	425993.546	1149856.179	26.014	CC
860	425991.666	1149857.036	26.060	CC
861	425991.413	1149859.027	25.957	CC
862	425992.813	1149860.207	25.786	CC
863	425994.252	1149858.903	25.679	CC
864	425992.173	1149864.238	25.633	CC
865	425990.950	1149865.749	25.596	CC
866	425992.004	1149868.165	25.528	CC
867	425993.723	1149868.822	25.318	CC
868	425995.008	1149866.338	25.340	CC
869	425994.148	1149864.373	25.559	CC
870	425992.652	1149864.071	25.655	CC
871	425991.051	1149865.427	25.605	CC
872	425984.290	1149866.730	25.679	CC
873	425982.360	1149866.601	25.825	CC
874	425981.266	1149868.331	25.780	CC
875	425981.700	1149870.083	25.618	CC
876	425983.397	1149870.451	25.495	CC
877	425984.539	1149869.086	25.509	CC
878	425984.531	1149866.936	25.699	CC
879	425989.960	1149877.879	25.102	CC
880	425988.977	1149879.149	24.964	CC

881	425989.296	1149880.537	24.805	CC
882	425990.592	1149880.536	24.698	CC
883	425991.678	1149879.187	24.765	CC
884	425991.116	1149877.504	24.923	CC
885	425989.594	1149877.891	25.079	CC
886	425981.402	1149876.270	25.279	CC
887	425980.846	1149875.107	25.302	CC
888	425979.567	1149875.413	25.404	CC
889	425979.187	1149876.865	25.360	CC
890	425980.931	1149877.452	25.205	CC
891	425981.472	1149875.881	25.263	CC
892	425981.012	1149875.017	25.316	CC
893	425943.510	1149828.129	33.312	H
894	425944.244	1149826.086	33.229	H
895	425944.458	1149823.270	33.217	H
896	425943.824	1149820.938	33.316	H
897	425942.636	1149819.119	33.326	H
898	425940.541	1149817.816	33.280	H
899	425937.961	1149818.233	33.273	H
900	425935.488	1149819.281	33.223	H
901	425934.350	1149821.543	33.236	H
902	425933.689	1149824.450	33.222	H
903	425934.265	1149827.450	33.307	H
904	425936.868	1149828.832	33.238	H
905	425940.213	1149828.925	33.340	H
906	425947.507	1149834.017	32.266	H
907	425946.013	1149836.423	32.208	H
908	425945.962	1149836.396	32.208	H
909	425945.539	1149839.666	31.881	H
910	425946.611	1149843.374	31.478	H
911	425947.682	1149845.698	31.284	H
912	425949.903	1149847.237	30.939	H
913	425952.552	1149847.132	30.646	H
914	425955.582	1149845.252	30.547	H

915	425957.520	1149841.038	30.909	H
916	425957.538	1149837.619	31.446	H
917	425957.015	1149835.789	31.661	H
918	425955.776	1149834.639	31.698	H
919	425953.224	1149834.015	31.918	H
920	425949.295	1149833.289	32.255	H
921	425947.363	1149833.576	32.327	H
922	425955.741	1149826.890	32.120	H
923	425957.332	1149828.615	31.757	H
924	425960.666	1149829.444	31.407	H
925	425964.554	1149831.487	30.741	H
926	425968.283	1149831.494	30.217	H
927	425971.103	1149828.690	30.239	H
928	425971.848	1149825.330	30.385	H
929	425972.576	1149822.316	30.591	H
930	425971.760	1149819.179	30.834	H
931	425969.998	1149816.402	31.384	H
932	425966.498	1149814.981	31.950	H
933	425962.368	1149815.412	32.425	H
934	425959.367	1149817.174	32.651	H
935	425957.956	1149821.140	32.526	H
936	425956.701	1149827.099	32.212	H
937	425960.650	1149829.376	31.442	H
refwh	425402.063	1149758.394	57.065	

Appendix C.12 Sumburgh Head Multiple Field System

Point Id	EASTING	NORTHING	HEIGHT	Type	Slope	ft ht in	ft ht out	min st	all max	max st	dense	dir face	face2	width
1	440674.4	1108414	37.71	B	33	0.2	0.2	0.2	0.5	0.5	D			1.4
2	440680.3	1108416	38.44	B	33	0.3	0.3	0.2	0.3	0.3	D			2.5
3	440687.1	1108419	39.32	B	33	0.6	0.2	0.2	0.2		D	S	N	1.9
4	440691.9	1108422	39.9	B				0.4	1.2	1.2	D	S	N	1.9
5	440696	1108423	40.71	B					1.2	1.2	D	S	N	2.1
6	440699.9	1108424	41.69	B		0.8	0.3	0.3	0.7	0.7	D	S	N	2.4
7	440703.6	1108426	42.02	B		0.5	0.5	0.3	0.5	0.5	D	S	N	
8	440707.7	1108427	42.62	B	45	0.3	0.3	0.2	0.6	0.6	D	S	N	1.9
9	440710.8	1108428	43.24	B		0.3		0.2	0.6	0.6	D	S	N	1.7
10	440714.7	1108428	43.94	B		0.5		0.3	0.3		D	S	N	
11	440715.6	1108428	43.91	L	33	0.5		0.3	0.4	0.4	D	W	N	2
12	440717.1	1108424	43.32	L	33	0.7		0.2	0.4	0.4	D	W	N	2
13	440717.2	1108419	42.16	L	33	0.4		0.2	0.4	0.4	D	W	N	1
14	440716.6	1108414	41.58	B	33	0.4	0.2	0.2	0.4	0.4	D	W	N	1.8
15	440717.4	1108410	40.94	B	33	0.6	0.2	0.4	0.4	0.4	D	W	N	1.8
16	440718.7	1108406	40.38	L	33	0.4		0.2	0.4	0.4	D	W	N	1.5
17	440719.3	1108404	39.97	L	33	0.4		0.4	0.4	0.4	D	W	N	0.8
18	440718.5	1108405	40.12	L	33	0.2		0.2	0.2		L	S	N	1.2
19	440715.6	1108403	39.59	L	33	0.3		0.2	0.2			S	N	
20	440713.1	1108402	39.38	L	33	0.4		0.2	0.2			S	N	
21	440711.1	1108402	38.99	L	33	0.3	0.2							
22	440722.4	1108430	45.01	B	33	0.5	0.2	0.2	0.9	0.9	D	S	D	1.5
23	440728.3	1108430	45.87	B	33	0.6	0.2	0.2	1.3	1.3	D	S	D	1.5
24	440731.3	1108431	46.09	B	45	0.4	0.2	0.2	0.6	0.6	C	S	D	0.9
25	440735.1	1108430	46.44	B	33	0.6	0.2	0.2	0.8	0.8	D	S	D	1.2
26	440739.7	1108430	46.6	B	33	0.3	0.2	0.2	0.4	0.4	D	S	D	1.5
27	440743.4	1108431	46.85	B	33	0.4	0.2	0.3	0.8	0.8	D	S	D	1.5

28	440749.8	1108431	47.39	B	33	0.5	0.2				D	S	D	1.5
29	440753.8	1108432	48.39	B	33	0.6						S	D	1.5
30	440758.5	1108434	49.41	B	33	0.7		0.2	0.5	0.5	D	S	D	1.5
31	440784	1108445	55.66	D										
32	440783.6	1108448	56.3	D				0.3	0.7	0.7	F			
33	440783.4	1108451	56.84	D				0.2	0.6	0.6	F			
34	440783.3	1108453	57.19	D				0.3	0.3		D			
35	440783.9	1108456	57.53	D				0.3	0.5	0.5	F			
49	440700.6	1108425	41.91	B	33	0.2	0.7	0.2	0.8	0.8	D	W	N	2.8
50	440699.2	1108429	42.06	B		0.2	0.8	0.3	0.6	0.6	D	W	N	2.8
51	440696.8	1108432	42.46	B		0.2	0.8	0.2	0.2		D	W	N	2.8
52	440694	1108437	42.84	B		0.2	0.8	0.2	0.6	0.6	D	W	N	2.8
53	440691.5	1108441	43.1	B		0.2	0.8	0.1	0.4	0.4	D	W	N	
54	440689.7	1108446	43.42	B		0.2	0.4	0.2	0.2		D	W	N	
55	440687.2	1108450	43.92	B		0.2	0.8	0.2	0.3	0.3	D	W	N	
56	440685.4	1108453	44.22	B	33		0.7	0.2	0.4	0.4	D	W	N	1.2
57	440683.1	1108456	44.52	B	33	0.2	0.5	0.2	0.6	0.6	D	W	N	1.2
58	440681.3	1108457	44.64	B	33	0.2	0.8	0.3	0.4	0.4	D	W	N	1.6
59	440679.1	1108458	44.68	B	33	0.2	0.8	0.3	0.3		D	W	N	1.8
60	440675.3	1108458	44.42	B	33	0.2	0.7	0.3	0.8	0.8	D	W	N	
61	440670.7	1108462	44.57	L	33	0.7		0.2	0.6	0.6	D	S	D	1
62	440668.3	1108463	44.32	L	33	0.6						S	D	1
63	440667.1	1108462	43.84	L	33	0.9		0.2	0.3	0.3	D	S	D	1.6
64	440665.1	1108460	43.29	L	33	0.7		0.2	0.4	0.4		S	D	1.8
65	440662.7	1108459	42.91	L	33	0.4		0.2	0.4	0.4		S	D	1.8
66	440660.8	1108457	42.4	L	33	0.4		0.2	0.4	0.4		S	D	1
67	440658.6	1108456	41.91	L	33	0.4		0.2	0.3	0.3		S	D	0.8
68	440655.3	1108454	41.33	L	33	0.2		0.3	0.3			S	D	0.8
69	440669.9	1108463	44.55	L	33	0.4		0.2	0.4	0.4	D	W	D	0.6

70	440669.5	1108467	44.89	L		0.3	0.2	0.3	0.3		D	W	D	0.8
71	440667.9	1108472	45.6	L		0.3	0.2				D	W	D	0.8
72	440666.7	1108475	45.83	L		0.3	0.2	0.2	0.4	0.4	D	W	D	0.8
73	440665.6	1108479	46.09	L		0.4	0.2	0.2	0.4	0.4	D	W	D	1
74	440663.8	1108481	46.3	L		0.4	0.2	0.3	0.3		D	W	D	1
75	440660.8	1108484	46.39	L		0.4		0.3	0.3		D	W	D	0.8
76	440658.4	1108486	46.64	L		0.3		0.3	0.3		C	W	D	0.8
77	440654.3	1108490	46.59	L		0.3		0.3	0.3			W	D	0.8
78	440638.3	1108540	50.93	L	33									
79	440635.3	1108538	50.56	L		0.2		0.3	0.3		D			
80	440631.8	1108537	50.2	L		0.2		0.3	0.7	0.7	D			
81	440631.6	1108535	50.16	L		0.2		0.3	0.7	0.7	D	W	O	
82	440630.9	1108534	49.94	L		1		0.3	0.7	0.7	D	W	O	2.9
83	440631.6	1108531	49.83	L		1		0.3	0.8	0.8	D	W	O	2.9
84	440633.6	1108528	49.94	L		1.5		0.2	0.5	0.5	D	W	O	4
85	440636.5	1108526	49.96	L		1.1		0.3	0.6	0.6	D	W	O	2
86	440638.8	1108525	49.86	L		0.8		0.3	0.5	0.5	D	W	O	1.9
87	440641.9	1108523	49.86	L		0.8		0.2	0.4	0.4	D	W	O	1.8
88	440644.7	1108520	49.69	L		1					D	W	O	1.2
89	440647.3	1108518	49.71	L		0.8		0.2	0.2			W	O	1
90	440649.8	1108516	49.7	L		0.4		0.2	0.3	0.3	D	W	O	0.5
91	440650.9	1108515	49.9	L	45	0.3		1.4	1.4		D	W	O	
92	440639.4	1108539	51											
93	440642.8	1108536	50.97											
94	440645	1108535	51.05											
95	440647.6	1108532	50.97											
96	440649.2	1108529	50.91											
97	440650.6	1108525	50.67											
98	440653	1108523	50.78											

99	440655.4	1108522	50.89											
100	440656.5	1108519	50.83											
101	440651.7	1108515	49.83											
102	440648.1	1108518	49.77	L	45	0.2		0.2	0.3	0.3	D	W	A	
103	440646.7	1108515	49.06	L	45	0.4		0.2	0.4	0.4	D	W	A	
104	440645.4	1108514	48.7	L	45	0.6		0.2	0.5	0.5	D	W	A	
105	440644.7	1108511	48.28	L	45	0.6		0.2	0.5	0.5	D	W	A	
106	440644.3	1108509	47.97	L	90	0.9		0.2	0.9	0.9	D	W	A	
107	440644.5	1108506	47.42	L	90	0.7		0.2	0.4	0.4	D	W	A	
108	440644	1108505	47.06	L	45	0.1		0.4	0.4		D	W	A	
109	440630.2	1108525	48.54	L	33	0.2	0.2	0.2	0.3	0.3	D	N	U	
110	440628	1108522	47.62	L	33		0.3	0.3	0.5	0.5	D	N	U	
111	440625.8	1108518	46.75	L	33		0.2	0.3	0.3		D	N	U	
112	440624.7	1108513	46.21	L	33		0.2					N	U	
113	440624.3	1108510	45.65	B	33	0.4	0.2					E	D	
114	440623.4	1108506	45.06	B	33	0.2	1.2	0.3	0.3		L	W	U	
115	440624.1	1108503	44.59	B	33	0.3	1	0.2	0.5	0.5	L	W	U	
116	440624.7	1108499	43.87	B	33	0.2	0.6	0.2	0.4	0.4	L	W	U	
117	440622.6	1108494	42.83	B	33	0.2	0.3	0.3	0.6	0.6	C	W	U	
118	440622.1	1108494	42.68	L	33	0.5		0.2	0.6	0.6	D	W	N	1.5
119	440619	1108493	42.09	L	33	1.5		0.2	0.2		D	W	N	2.3
120	440614.5	1108491	41.35	L	33	1.4		0.2	0.4	0.4	D	W	N	2.4
121	440611.7	1108490	40.89	L	33	1.5		0.2	0.5	0.5	D	W	N	2.4
122	440608.7	1108490	40.58	L	33	1.4		0.2	0.3	0.3	D	W	N	2.7
123	440606.3	1108490	40.3	L	33	1		0.2	0.3	0.3	D	W	N	2
124	440604.1	1108492	40.12	L	33	0.4		0.2	0.3	0.3	D	W	N	0.6
125	440600.6	1108542	46.22	L	33	0.6		0.2	0.5	0.5	L	W	D	2
126	440596.3	1108544	45.81	L	33	0.6		0.3	0.7	0.7	L	W	D	1.8
127	440592	1108545	45.38	L	33	0.5						W	D	1.6

128	440588.5	1108546	45.04	L	33	0.7		0.2	0.3	0.3	L	W	D	1.4
129	440584	1108546	44.26	L	33	0.5		0.3	0.6	0.6	L	W	D	1.4
130	440580.5	1108547	43.8	L	33	0.2		0.3	0.6	0.6	L	W	D	0.5
150	440575.5	1108563	44.06	L		0.3		0.3	1.3	1.3	D	W	O	
151	440574.3	1108567	44.1	L		0.3		0.2	0.2		L	W	O	
152	440573.5	1108569	44	L		0.2						W	O	
153	440571.9	1108573	44.06	L		0.3		0.2	0.4	0.4	D	W	O	0.4
154	440570	1108575	43.98	L		0.3		0.3	0.7	0.7	D	W	O	0.6
155	440568.6	1108578	43.92	L		0.7					D	W	O	1.8
156	440566.8	1108579	43.75	L		0.7		0.3	0.4	0.4	D	W	O	1.7
157	440567.1	1108582	43.86	L		1		0.2	0.5	0.5	D	W	O	1.8
158	440567.4	1108585	44.03	L		1		0.3	0.6	0.6	D	W	O	2.5
159	440566.6	1108590	44.08	L		1.1		0.2	0.4	0.4	L	W	O	2.9
160	440566.2	1108593	44.06	L		0.8		0.2	0.5	0.5		W	O	2
161	440566	1108598	44.16	L		0.7		0.4	0.4			W	O	1.4
162	440566	1108602	44.34	L		1.2		0.2	0.4	0.4	L	W	O	3
163	440566.1	1108606	44.19	L	33	1.2		0.2	0.4	0.4	D	W	O	3.5
164	440566.9	1108609	44.4	L	33	1.5		0.2	1.3	1.3		W	O	3.4
165	440567.4	1108612	44.3	L	33	0.6						N	O	1
166	440569.5	1108613	44.52	L		0.3						N	O	0.5

Sumburgh Head: second day

POINT_ID	EASTINGS	NORTHINGS	HEIGHT	type	slope	ft ht in	ft ht out	min st		max st	dense	dir face		width
50	440636.1	1108666	62.37	L	33		0.2	0.2	0.2		L	W	D	0.4
51	440633.9	1108663	61.9	L	33		0.5	0.7	0.7		L	W	D	0.5
52	440632.6	1108660	61.7	L	33		0.5					W	D	0.5
53	440632.1	1108658	61.48	L	45		0.4					W	D	0.2
54	440631.8	1108654	61.25	L	45		0.4	0.2	0.2		L	W	D	0.4
55	440631.9	1108653	61.2	L	33		0.4	0.3	0.3		L	W	D	0.4

56	440632.2	1108650	61.07	L	33	0.5	0.2	0.2		L	W	D	0.6
57	440632.5	1108647	61.01	L	33	0.5					W	D	0.6
58	440632.7	1108645	60.92	L	33	0.5					W	D	0.8
59	440633.8	1108642	60.92	L	33	0.5	0.3	0.3		L	W	D	1
60	440634	1108641	60.84	L	33	0.5	0.3	0.3		L	W	D	1
61	440633.8	1108639	60.78	L	33	0.4	0.2	0.2		L	W	D	0.8
62	440634.2	1108637	60.66	L	33	0.3	0.2	0.6	0.6	L	W	D	0.4
63	440634.7	1108634	60.53	L	33	0.3	0.2	0.3	0.3	L	W	D	0.3
64	440634.9	1108631	60.26	L	33	0.5	0.2	1.1	1.1	L	W	D	1.6
65	440634.9	1108628	60.04	L	33	1.2	0.2	0.4	0.4	L	W	D	3
66	440634.9	1108625	59.86	L	33	0.8					W	D	2
67	440634.7	1108623	59.79	L	33	0.5					W	D	0.5
68	440634.3	1108621	59.69	L	33	0.3					W	D	0.5
69	440634.8	1108618	59.54	L	33	0.4					W	D	0.5
70	440635.9	1108616	59.43	L	33	0.4					W	D	0.5
71	440636.8	1108614	59.44	L	33	0.4					W	D	0.5
72	440637.6	1108611	59.45	L	33	0.4					W	D	0.5
73	440638.2	1108609	59.3	L	33	0.4					W	D	0.5
74	440651.3	1108652	64.71	L	33	0.3	0.2	0.2		L	W	D	0.2
75	440650.2	1108649	64.05	L	33	0.5	0.4	0.4	0.4	L	W	D	0.6
76	440649	1108648	63.37	L	33	0.5					W	D	0.4
77	440647.2	1108646	62.73	L	33	0.5	0.5	0.5		L	W	D	0.4
78	440645.9	1108644	62.39	L	33	0.5					W	D	0.6
79	440645.9	1108643	62.38	L	33	0.5					W	D	0.6
80	440645.4	1108643	62.33	L	33	0.5					W	D	0.6
81	440644.7	1108642	62.21	L	33	0.5	0.6	0.2	0.2	L	W	A	0.7
86	440639.7	1108607	59.41	L	33	0.5	0.2	1	1	D	SW	A	0.6
87	440642.1	1108607	59.53	L		0.5					SW	A	0.8
88	440645.1	1108607	59.7	L		0.6	0.3	0.3		L	SW	A	1

89	440647.2	1108608	59.94	L		0.4					SW	A	1
90	440649.2	1108607	60.13	L		0.4	0.5	0.5		L	S	A	0.5
91	440650.2	1108607	60.08	L		0.5	0.2	0.2		L	S		0.5
92	440651.1	1108608	60.33	L		0.8	0.5	0.5		L	S		0.8
93	440652.1	1108607	60.02	L	45	0.3	0.5	0.5		D	SW	D	0.3
94	440653.6	1108605	60.12	L	45	0.3	0.3	0.6	0.6	D	SW	D	0.3
95	440655.4	1108602	59.85	L	45	0.3	0.3	0.3		D	SW	D	0.3
96	440656.9	1108600	59.66	L	45	0.3	0.3	0.8	0.8	D	SW	D	0.3
123	440569.7	1108612	44.69	L	33	0.5					NW	D	0.7
124	440567.3	1108611	44.36	L	33	1.5	0.2	1.3	1.3	D	NW	D	2.5
125	440565.9	1108610	44.27	L	33	1.3	0.2	0.2		L	NW	D	4
126	440566.2	1108609	44.32	L	33	1.7	0.2	0.4	0.4	D	W	D	4
127	440566.1	1108606	44.21	L	33	1.7	0.4	0.4		D	W	D	0.7
128	440565.9	1108603	44.36	L	33	0.6	0.4	0.4		D	W	D	0.6
129	440566.1	1108600	44.32	L	33						W	D	
130	440566	1108598	44.22	L	33						W	D	
131	440565.8	1108595	44.08	L	33						W	D	
132	440566.4	1108591	44.12	L	33						W	D	
133	440566.9	1108588	44.11	L	33	0.4	0.4	0.4		L	W	D	0.5
134	440567.1	1108586	44.05	L	33	0.6	0.2	0.5	0.5	D	W	D	1.2
135	440566.9	1108583	43.94	L	33	0.6	0.5	0.5		D	W	D	0.8
136	440566.9	1108579	43.78	L	33	0.7	0.2	0.2		D	W	D	1
137	440568.4	1108578	43.97	L	33	0.6	0.3	0.3		D	SW	D	1.2
138	440570.4	1108576	44.14	L	33	0.6				D	SW	D	0.8
139	440571.5	1108575	44.21	L	33	0.3	0.3	0.5	0.5		SW	D	0.6
140	440572.1	1108573	44.16	L	33	0.3	0.7	0.4	0.4	D	SW	D	0.5
141	440572.6	1108571	44.05	L	33	0.3				D	W	D	0.2
142	440572.8	1108570	44.06	L	33	0.2	0.5	1.3	1.3	D	W	D	0.2
143	440575	1108581	44.91	D			0.4	0.6	0.6	C	S	A	

144	440574.2	1108580	44.75	D			0.4	0.4		C	S	A	
145	440571.9	1108580	44.34	D			0.6	0.8	0.8	C	S	A	
146	440599.2	1108544	46.31	L	33	0.5	0.2	0.9	0.9	D	S	A	0.9
147	440595.3	1108544	45.77	L	33	0.5	0.2	0.6	0.6	D	S	A	0.7
148	440592.1	1108545	45.43	L	33	0.3					S	A	0.7
149	440589	1108546	45.17	L	33	0.5	0.3	0.3		L	S	A	0.6
150	440587.5	1108546	44.95	D			0.4	0.5	0.5	D	S	A	
151	440586.1	1108547	44.64	D			0.4	0.5	0.5	L	S	A	
152	440582.9	1108548	44.2	D			0.4	0.7	0.7	D	S	A	
153	440580.8	1108547	43.89	D			0.2	1	1	C	SE	A	
154	440632	1108536	50.29	L	33	0.2	0.2	0.6	0.6	C	SE	A	
155	440630.6	1108534	49.97	L	33	0.3	0.4	0.5	0.5	D	NW	A	0.5
156	440631.2	1108531	49.87	L	33	1	0.4	0.4		D	NW	A	1
157	440632.7	1108528	49.87	L	33	1	0.2	0.6	0.6	D	W	D	1.5
158	440634.9	1108527	50.07	L	33	1.2	0.2	0.4	0.4	D	SW	D	3
159	440637.4	1108526	49.96	L	33	0.8	0.2	0.5	0.5	D	SW	D	1.5
160	440640.3	1108524	49.96	L	33	0.8	0.4	0.6	0.6	D	SW	D	1
161	440642.2	1108523	49.91	L	45	0.6	0.2	0.2		L	SW	D	0.6
162	440644.6	1108521	49.83	L	45	0.6	0.2	0.3	0.3	L	SW	D	0.6
163	440647.1	1108519	49.8	L	45	0.4	1.3	1.3		L	SW	D	0.3
164	440650.1	1108516	49.77	L	33	0.2	0.2	0.2		L	SE	A	0.3
165	440652.1	1108516	50.17	L	33	0.2	1.5	1.5		L	SE	A	0.3
166	440654.2	1108518	50.57	L	33	0.2				L	SE	A	0.3
167	440656.4	1108519	50.85	L	33	0.2				L	SE	A	0.3
183	440617.8	1108555	50.28	L	33	0.3	0.2	0.2		L	SE	A	0.3
184	440615.9	1108554	50.21	L	33	0.3	0.2	0.2		D	SE	A	0.3
185	440614	1108553	49.84	L	33	0.3	0.3	0.8	0.8	D	SE	A	0.3
186	440612.9	1108553	49.46	L	33	0.3	0.5	0.5		D	SE	A	0.3
187	440610.6	1108550	48.59	L	33	0.3	0.2	0.2		L	SE	A	0.3

188	440608	1108548	47.76	L	33	0.3	0.3	0.3	L	SE	A	0.3
189	440610.7	1108534	46.49									
190	440611.8	1108532	46.53									
191	440613.2	1108530	46.42									
192	440613.7	1108528	46.21									
193	440614.4	1108525	46.07									
194	440614.2	1108523	45.72									
195	440614.8	1108522	45.79									
196	440615.8	1108520	45.66									
197	440616.2	1108517	45.49									
198	440617.5	1108515	45.43									
199	440619.9	1108514	45.63									
200	440622.6	1108513	45.9									
201	440623.6	1108513	45.98									
202	440624.5	1108509	45.56									
203	440623.5	1108507	45.18									
204	440623.1	1108505	44.92									
205	440625.4	1108503	44.8									
206	440624.7	1108500	44.19									
207	440624.3	1108498	43.69									
208	440623.8	1108496	43.31									
209	440622.9	1108494	42.95									
210	440622.9	1108492	42.34									
211	440624	1108494	42.98									
212	440625.8	1108493	43.11									
213	440628.1	1108493	43.11									
214	440630.5	1108492	43.16									
215	440631.5	1108491	43.28									
216	440632.5	1108490	43.31									

217	440647.2	1108517	49.55	L	33	0.5	0.2				D	W	A	0.6
218	440646.4	1108515	49.07	L	33	0.5	0.3				D	W	A	0.6
219	440645.3	1108513	48.58	L	33	0.5	0.2	0.4	0.4		D	W	A	0.6
220	440644.3	1108510	48.11	L	33	0.5	0.2				D	W	A	0.6
221	440644	1108508	47.75	L	33	0.5	0.2	0.4	0.4		D	W	A	0.4
222	440644.1	1108506	47.17	L	33	0.5	0.2				D	W	A	0.4
223	440644.1	1108502	46.72	D	90		0.2	1.1	1.1		C	W	A	
224	440644.5	1108500	46.5	D	90		0.3	0.4	0.4		C	W	N	
225	440635.8	1108503	45.83	L	33	0.6	0.2	0.4	0.4		D	SW	N	
226	440637.8	1108501	45.66	L	33		0.6	0.8	0.8		D	SW	N	0.5
227	440640.3	1108499	45.72	L	33		0.3	0.3	0.3		D	SW	N	0.4
228	440642.4	1108496	45.68	L	33		0.3	0.3	0.3		D	W	N	0.4
229	440642.7	1108495	45.57	L	33		0.2	0.4	0.4		D	W	N	0.4
230	440641.5	1108492	45.11	L	33		0.3	0.3	0.3		D	W	N	0.4
231	440640.4	1108490	44.56	L	33		0.5	0.3	0.3		L	W	N	0.8
232	440639.8	1108489	44.25	L	33		0.7	0.4	0.5	0.5	D	W	N	0.8
233	440637.5	1108487	43.56	L	33		0.7	0.4	1.2	1.2	D	W	N	0.8
234	440634.7	1108486	43.03	L	33		0.4	0.2	0.4	0.4	D	NW	N	0.6
235	440632.1	1108485	42.47	L	33		0.4	0.2	0.4	0.4	D	NW	N	0.6
236	440628.5	1108484	41.77	L	33		0.3	0.4	0.5	0.5	D	NW	N	
237	440614.4	1108481	39.55	L	45	0.2		0.2	0.3	0.3	D	S	N	0.2
238	440616.6	1108481	39.73	L	45	0.3		0.2	0.3	0.3	D	S	N	0.6
239	440620	1108481	39.87	L	45	0.4		0.2	0.3	0.3	D	S	N	1.5
240	440623.3	1108481	40.17	L	45	0.6		0.2	0.3	0.3	D	S	N	2
241	440626.9	1108480	40.57	L	45	1		0.2	0.3	0.3	D	S	N	2
242	440628.2	1108479	40.81	L	45	1		0.3	0.5	0.5	D	W	N	2
243	440628.9	1108479	40.93	L	45	1		0.3	0.5	0.5	D	W	N	2
244	440629	1108479	40.91	L	45	1		0.3	0.5	0.5	D	W	N	2
245	440629.8	1108476	40.59	L	45	0.8		0.2	0.3	0.3	D	W	N	0.8

246	440630.1	1108474	40.19	L	45	0.6	0.2	0.3	0.3	D	W	N	0.6
247	440630.3	1108471	39.77	L	45	0.4	0.2	0.4	0.4	D	W	N	0.5
248	440630.4	1108468	39.3	L	45	0.4	0.2	0.4	0.4	D	W	N	0.5
249	440628.4	1108461	38.04										
250	440627.9	1108459	37.47										
251	440627.3	1108455	36.91										
252	440588	1108453	32.72										
253	440585.1	1108452	32.42										
254	440581	1108449	31.88										
255	440579.2	1108451	32.01										
256	440577.6	1108453	32.26										
257	440577.7	1108455	32.42										
258	440584	1108447	31.53										
259	440583.4	1108445	31.16										
260	440582.6	1108442	30.39										
261	440579.8	1108437	29.55										
262	440578.7	1108436	29.12										
263	440577.3	1108435	28.68										
264	440602.6	1108381	23.75	D	33	0.5	0.3	1.7	1.7	D	W	N	0.5
265	440602.9	1108384	24.25	D	33	0.6	0.4	0.4		D	W	N	0.8
266	440602.6	1108387	24.82	D	33	0.6	0.3	0.3		D	W	N	0.6
267	440602.2	1108390	25.35	D	33	0.6	0.3	0.5	0.5	D	W	N	0.6
268	440601.3	1108393	25.58	D	33	0.6	0.3	0.3		D	W	N	0.6
269	440600.6	1108397	25.83	D	33	0.6	0.4	0.4		D	W	N	0.6
270	440600.4	1108398	26.19	D	33	0.6	0.3	0.3		D	W	N	0.6
271	440599.7	1108400	26.26	D	33	0.6	0.2	0.6	0.6	D	W	N	0.6
272	440598.2	1108401	26.14	D	33	0.3	0.2	0.4	0.4	D	W	N	0.6
273	440595.7	1108403	25.88	D	33	0.3	0.3	0.6	0.6	D	W	N	0.6
274	440592.5	1108405	25.68	D	33	0.4	0.4	0.4		D	W	N	0.4

275	440591.1	1108406	25.71	D	33	0.4		0.2	0.4	0.4	D	W	N	0.4
276	440589.1	1108408	25.87	D	33	0.4		0.2	0.6	0.6	D	W	N	0.4
277	440586.5	1108410	25.72	D	33	0.5		0.3	1.5	1.5	D	W	N	1
278	440583.9	1108413	25.5	D	33	0.5		0.5	1.2	1.2	D	W	N	0.8
279	440582	1108414	25.3	D	33	0.5		0.4	0.6	0.6	D	S	N	1.3
280	440576.9	1108414	24.66	D	33	0.5		0.4	1	1	D	S	N	1
281	440571.2	1108414	24.05	D	33	0.5		0.4	0.5	0.5	D	S	N	0.6
282	440566	1108414	23.49				0.2	0.4	0.4		D	S	N	
283	440561.7	1108413	22.99				0.4	1.1	1.1		D	S	N	
284	440558.9	1108413	22.76				0.4	0.6	0.6		C	S	N	
285	440557.7	1108413	22.69				0.4				D	S	N	0.5
286	440597.6	1108510	41.77											
287	440595.2	1108510	41.15											
288	440593	1108510	40.82											
289	440589.1	1108510	40.32											
290	440587	1108509	39.82											
291	440584.8	1108509	39.52											
292	440581.9	1108510	39.27											
293	440578.9	1108511	38.99											
294	440578.9	1108512	39.24											
295	440578.6	1108513	39.57											
296	440577.4	1108515	39.57											
297	440576.1	1108518	39.89											
298	440575.5	1108521	40.28											
299	440574.8	1108524	40.57											
300	440574	1108526	40.8											
0	440519	1108606	36.23											

Appendix C.13 Clevigarth Broch Boundary

Point Id	Type	EASTING	NORTHING	Height	Slope	Ht In	Ht out	St size	All st max	St sz max	Dense	Dir face	Width
1-070	B	440756.3	1112928	22.035	0	0	0	0	0	0	o	o	0
1-071	B	440741.3	1112940	21.453	45	0.2	0.2						
1-072	B	440740.2	1112945	21.34	45	0.2	0.2						
1-073	B	440738.6	1112950	20.984	45	0.2	0.2						
1-074	B	440736	1112954	20.648	45	0.2	0.2						
1-075	B	440731.8	1112957	20.521	45	0.2	0.2	0.2	0.3	0.3			0.7
1-076	B	440727.6	1112958	20.468	45	0.2	0.2	0.3	0.3				0.7
1-077	B	440724.1	1112960	20.453	45	0.2	0.2	0.2	0.2				0.7
1-078	B	440722	1112960	20.371	45	0.2	0.2	0.3	0.3				0.7
1-079	B	440711.1	1112967	19.812	45	0.2	0.2						0.7
1-080	B	440705.1	1112970	19.44	45	0.2	0.2						0.7
1-081	B	440698	1112974	18.908	45	0.2	0.2						0.7
1-082	B	440692.3	1112976	18.508	45	0.2	0.2						0.7
1-083	B	440687.2	1112978	18.205	45	0.2	0.2						0.7
1-084	D	440685.6	1112980	18.068									
1-085	D	440682.7	1112980	17.943									
1-086	D	440681.2	1112979	17.865									
1-087	D	440678.6	1112977	17.816				0.6	0.6		FC		
1-088	D	440676.2	1112975	17.82				0.3	0.3		FC		
1-089	D	440674.3	1112973	17.776				0.4	0.4		FC		
1-090	D	440673	1112972	17.77				0.3	0.3		FC		
1-091	D	440671.7	1112970	17.754			0.2	0.9	0.9		C	W	
1-092	D	440668.2	1112965	17.862			0.2	0.4	0.4		C	W	
1-093	D	440665.1	1112961	17.73			0.3	0.4	0.4		D	W	
1-094	D	440662.2	1112956	17.769			0.4					W	
1-095	D	440674.6	1112981	17.571				0.4	0.4		D		
1-096	D	440670.6	1112982	17.437		0.2	0.2						
1-097	D	440668.1	1112982	17.335		0.2	0.2						
1-098	D	440664.8	1112981	17.287		0.2	0.2						
1-099	D	440659	1112979	17.094		0.2	0.2	0.5	0.5		D		
1-100	D	440654.7	1112978	16.967				1	1		C		

1-101	D	440649.3	1112976	16.866			0.4	0.7	0.7	C		
1-102	D	440644.4	1112974	16.6								
1-103	D	440644.4	1112974	16.595			0.4	0.8	0.8	C		
1-104	D	440639.7	1112973	16.369			0.4	0.5	0.5	C		
1-105	D	440636.2	1112973	16.232			0.4	0.5	0.5	C		
1-106	D	440634.4	1112973	16.218			0.3	0.3		C		
1-107	D	440630.1	1112973	15.971			0.3	0.4	0.4	D		
1-108	D	440626.5	1112972	15.835			0.5	0.6	0.6	C		
1-109	D	440623.6	1112972	15.744			0.5	0.6	0.6	C		
1-110	D	440620.3	1112969	15.513			0.5	0.6	0.6	C		
1-111	D	440617.4	1112967	15.446			0.4	0.7	0.7	C		
1-112	D	440615.9	1112965	15.362			0.8	0.8		C		
1-113	D	440615.9	1112965	15.363			0.3	1	1	C		
1-114	D	440613.8	1112963	15.279			0.4	0.6	0.6	FC		
1-115	D	440613.8	1112963	15.285			0.2	0.8	0.8	C		
1-116	D	440609.9	1112964	15.22			0.3	0.6	0.6	C		
1-117	D	440606.4	1112967	15.011			0.4	0.4		C		
1-118	D	440603.3	1112968	14.982			0.4	0.6	0.6	C		
1-119	D	440587.6	1112974	14.612			0.2	0.8	0.8	C		
1-120	D	440581.6	1112976	14.484	0.2	0.2						
1-121	D	440574.4	1112980	14.125	0.2	0.2	0.3	0.5	0.5	D		
1-122	D	440730.1	1112911	22.577			0.5	0.9	0.9	FC		
1-142	D	440703	1112881	21.23	0.2	0.2	0.4	0.6	0.6	D		2
1-143	D	440700.5	1112874	20.733	0.3	0.3						1
1-144	D	440698.2	1112869	20.546	0.3	0.4					E	1.1
1-145	D	440695.3	1112864	20.403	0.3							
1-146	D	440692.8	1112860	20.222	0.3							
1-147	D	440689.2	1112855	19.939	0.3							
1-148	D	440685.2	1112850	19.699	0.3							
1-149	D	440682.8	1112845	19.349	0.3							
1-150	D	440680.6	1112840	18.982	0.3							
1-151	D	440677.7	1112836	18.697	0.4							
1-152	D	440676.8	1112833	18.594	0.4							
1-153	D	440677.5	1112828	18.61	0.4							

1-154	D	440675.7	1112825	18.384	0.4
1-155	D	440675.7	1112825	18.387	0.4
1-156	D	440673.6	1112819	18.196	0.4
1-157	D	440672.4	1112814	18.067	0.4
Clevigart		440099.4	1112659	18.736	

Appendix C.14 Sae Breck Broch Boundary

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	Ht In	Ht Out	Min St	Max St	Min Stone	All max st	Max Stone	Dense	Dir face	Face	Width
1	421034.190	1178015.257	58.433	Y				M		0.4	0.4		D			o
2	421027.103	1178012.283	57.317	B	33	B	B									A
3	421020.769	1178010.726	56.709	Y				M	M	0.3	0.4	0.4	F			
4	421015.189	1178009.019	56.256	Y				M	A	0.3	0.5	0.5	F			
5	421008.051	1178007.718	55.455	Y				S	M	0.2	0.3	0.3	C			
6	421001.643	1178006.587	54.728	Y				S	A	0.2	0.6	0.6	F			
7	420995.229	1178005.221	53.678	Y				M	M	0.3	0.4	0.4	F			
8	420989.899	1178003.646	52.543	Y				M	L	0.3	0.7	0.7	F			
9	420988.194	1178003.376	52.247	Y				A	A	0.5	0.6	0.6	D			
10	420988.393	1177966.940	49.232	Y				M	A	0.4	0.6	0.6	F			
11	420985.936	1177970.691	49.519	L	33		B							W	T	
12	420983.147	1177977.939	49.923	L	33		C							W	T	
13	420981.457	1177982.426	50.122	L	33		C							W	T	
14	420980.074	1177985.106	50.278	L	33		C							W	T	
15	420979.289	1177987.393	50.348	B	33		B									
16	420976.965	1177990.347	50.545	B	33		B									
17	420975.138	1177992.267	50.664	B	33		B									
18	420974.243	1177994.332	50.690	B	33		B									
19	420973.644	1177990.587	50.383	M		C										
20	420972.339	1177993.691	50.548	M												
21	420972.304	1177996.651	50.765	M												
22	420973.203	1177999.582	51.193	M												
23	420973.459	1178000.194	51.149	L	33	C				0.4	0.4		L		N	B
24	420968.333	1177998.922	50.648	B	33	B	B									B
25	420963.177	1177998.958	50.040	B	33	B	B			0.3	0.3		L			B
26	420958.043	1177999.295	49.375	B	33	B	C			0.3	0.5	0.5	D		T	B

27	420958.102	1177999.422	49.399	B	33	B	C	0.3	0.4	0.4	D	T	C
28	420952.219	1177999.940	48.705	L	33		B	0.3	0.3		L		B
29	420947.457	1178000.928	48.235	L	33		B	0.4	0.7	0.7	D		C
30	420943.033	1178001.176	47.578	L	33	C						N	A
31	420938.912	1178002.199	47.226	B	33	C	C						G
32	420935.787	1178002.830	46.681	B	33	C	C						D
33	420929.221	1178003.170	45.458	B	33	B	B						C
34	420923.772	1178003.945	44.484	B	33	C	D						G
35	420917.737	1178004.004	43.874	B	33	D	D						G
36	420910.025	1178004.774	43.311	B	33	C	C						I
37	420909.787	1178004.821	43.350	B	33	D	C					N	I
38	420902.976	1178005.347	42.993	B	33	D	B					N	H
39	420895.843	1178006.011	42.383	B	33	D	C					N	H
40	420890.927	1178007.583	42.054	B	33	D	C					N	H
41	420885.428	1178009.294	41.507	B	33	D	C					N	I
42	420878.421	1178010.826	41.007	B	33	C	C						H
43	420871.317	1178011.893	40.316	B	33	C	B					N	G
44	420863.500	1178012.815	39.139	B	33	B	C					T	E
45	420857.012	1178014.257	38.321	B	33	D	C					N	E
46	420850.217	1178016.258	37.202	B	33	E	C					N	I
47	420844.554	1178017.820	36.446	B	33	E	C					N	I
48	420838.993	1178019.369	35.667	B	33	F	C					N	J
49	420833.206	1178020.628	35.017	B	33	F	C					N	J
50	420828.091	1178021.466	34.598	B	33	F	B					N	J
51	420823.972	1178021.932	34.235	B	33	F	B					N	J
52	420821.423	1178023.231	34.101	B	33	D	B					N	G
53	420817.837	1178024.076	33.778	B	33	D	B					N	G
54	420813.483	1178024.804	33.348	B	33	B	B						E
55	420809.291	1178024.030	32.749	B	33	A	B					T	D

56	420805.976	1178022.806	31.878	B	33	D	B								N	G
57	420802.482	1178022.430	31.113	B	33	D	C								N	G
58	420799.719	1178022.335	30.738	B	33	D	D									H
59	420797.273	1178022.981	30.327	B	33	D	D									J
60	420794.202	1178021.538	29.708	B	33	C	D								T	H
61	420791.388	1178019.867	29.441	D						0.3	0.5	0.5	C			
62	420789.298	1178018.334	29.382	D						0.3	0.5	0.5	C			
63	420787.715	1178019.364	29.305	D						0.3	0.6	0.6	C			
64	420975.645	1178000.898	51.379	L	33		E	S	M	0.2	0.4	0.4	L	W	T	E
65	420973.190	1178005.600	51.489	L	33	B	E	M	A	0.3	0.6	0.6	L	W	T	E
66	420970.808	1178009.665	51.797	L	33	B	E	M	M	0.3	0.4	0.4	L	W	T	E
67	420969.333	1178013.263	51.925	L	33	C	F	M		0.4	0.4		L	W	T	G
68	420967.827	1178016.481	52.007	L	33	B	E	A	A	0.5	0.6	0.6	C	W	T	G
69	420966.393	1178019.790	52.094	L	33	B	E	S	S	0.2	0.4	0.4	L	W	T	G
70	420965.270	1178023.998	52.051	L	33	B	E	M	M	0.3	0.8	0.8	F	W	T	E
71	420964.553	1178027.484	52.329	L	33	C	E	M	M	0.3	0.4	0.4	F	W	T	E
72	420963.944	1178030.286	52.388	L	33	C	E	S	S	0.2	0.4	0.4	F	W	T	E
73	420964.180	1178033.466	52.635	L	33	B	F	S	S	0.2	0.6	0.6	C	W	T	E
74	420964.524	1178036.500	52.721	L	90	B	F	S	S	0.2	0.6	0.6	C	W	T	F
75	420965.019	1178039.805	52.767	L	45	B	E	S	S	0.2	0.8	0.8	C	W	T	E
76	420965.663	1178043.280	52.820	L	45	C	E	M	M	0.3	0.9	0.9	F	W	T	E
77	420966.984	1178047.690	53.063	L	45	C	E	M	M	0.3	0.5	0.5	F	W	T	E
78	420968.343	1178051.269	53.329	L	33	C	D	M	M	0.3	0.4	0.4	D	W	T	E
79	420969.981	1178055.711	53.619	L	33	C	D	M	M	0.3	0.4	0.4	D	W	T	E
80	420971.841	1178059.073	53.738	L	33	B	D							W	T	E
81	420973.627	1178061.879	53.952	L	33	B	E	M	M	0.3	0.4	0.4	L	W	T	E
82	420975.349	1178064.828	53.927	L	33	B	D	M	M	0.3	0.4	0.4	L	W	T	E
83	420977.256	1178070.225	54.068	L	33		D							W	T	G
84	420978.279	1178075.316	54.071	L	33		E							W	T	E

85	420979.210	1178079.591	54.096	L	33		E	M		0.3	0.3		L	W	T	E
86	420979.889	1178084.324	54.024	L	45		E	S	M	0.2	0.4	0.4	D	W	T	C
87	420979.986	1178088.231	53.911	L	33	B	E	S		0.2	0.2		L	W	T	D
88	420980.256	1178091.966	53.682	L	33	B	E	M	A	0.3	0.6	0.6	D	W	T	E
89	420980.251	1178096.159	53.603	L	33	B	F	S	M	0.2	0.4	0.4	D	W	T	G
90	420980.369	1178101.015	53.693	L	33	B	F	M	L	0.4	0.8	0.8	D	W	T	H
91	420980.173	1178105.745	53.771	L	33	B	F	M	L	0.4	0.7	0.7	D	W	T	H
92	420980.421	1178109.498	53.965	L	33	B	F	M	A	0.3	0.5	0.5	C	W	T	G
93	420979.345	1178114.014	53.555	L	33	B	F	S	L	0.2	0.8	0.8	F	W	T	G
94	420978.682	1178117.722	52.993	L	33	B	F							W	T	G
95	420978.444	1178121.061	52.711	L	90	A	F	M	A	0.3	0.5	0.5	C	W	T	E
96	420979.060	1178126.152	51.870	L	33	A	E	S	M	0.2	0.4	0.4	L	W	T	E
97	420980.176	1178130.579	51.795	L	33		F	S	M	0.2	0.3	0.3	L	W	T	E
98	420983.030	1178133.394	51.602	L	33		F	M	A	0.3	0.5	0.5	L	W	T	E
99	420986.083	1178136.378	51.357	L	33		F	S	M	0.2	0.4	0.4	L	W	T	D
100	420987.680	1178140.279	51.049	L	33		F							W	T	D
101	420989.591	1178143.003	50.824	L	33		D							W	T	C
102	420991.622	1178146.534	50.380	L	33		D							W	T	D
103	420993.036	1178150.462	49.924	L	33		D							W	T	C
104	420994.178	1178153.723	49.558	L	33		D							W	T	C
105	420995.973	1178157.178	49.225	L	33		C							W	T	B
106	420998.510	1178160.271	48.946	L	33		C							W	T	B
107	421002.648	1178162.883	48.800	L	33		C							NW	T	B
108	421007.392	1178163.802	48.745	L	33		C							N	T	B
109	421012.132	1178164.928	48.719	L	33		C							N	T	A
110	421016.469	1178165.362	48.734	L	33		C							N	T	B
111	421023.192	1178168.112	48.718	L	33		B							NW	T	B
112	421028.871	1178170.297	48.797	L	33		C							NW	T	B
113	421035.417	1178172.860	48.567	L	33		C	S	M	0.2	0.3	0.3	L	NW	T	B

114	421039.640	1178175.684	48.396	L	33	B	C	M		0.3	0.3		L	NW	T	B
115	421042.717	1178178.126	48.309	L	33	B	C							NW	T	B
116	421046.872	1178180.872	48.129	L	33			M	M	0.3	0.4	0.4	L			C
117	421050.931	1178183.219	48.127	Y				S	M	0.2	0.4	0.4	L			
118	421055.990	1178186.179	47.947	Y				M	L	0.3	0.7	0.7	F			
119	421060.545	1178187.756	47.870	Y				M	A	0.3	0.5	0.5	D			
120	421064.755	1178189.434	47.798	Y				S	M	0.2	0.3	0.3	F			
121	421068.851	1178191.272	47.625	Y				S	L	0.2	0.7	0.7	F			
122	421072.639	1178193.091	47.431	Y				S	L	0.2	0.7	0.7	D			
123	421078.237	1178195.129	46.607	Y				S	A	0.2	0.5	0.5	F			
124	421083.194	1178197.996	45.505	L	33		C	M		0.4	0.4		L	NW	T	C
125	421087.804	1178200.578	44.851	L	33		D	M		0.3	0.3		L	NW	T	C
126	421090.754	1178202.532	44.571	L	33		E	S	A	0.2	0.5	0.5	D	NW	T	C
127	421093.965	1178204.354	44.214	L	33		D	S	L	0.2	0.7	0.7	F	NW	T	E
128	421097.701	1178206.089	43.787	L	33		D	M	A	0.3	0.5	0.5	F	NW	T	E
129	421100.351	1178207.051	43.616	L	33		D	M	M	0.3	0.4	0.4	F	NW	T	C
130	421102.969	1178208.254	43.324	L	33		C	S	M	0.2	0.3	0.3	D	NW	T	C
131	421105.397	1178210.568	43.232	L	33		C							NW	T	C
132	421108.948	1178213.747	43.197	Y				M	A	0.3	0.6	0.6	F			
133	421112.782	1178216.504	43.141	Y				M	X	0.3	1	1	F			
134	421116.520	1178219.348	43.000	L	33		C	S	M	0.2	0.4	0.4	F	NW	T	
135	421120.744	1178222.454	42.848	L	33		C	S	L	0.2	0.9	0.9	F	NW	T	
136	421124.231	1178225.840	42.933	L	33		C	S	A	0.2	0.5	0.5	F	NW	T	
137	421127.831	1178229.086	42.900	L	33		C	S	A	0.2	0.5	0.5	D	NW	T	
138	421131.331	1178232.057	42.840	L	33		C	M	M	0.3	0.4	0.4	F	NW	T	
139	421134.685	1178234.380	42.829	L	33		D	M	L	0.3	0.7	0.7	F	NW	T	
140	421137.567	1178237.077	42.736	L	33		D	M	M	0.3	0.4	0.4	D	NW	T	
141	421139.018	1178239.760	42.617	L	33		C	S	A	0.2	0.6	0.6	D	NW	T	
142	421120.076	1178093.271	42.477	B	33	C	C									B

143	421123.602	1178095.951	42.006	B	33	C	C									B
144	421126.341	1178098.078	41.461	B	33	C	C	S	A	0.2	0.4	0.4	L			B
145	421128.949	1178100.267	40.904	B	33	B	B									B
146	421133.278	1178094.864	40.730	Y				M		0.4	0.4		F			
147	421135.704	1178092.532	40.618	Y				M		0.3	0.3		F			
148	421138.192	1178089.129	40.657	Y				M		0.3	0.3		F			
149	421217.568	1178125.147	36.277													
150	421217.606	1178125.204	36.275													
151	421217.498	1178125.048	36.294	L	33		F							SE	T	E
152	421215.375	1178120.960	36.499	L	33		E	L		0.8	0.8		L	SE	T	C
153	421212.418	1178115.180	36.430	L	33		F	S	A	0.2	0.6	0.6	L	SE	T	G
154	421208.642	1178109.597	36.747	L	33		F							SE	T	G
155	421205.858	1178104.627	36.709	L	33		F	M		0.3	0.3		L	SE	T	J
156	421204.650	1178100.712	36.762	L	33		F	M		0.3	0.3		L	SE	T	G
157	421202.749	1178096.263	36.493	L	33		F	T	A	0.1	0.5	0.5	D	SE	T	G
158	421200.951	1178093.039	36.210	L	33		E	M	M	0.3	0.4	0.4	D	SE	T	E
159	421199.639	1178090.925	36.008	L	33		E	M	X	0.3	1	1	C	SE	T	E
160	421197.716	1178087.111	35.767	L	33		E	M	A	0.3	0.5	0.5	C	SE	T	C
161	421195.657	1178083.293	35.601	L	33		F	M	M	0.3	0.4	0.4	F	SE	T	
162	421192.373	1178078.397	35.641	L	33		E							SE	T	E
163	421189.402	1178073.428	35.590	L	33		F	M		0.3	0.3		D	SE	T	E
164	421186.573	1178068.796	35.466	L	45		F							SE	T	H
165	421183.742	1178063.608	35.741	L	33		F							SE	T	G
166	421181.480	1178058.517	36.384	L	33		F	S	L	0.2	0.7	0.7	D	SE	T	G
167	421178.932	1178057.249	36.964	B	33		B							SE	T	A
168	421175.561	1178056.100	37.849	B	33	A	C	T		0.1	0.1			SE	T	A
169	421172.435	1178054.370	38.322	L	90	A	D	M	A	0.3	0.5	0.5	F	SE	T	B
170	421168.716	1178052.586	38.978	L	45	B	E	T	A	0.1	0.6	0.6	F	SE	T	C
171	421163.677	1178050.693	39.439	L	45	B	E	T	L	0.1	0.8	0.8	F	SE	T	C

172	421158.268	1178048.667	40.153	L	45	B	D	S	M	0.2	0.3	0.3	C	SE	T	C
173	421154.522	1178046.977	40.420	L	45	B	D	S	L	0.2	0.7	0.7	C	SE	T	E
174	421151.030	1178045.516	41.029	B	33	C	D	S	M	0.2	0.4	0.4	L	SE	T	E
175	421146.679	1178042.420	42.198	D				T	L	0.1	0.6	0.6	F			
176	421140.602	1178040.054	43.440	B	45	C	C	S	L	0.2	0.9	0.9	L	N	N	C
177	421135.415	1178038.526	44.252	D				S	A	0.2	0.6	0.6	F			
178	421129.066	1178036.534	45.468	B	33	C	D	S	L	0.2	0.9	0.9	D	S	T	C
179	421124.286	1178034.520	46.242	B	33	B	C	S	A	0.2	0.5	0.5	D	S	T	A
180	421119.930	1178033.033	46.902	L	33	C	D	S	A	0.2	0.5	0.5	L	S	T	B
181	421112.791	1178031.521	48.302	L	33		E	S	A	0.2	0.6	0.6	D	S	T	B
182	421108.644	1178029.982	49.067	L	33		D	T	L	0.1	0.7	0.7	D	S	T	B
183	421104.731	1178028.681	50.164	L	45		E	M	L	0.3	0.7	0.7	C	S	T	C
184	421100.099	1178027.949	51.736	L	33		F	M	X	0.3	1	1	C	S	T	C
185	421095.139	1178027.129	52.963	L	33		E	M	L	0.3	0.8	0.8	F	S	T	C
186	421089.552	1178026.749	54.178	L	33		E	M	L	0.4	0.8	0.8	D	S	T	C
187	421085.035	1178025.858	54.933	L	33		C	M	L	0.3	0.7	0.7	D	S	T	B
188	421081.692	1178024.929	55.475	L	33		D	M	A	0.4	0.6	0.6	F	S	T	B
189	421077.563	1178024.010	56.109	L	33		C	M	A	0.3	0.5	0.5	F	S	T	B
190	421073.547	1178023.183	56.751	L	33		C	T	A	0.1	0.6	0.6	F	S	T	A
191	421069.186	1178022.438	57.498	L	45		D	S	A	0.2	0.5	0.5	C	S	T	B
192	421064.250	1178022.049	58.465	L	45		E	S	M	0.2	0.4	0.4	F	S	T	C
193	421059.891	1178021.328	58.891	L	33		E	S	M	0.2	0.4	0.4	F	S	T	C
194	421054.523	1178020.960	59.833	L	33		B	S	A	0.2	0.6	0.6	D	S	T	C
195	421050.333	1178019.887	60.009	L	33		B	S	M	0.2	0.4	0.4	D	S	T	B
196	421046.773	1178020.316	59.835	L	33		E	M	M	0.3	0.4	0.4	L	S	T	C
197	421044.577	1178018.544	59.711	L	33		E	M		0.3	0.3		L	S	T	C
198	421043.680	1178017.082	59.635													
199	421043.341	1178016.023	59.504													
200	421045.716	1178013.971	59.442													

201	421048.637	1178012.508	59.357
202	421051.969	1178012.280	59.177
203	421053.651	1178013.844	59.052
204	421066.696	1178023.790	58.220
205	421068.726	1178026.100	58.286
206	421069.950	1178028.508	58.127
207	421070.520	1178030.701	58.197
208	421070.801	1178033.290	58.222
209	421070.998	1178035.855	58.185
210	421072.190	1178038.393	58.251
211	421073.209	1178041.340	57.962
212	421072.719	1178043.693	58.454
213	421070.968	1178046.390	58.884
214	421068.835	1178048.698	59.197
215	421066.028	1178050.856	59.494
216	421063.840	1178051.895	59.721
217	421061.216	1178052.464	59.981
218	421060.008	1178052.608	60.090
219	421053.351	1178052.765	60.439
220	421049.826	1178051.334	60.817
221	421045.793	1178049.663	60.797
222	421041.784	1178048.065	60.720
223	421039.437	1178045.774	60.652
224	421037.682	1178042.983	60.788
225	421036.442	1178038.817	60.430
226	421036.035	1178034.614	60.257
227	421037.812	1178029.724	60.272
228	421038.439	1178025.742	60.076
229	421041.160	1178021.771	59.964

230	421043.070	1178018.998	59.839
231	421049.642	1178024.577	60.673
232	421047.923	1178027.192	60.751
233	421045.737	1178029.746	60.764
234	421043.544	1178032.710	60.704
235	421042.523	1178035.746	60.655
236	421044.094	1178039.113	61.058
237	421046.155	1178041.424	61.303
238	421047.914	1178043.331	61.765
239	421051.542	1178044.669	61.531
240	421054.850	1178044.761	61.321
241	421058.292	1178044.892	60.822
242	421061.094	1178042.484	60.563
243	421063.044	1178038.948	60.112
244	421063.020	1178034.314	59.907
245	421063.515	1178034.392	59.726
246	421072.722	1178039.567	58.135
247	421072.038	1178035.985	58.034
248	421071.055	1178032.144	58.202
249	421070.054	1178027.898	58.048
250	421068.538	1178025.542	58.221
251	421067.098	1178023.399	58.115
252	421052.462	1178027.459	60.811
253	421049.225	1178032.988	61.414
254	421048.428	1178035.552	61.313
255	421052.263	1178036.701	61.442
256	421053.104	1178034.101	61.435
257	421037.263	1178020.298	59.719
258	421035.963	1178019.445	59.509

259	421037.403	1178017.600	59.257													
260	421038.774	1178018.804	59.726													
261	421040.784	1178056.256	60.024													
262	421038.557	1178056.198	59.860													
263	421036.456	1178057.949	59.997													
264	421036.238	1178060.516	59.994													
265	421038.071	1178062.516	60.015													
266	421040.820	1178062.707	60.103													
267	421042.705	1178060.876	60.349													
268	421042.754	1178058.389	60.294													
269	421132.158	1178068.957	42.846													
270	421136.627	1178071.619	41.842													
271	421140.038	1178074.032	41.334													
272	421143.012	1178075.840	40.897													
273	421146.781	1178078.473	40.541													
274	421150.023	1178080.471	40.028													
275	421153.600	1178082.962	39.365													
276	421158.808	1178085.162	38.602													
277	421161.491	1178087.106	38.395													
278	421164.442	1178089.618	38.165													
279	421166.550	1178091.819	38.100													
280	421168.649	1178093.835	38.018													
281	421170.873	1178096.162	37.857													
282	421172.858	1178097.213	37.830													
283	421186.392	1178135.585	39.871	B	33	D	B							N	SW	B
284	421190.508	1178134.469	39.662	B	33	C	B	S	M	0.2	0.4	0.4	D	N	SW	B
285	421194.030	1178132.786	39.044	B	33	C	B	S	M	0.2	0.4	0.4	F	N	SW	C
286	421197.450	1178131.592	38.753	B	90	C	B	S	A	0.2	0.6	0.6	F	N	SW	C
287	421200.625	1178130.712	38.412	B	45	C	B							N	SW	C

288	421203.137	1178129.526	38.151	B	45	C	B	M		0.3	0.3		L	N	SW	B
289	421206.348	1178128.298	37.769	B	45	C	B	M		0.3	0.3		L	N	SW	B
290	421209.911	1178127.090	37.355	B	33	C	B	M		0.3	0.3		L	N	SW	B
291	421213.566	1178125.969	36.813	B	33	C	B	M		0.3	0.3		L	N	SW	B
292	421215.952	1178125.202	36.544	B	33	C	B	M		0.3	0.3		L	N	SW	B
293	421217.269	1178124.719	36.316	B	33	C	B	M		0.3	0.3		L	N	SW	B
294	421217.267	1178124.683	36.311	L	33	D								N	SW	B
295	421219.916	1178124.514	35.802	L		D		M	A	0.3	0.5	0.5	F	N	SW	B
296	421222.208	1178124.356	35.429	L	90	D		M	L	0.3	0.7	0.7	C	N	SW	B
297	421224.460	1178123.572	34.837	B	33	D	S	M	A	0.3	0.5	0.5	D	N	SW	B
298	421226.400	1178122.788	34.455	B	33	D	S	S	M	0.2	0.3	0.3	L	N	SW	D
299	421228.050	1178121.649	34.000	B	33								L			D
300	421230.237	1178121.235	33.231	B	33								L			D
301	421232.907	1178120.985	32.532	B	33	D	M	S	M	0.2	0.3	0.3	L	N	SW	D
302	421234.471	1178120.507	31.957	B	33	C	M	S	M	0.2	0.3	0.3	L	N	SW	D
303	421235.676	1178120.357	31.565	B	33	C	A	S	M	0.2	0.4	0.4	L	N	SW	C
304	421236.714	1178118.663	31.329	B	33			S	M	0.2	0.3	0.3	F			B
305	421238.615	1178116.199	30.172	B	90			M	M	0.3	0.4	0.4	F			A
306	421237.054	1178120.467	30.903	L	33											
307	421237.091	1178120.618	30.531	L	33											
308	421239.197	1178119.583	30.322	L	33											
309	421241.480	1178118.992	29.053	L	33											
310	421243.661	1178117.955	27.937	L	33											
ref2	421053.336	1178033.475	61.428	L	33											

Appendix C.15 Tumblin1 Broch Boundary

Point Id	Eastings	Northings	Height	Type	Slope	HtIn	HtOt	MinSt	All max	MaxSt	Stmin	Stmax	Dens	DirFac	Face	Width
111	434531.05	1153948.03	91.01	B	33	C	C	0.2	0.3	0.3	S	M	D	W	T	B
112	434562.34	1154038.62	82.13	B	33	C	C	0.2	0.3	0.3	S	M	D	W	T	B
113	434561.60	1154036.28	82.58	B	33	A	C	0.2	0.3	0.3	S	M	F	W	T	B
114	434560.31	1154033.64	82.88	B	33	B	C	0.2	0.3	0.3	S	M	D	W	T	D
115	434559.24	1154030.24	83.28	B	33	B	C	0.2	0.4	0.4	S	M	D	W	T	E
116	434558.09	1154028.34	83.52	B	33	B	D	0.2	0.3	0.3	S	M	D	W	T	F
117	434556.67	1154026.17	83.65	B	33	B	D	0.2	0.2		S		L	E	N	F
118	434554.69	1154023.48	83.89	B	33	B	C	0.4	0.7	0.7	M	L	D	W	T	C
119	434553.74	1154020.90	84.21	B	33	B	D	0.2	0.4	0.4	S	M	D	W	T	E
120	434552.78	1154018.00	84.28	B	33											E
121	434551.68	1154016.09	84.42	B	33											D
122	434549.76	1154012.78	84.65	B	33	A	D	0.2	0.4	0.4	S	M	D	N	T	B
123	434548.04	1154011.07	84.89	B	33	A	C									C
124	434546.18	1154009.34	84.80	B	33	A	C									B
125	434543.99	1154009.14	84.84	B	33			0.3	0.95	0.95	M	L	D	N	T	
126	434541.04	1154009.51	84.86	D	33	A	C	0.2	0.5	0.5	S	A	D	N	T	B
127	434539.39	1154009.80	84.87	B	33	A	C	0.3	0.3		M		L			B
128	434536.99	1154010.96	84.59	B	33		C									C
129	434534.64	1154011.37	84.35	B	33	A	D	0.3	0.4	0.4	M	M	D	N	T	C
130	434532.64	1154011.15	84.22	B	33	A	D	0.2	0.3	0.3	S	M	D	N	T	D
131	434530.50	1154010.76	84.16	B	33	A	D	0.2	0.4	0.4	S	M	D	N	T	E
132	434528.42	1154010.45	83.95	B	33	A	E	0.2	0.5	0.5	S	A	D	N	T	E
133	434526.23	1154010.63	83.69	B	33		E	0.3	0.3		M		D	S	N	B
134	434525.14	1154010.09	83.65	L	45		E	0.2	0.4	0.4	S	M	D	NW	T	B
135	434524.10	1154008.20	83.67	L	45		D	0.3	0.3		M		L	W	N	A
136	434522.16	1154006.32	83.81	L	45		D	0.3	0.3		M		L	W	N	A

137	434519.94	1154005.08	83.67	L	90	D	0.3	0.6	0.6	M	A	D	NW	T	A
138	434515.77	1154003.83	83.31	L	45	D	0.3	0.5	0.5	M	A	F	N	T	C
139	434509.98	1154002.03	83.06	L	33	D	0.3	0.5	0.5	M	A	C	N	T	C
140	434505.69	1154001.37	83.00	L	33	D	0.2	0.4	0.4	S	M	C	N	T	B
141	434501.03	1154001.13	82.66	L	33	C	0.2	0.4	0.4	S	M	C	N	T	A
142	434498.44	1154000.54	82.67	L	33	D	0.2	0.7	0.7	S	L	C	N	T	B
143	434495.64	1153999.48	82.65	L	33	E	0.2	0.4	0.4	S	M	C	NW	T	B
144	434493.39	1153997.59	82.70	L	33	E	0.2	0.6	0.6	S	A	C	NW	T	B
145	434490.32	1153996.31	82.44	L	33	E	0.2	0.4	0.4	S	M	C	N	T	C
146	434488.04	1153995.78	82.12	L	33	D	0.2	0.4	0.4	S	M	C	N	T	B
147	434486.39	1153996.11	82.03	L	33	D	0.2	0.4	0.4	S	M	D	NW	T	B
148	434484.36	1153994.55	82.04	L	33	D	0.3	0.3		M		L	SE	N	B
149	434482.59	1153992.88	82.04	L	33	C	0.2	0.2		S		L	SE	N	A
150	434480.96	1153992.23	81.80	L	33	C	0.2	0.2		S	M	L	SE	N	B
151	434478.92	1153991.27	81.74	L	33	D									B
152	434477.26	1153990.56	81.49	L	33	D									B
153	434475.82	1153988.59	81.46	L	33	D									B
154	434473.11	1153985.87	81.33	L	33	D	0.2	0.2		S		F	SE	N	
155	434470.69	1153984.20	81.18	L	90	D	0.4	0.4		M		L	SE	N	B
156	434466.45	1153982.16	80.99	L	33	E	0.3	0.3		M		D	SE	N	B
157	434461.73	1153979.82	80.85	L	33	D						L			B
158	434456.89	1153976.23	80.75	L	33	D	0.2	0.4	0.4	S	M	D	W	T	B
159	434454.90	1153973.83	80.79	L	33	D	0.2	0.3	0.3	S	M	D	W	T	B
160	434453.27	1153970.88	80.71	L	33	E									B
161	434451.48	1153967.49	80.73	L	45	E	0.3	1.2	1.2	M	X	C	W	T	B
162	434451.78	1153963.67	80.83	L	45	D	0.1	0.5	0.5	T	A	C	W	T	A
163	434451.55	1153962.72	80.90	L	45	D	0.2	0.5	0.5	S	A	C	W	T	B
164	434450.56	1153960.31	80.94	L	33	E	0.2	0.5	0.5	S	A	D	W	T	C
165	434450.33	1153959.17	81.09	L	90	E	0.3	0.5	0.5	M	A	BUILT	W	T	B

166	434451.31	1153962.27	80.89	L	33		E	0.2	0.6	0.6	S	A	C	W	T	C
167	434450.42	1153959.64	81.04	L	33		E	0.3	0.5	0.5	M	A	C	W	T	C
168	434449.39	1153956.78	81.27	L	33	B	A	0.3	0.5	0.5	M	A	C	W	T	D
169	434448.64	1153954.14	81.46	L	90		A	0.2	0.6	0.6	S	A	C	W	T	
170	434448.34	1153951.84	81.70	L	45		E	0.2	0.4	0.4	S	M	D	W	T	A
171	434447.60	1153949.04	81.84	L	33		E	0.2	0.4	0.4	S	M	F	W	T	B
172	434447.39	1153947.14	82.00	L	45		E	0.3	0.3		M		F	W	T	A
173	434447.74	1153945.77	82.16	L	33		E	0.2	0.5	0.5	S	A	F	W	T	B
174	434447.71	1153943.61	82.49	L	45		F	0.2	0.4	0.4	S	M	F	W	T	A
175	434446.58	1153941.42	82.51	L	33		F	0.2	0.4	0.4	S	M	F	NW	T	B
176	434443.10	1153938.79	82.01	L	33		F	0.2	0.4	0.4	S	M	F	NW	T	B
177	434440.52	1153937.28	81.73	L	90		E	0.6	0.6		A		L	NW	T	
178	434435.56	1153935.62	80.91	L	33	B	E	0.4	0.5	0.5	M	A	D	NW	T	B
179	434431.54	1153935.26	80.09	L	33	B	F	0.2	0.4	0.4	S	M	D	NW	T	B
180	434428.87	1153933.97	79.65	L	33	C	F	0.2	0.8	0.8	S	X	D	NW	T	C
181	434425.76	1153932.69	79.15	L	45	B	F	0.2	0.5	0.5	S	A	D	NW	T	C
182	434423.29	1153931.09	78.70	L	45	B	E	0.2	0.3	0.3	S	M	L	NW	T	D
183	434419.51	1153928.63	78.25	L	45	B	F	0.2	0.2		S		L	NW	T	D
184	434415.93	1153926.89	77.56	L	45	B	F	0.2	0.2		S		L	NW	T	D
185	434412.86	1153925.08	77.16	L	45	C	E	0.2	0.3	0.3	S	M	L	NW	T	G
186	434410.77	1153924.15	76.86	L	45	B	E							NW	T	D
187	434407.43	1153922.89	76.21	L	45	B	F	0.2	0.2		S		L	NW	T	D
188	434405.81	1153921.93	76.01	L	45	C	F	0.2	0.3	0.3	S	M	L	NW	T	D
189	434405.12	1153921.66	75.70	L	45	C	F							NW	T	C
190	434402.21	1153920.84	75.00	L	45	B	E	0.2	0.2		S		L	NW	T	C
191	434399.84	1153919.34	74.51	L	45		F	0.2	0.8	0.8	S	X	L	NW	T	B
192	434396.57	1153917.49	74.04	L	33		E	0.4	0.4		M		L	NW	T	B
193	434394.00	1153914.70	73.63	L	33		E							NW	T	B
194	434393.50	1153913.10	73.64	L	33		D							NW	T	B

195	434391.91	1153910.79	73.48	L	33		C					NW	T	D
196	434391.28	1153910.18	73.24	L	33		E	0.3	0.3	M	L	NW	T	D
211	434378.71	1153905.54	72.17	B	33	B	D	0.5	0.5	A	L	W	T	B
212	434377.26	1153903.74	72.40	B	33	B	D	0.2	0.2	S	L	W	T	B
213	434376.54	1153901.49	72.69	B	45	C	E	0.3	0.3	M	L	W	T	C
214	434376.66	1153901.48	72.70	B	45	C	F	0.3	0.3	M	L	W	T	D
215	434376.25	1153900.68	72.82	B	45	A	E	0.2	0.2	S	L	W	T	C
216	434376.03	1153899.30	72.87	B	45		E	0.3	0.3	M	L	W	T	C
217	434375.16	1153897.57	72.82	L	45		E	0.2	0.2	S	L	W	T	B
218	434374.36	1153896.24	72.82	L	45		E							A
219	434373.16	1153894.09	72.77	L	45		E							A
220	434371.32	1153891.87	72.65	L	45		E							A
221	434370.08	1153890.56	72.53	L	45		E	0.3	0.3	M	L	W	T	A
222	434369.02	1153888.02	72.54	L	45		D						T	A
223	434368.23	1153885.20	72.39	L	45		D	0.3	0.3	M	L	W	T	A
224	434366.93	1153883.19	72.34	L	33		D					W	T	
225	434365.36	1153881.39	72.21	L	45		D					NW	T	
226	434361.82	1153878.70	71.85	L	45		D					NW	T	
227	434359.76	1153877.61	71.75	L	45		D					NW	T	
228	434357.32	1153875.73	71.42	L	33		D					NW	T	
229	434355.49	1153874.43	71.20	L	33		D					NW	T	
230	434354.53	1153873.48	71.12	L	45		D					NW	T	
231	434352.38	1153871.96	70.97	L	33		E					W	T	
232	434350.02	1153869.38	70.94	L	45		E					W	T	
233	434348.87	1153866.83	71.01	L	45		D					W	T	
234	434347.12	1153864.16	71.24	L	45		E					W	T	
235	434345.27	1153861.05	71.40	L	45	B	D					W	T	
236	434344.07	1153858.66	71.45	L	45	B	D					W	T	
237	434342.06	1153856.38	71.39	L	33	B	D					W	T	

238	434341.11	1153855.01	71.32	L	33	B	D	W	T
239	434340.78	1153852.69	71.44	L	33	B	E	W	T
240	434339.96	1153850.84	71.45	L	45	C	E	W	T
241	434338.79	1153850.08	71.54	L	33		D	W	T
242	434338.13	1153847.20	71.70	L	45	B	D	W	T
243	434337.41	1153844.79	71.56	L	45	B	D	W	T
244	434337.02	1153843.06	71.58	L	33	B	E	W	T
245	434337.34	1153841.10	71.88	L	33	B	C	W	T
246	434337.82	1153838.43	72.18	L	33	A	D	W	T
247	434338.07	1153835.80	72.46	L	33	A	D	W	T
248	434338.48	1153833.81	72.52	L	33	B	D	W	T
249	434338.46	1153832.01	72.40	L	33	B	E	W	T
250	434338.60	1153829.86	72.74	L	33	B	E	W	T
251	434338.66	1153827.76	72.70	L	33		E	W	T
252	434337.87	1153826.72	72.64	L	33	B	D	W	T
253	434337.32	1153824.90	72.54	L	45	B	D	W	T
254	434336.47	1153824.10	72.57	L	33		E	W	T
255	434335.65	1153822.17	72.54	L	33	B	D	W	T
256	434334.38	1153818.06	72.47	L	33	B	E	W	T
257	434333.38	1153815.94	72.52	L	33	A	E	W	T
258	434331.95	1153813.58	72.49	L	33	A	D	W	T
259	434330.54	1153811.22	72.39	L	33	B	D	W	T
260	434329.91	1153809.92	72.27	L	33	B	D	W	T
261	434329.47	1153807.07	72.31	L	33	B	D	W	T
262	434329.02	1153804.34	72.28	L	33	B	D	W	T
263	434328.71	1153801.54	72.16	L	33		D	W	T
264	434329.28	1153797.91	72.19	L	33		D	W	T
265	434330.29	1153794.05	72.45	L	33	B	E	W	T
266	434329.61	1153791.33	72.35	L	33		C	W	T

267	434328.43	1153789.11	72.25	L	33		B	W	T
268	434327.58	1153786.35	71.98	L	33		C	W	T
269	434327.32	1153784.08	71.95	L	33		D	SW	T
270	434328.54	1153782.34	72.11	L	33		C	SW	T
271	434330.33	1153780.47	72.20	L	33	B	D	W	T
272	434331.07	1153777.72	72.10	L	33	A	C	W	T
273	434331.36	1153773.93	72.07	L	33	A	D	W	T
274	434330.43	1153769.53	71.91	L	33	A	C	W	T
275	434330.69	1153765.20	71.76	L	33	A	C	W	T
276	434330.76	1153761.12	71.78	L	33	A	C	W	T
277	434330.13	1153755.01	71.51	L	33	A	C	W	T

Appendix C.16 Tumblin 2 Broch Boundary

Point Id	Eastings	Northings	Height	Type	Slope	Ht In	Ht Out	Min St	All max	Max St	St min	St max	Dense	Dir Fac	Face	Width
287	434327.40	1153766.57	71.19	B	33	B	C							SW	T	B
288	434267.94	1153878.99	58.98	B	33	B	C							SW	T	B
289	434268.24	1153877.89	59.15	B	33	B	C							SW	T	C
290	434270.19	1153872.08	60.00	B	33	B	C							SW	T	C
291	434271.86	1153866.21	60.86	B	33	B	D							SW	T	E
292	434273.32	1153859.41	61.48	B	33	B	D							SW	T	D
293	434273.91	1153857.74	61.50	B	33	B	C							SW	T	C
294	434274.71	1153854.76	61.86	B	33	B	D	0.3	0.4	0.4	M	M	L	SW	T	E
295	434276.21	1153849.84	62.72	B	33	B	C							SW	T	C
296	434277.28	1153845.89	63.17	L	33	B	D							SW	T	C
297	434278.43	1153842.32	63.58	L	33		E							SW	T	B
298	434278.92	1153840.33	63.77	L	33	B	E							SW	T	C
299	434279.41	1153838.75	63.94	L	33	B	D							SW	T	C
300	434279.81	1153836.58	64.04	L	33		E							SW	T	C
301	434280.75	1153834.99	64.06	L	45		E							SW	T	B
302	434280.78	1153833.11	64.14	L	45	A	D							SW	T	C
303	434281.46	1153830.69	64.40	L	45	A	D							SW	T	C
304	434283.28	1153826.27	64.82	L	45		E							SW	T	B
305	434284.71	1153822.32	65.05	L	33	A	E							SW	T	C
306	434286.48	1153818.14	65.38	L	33	A	D							SW	T	D
307	434288.65	1153812.11	65.52	L	33	B	E							SW	T	C
308	434290.55	1153807.70	65.83	B	33	C	E							SW	T	B
309	434291.71	1153804.81	65.85	B	33	C	E							SW	T	C
310	434292.87	1153801.76	66.07	B	33	C	E							SW	T	D
311	434295.19	1153796.84	66.67	B	33	C	E							SW	T	D
312	434296.55	1153792.39	66.89	B	33	B	D							SW	T	D
313	434297.70	1153788.00	67.15	B	33	B	E							SW	T	D

314	434298.67	1153785.08	67.45	B	33	A	C							SW	T	D
315	434299.58	1153781.66	67.67	B	33	A	C							SW	T	C
316	434299.82	1153780.43	67.83	B	45	C	D							SW	T	D
317	434300.73	1153778.17	68.15	B	45	C	D							SW	T	D
318	434301.96	1153775.17	68.37	B	45	C	D	0.3	0.3		M		L	SW	T	D
319	434303.23	1153772.28	68.48	B	33	C	D							SW	T	D
320	434304.71	1153770.13	68.72	B	33	B	D							SW	T	D
321	434306.44	1153767.95	68.93	B	33	B	E							SW	T	D
322	434308.99	1153765.39	69.20	B	33	A	C	0.2	0.3	0.3	S	M	L	SW	T	D
323	434310.68	1153763.21	69.39	B	33	B	D							SW	T	D
324	434312.05	1153761.38	69.65	B	33	B	D							SW	T	D
325	434314.60	1153758.28	69.89	B	33	B	D							SW	T	D
326	434317.65	1153755.67	70.12	B	33	B	D							S	T	C
327	434322.49	1153752.48	70.92	B	33	B	D							S	T	D
328	434325.04	1153750.92	71.27	B	33	B	D							S	T	D
329	434328.96	1153749.04	71.52	B	33	B	C							S	T	C
330	434329.75	1153748.80	71.66	B	33	B	C							S	T	B
331	434330.89	1153757.59	71.72	B	33	C	E							S	T	D
332	434330.66	1153755.47	71.55	B	45	C	D							S	T	D
333	434330.97	1153752.19	71.57	B	45	C	E							S	T	D
334	434331.11	1153749.73	71.69	B	45	C	D							S	T	D
335	434330.77	1153748.44	71.87	B	45	C	D							S	T	C
336	434331.52	1153746.83	71.94	B	45	C	E							W	T	C
337	434332.21	1153745.10	72.06	B	45	C	E							W	T	C
338	434332.68	1153744.01	72.03	B	45	C	D							W	T	C
339	434333.04	1153743.28	72.15	B	33	C	D							W	T	C
340	434333.38	1153741.86	72.11	B	33	C	D							W	T	C
341	434333.56	1153740.04	72.25	B	33	C	D							W	T	C
342	434333.77	1153738.24	72.36	B	33	A	C							W	T	C

343	434334.41	1153736.72	72.45	B	33	A	D							W	T	D
344	434335.27	1153735.00	72.56	B	33	B	E							W	T	D
345	434335.78	1153732.85	72.65	B	33	C	E							W	T	C
346	434336.00	1153731.28	72.74	B	33	B	D							W	T	D
347	434335.63	1153729.65	72.69	B	33	C	D	0.2	0.2		S		L	W	T	D
348	434335.97	1153726.59	72.63	B	33	B	D							W	T	D
349	434336.21	1153724.94	72.81	B	33	C	D							W	T	D
350	434336.24	1153723.22	72.75	B	33	B	D							W	T	D
351	434336.90	1153721.59	72.83	B	33	C	E	0.3	0.4	0.4	M	M	L	W	T	D
352	434338.71	1153718.79	73.08	B	33	C	D							W	T	D
353	434339.42	1153717.18	73.09	B	33	B	C							W	T	C
354	434340.57	1153714.57	73.20	B	33	B	C							W	T	C
355	434341.85	1153711.33	73.35	B	33	C	D							W	T	C
356	434342.55	1153709.22	73.36	B	33	C	D	0.1	0.3	0.3	T	M	L	W	T	D
357	434343.97	1153705.54	73.42	B	33	C	D	0.3	0.3		M		L	W	T	D
358	434344.79	1153702.66	73.27	B	33	C	D							W	T	D
359	434346.07	1153699.41	73.23	B	33	C	E							W	T	D
360	434346.18	1153699.52	73.23	B	33	C	E							W	T	D
361	434347.64	1153697.00	73.10	B	45	C	D							W	T	D
362	434348.34	1153694.62	72.90	B	45	C	D							W	T	D
363	434348.88	1153692.87	72.69	B	45	C	D							W	T	C
364	434348.66	1153689.83	72.68	B	45	C	D							W	T	C
365	434348.14	1153686.46	72.42	B	45	B	D							W	T	C
366	434348.32	1153684.00	72.25	B	45	B	D							W	T	C
367	434348.32	1153681.36	71.79	B	45	B	D							W	T	B
368	434348.40	1153681.37	71.79	B	33	B	D							W	T	C
369	434348.60	1153677.76	71.49	B	33	C	D							W	T	D
370	434349.10	1153674.91	71.14	B	33	C	D							W	T	D
371	434349.17	1153673.36	70.97	B	33	C	D							W	T	C

372	434348.92	1153671.55	70.82	B	33	C	D	W	T	D
373	434349.03	1153668.88	70.62	B	33	B	D	W	T	D
374	434349.42	1153666.46	70.40	B	33	C	D	W	T	D
375	434350.20	1153662.68	70.04	B	45	C	D	W	T	D
376	434350.35	1153659.67	69.71	B	45	C	D	W	T	D
377	434350.88	1153656.79	69.51	B	45	C	D	W	T	D
378	434351.47	1153651.79	69.01	B	45	C	D	W	T	D
379	434351.66	1153648.84	68.36	B	33	C	D	W	T	D
380	434351.84	1153646.34	68.32	B	33	C	C			D
381	434351.30	1153643.34	67.79	B	33	C	C			D
382	434350.81	1153640.09	67.35	B	33	C	C			D

Appendix C.17 Belmont Norse Yards

Point Id	EASTINGS	NORTHINGS	Height	Type	S Yard	N Yard	Belmont	slope	F Ht In	F Ht Out	Min St	All max	Max st	Dense	Dir face	Face	Width	width
103	456823.178	1200707.024	31.939	D	D			45	B	D	M	L	L	S	D	NW	1	B
104	456821.77	1200705.616	31.916	D	D			45	B	D				C	D	NW	1	B
105	456819.834	1200703.352	31.972	D	D			45	B	D	M	M		C	D	NW	1	B
106	456818.917	1200701.345	32.268	D	D			45	Z	B	M	L	L	C	D	NW	1	B
107	456817.894	1200698.687	32.58	D	D			45	Z	B	L	L		C	D	NW	1	B
108	456817.214	1200696.946	32.92	D	D			45	Z	B	L	L		C	D	NW	1	B
109	456815.974	1200694.866	33.139	D	D			45	Z	B	L	L		C	D	NW	1	B
110	456815.936	1200694.863	33.135	B	B			45	F	F	M	L	L	C	Q		4	I
111	456817.959	1200692.898	33.451	B	B			45	F	F	M	L	L	C	Q	SW	4	I
112	456820.233	1200689.985	33.753	B	B			45	D	F	M	L	L	F	Q	SW	2	D
113	456822.028	1200687.527	33.992	B	B			45	C	F	M	L	L	F	Q	SW	2	D
114	456824.46	1200685.258	34.047	B	B			45	C	F	M	L	L	F	Q	SW	3	F
115	456826.874	1200682.95	34.387	B	B			45	C	D	M	L	L	F	T	SW	3	F
116	456829.349	1200679.682	34.754	B	B			45	C	D	M	L	L	F	T	SW	3	F
117	456832.43	1200676.7	35.411	B	B			45	C	D	M	L	L	F	T	SW	3	F
118	456835.449	1200674.718	35.788	B	B			45	B	D	M	L	L	F	T	SW	3	F
119	456837.995	1200673.006	36.208	B	B			33	B	C	M	L	L	F	T	SW	3	F
120	456839.259	1200670.836	36.338	B	B			33	B	C	M	L	L	F	T	SW	3	F
121	456842.741	1200674.165	36.212	B	B			33	B	C	M	L	L	F	T	SW	3	F
122	456842.815	1200674.752	36.134	B	B			33	B	C	M	L	L	F	T	E	3	F
123	456840.788	1200676.291	35.855	B	B			33	B	C	M	L	L	F	T	E	3	F
124	456838.805	1200677.365	35.747	B	B			33	B	C	M	L	L	F	T	NE	3	F
125	456837.567	1200676.142	35.76	B	B			33	B	B	M	M		D	T	NE	0.7	B
128	456841.437	1200668.57	36.676	B	B			33	B	B	M	M		D	Q		0.7	B
129	456844.252	1200665.586	37.069	B	B			33	B	C	M	M	M	D	D	SW	3	F

130	456847.201	1200662.967	37.316	B	B			33		B				N	D	SW		
131	456849.82	1200660.979	37.512	B	B			33		B				N	D	SW		
132	456852.324	1200663.449	37.569	B	B			33		B				N	D	SW		
133	456853.691	1200666.319	37.315	B	B			33		B				N	D	SW		
134	456854.127	1200669.08	36.886	B	B			33		B				N	D	NW		
135	456854.095	1200670.47	36.718	B	B			33		B				N	D	NW		
136	456851.842	1200672.33	36.559	B	B			33		B				N	D	NW		
137	456850.001	1200675.161	36.222	B	B			33	C	B				N	D	SW		
138	456847.372	1200677.126	36.023	B	B			33	C		M	X	X	D	D	SW		
172				D	D													
173				D	D													
174				D	D													
203	456852.72	1200713.285	32.565	D		D	D				M	M		C			0.4	A
204	456853.67	1200714.581	32.519	D		D	D				M	M		C			0.4	A
205	456855.479	1200717.111	32.306	D		D	D				M	M		C			0.4	A
206	456856.797	1200719.74	31.788	D		D	D				L	L		C			0.4	A
207	456858.279	1200721.637	31.962	D		D	D				L	L		C			0.4	A
208	456859.785	1200723.913	32.034	D		D	D				L	L		C			0.4	A
209	456860.439	1200724.92	32.058	D		D	D				M	M		C			0.4	A
210	456858.298	1200726.956	31.607	D		D	D				L	L		C			0.4	A
211	456856.94	1200729.591	31.316	D		D	D				X	X		C			0.4	A
212	456852.618	1200726.89	31.294	L		L	L	33	D		M	M		F	D	NW	1.5	C
213	456854.93	1200728.696	31.24	L		L	L	33	D		M	M		F	D	NW	1.5	C
214	456856.673	1200730.195	31.247	L		L	L	33	D		M	M		F	D	NW	1.5	C
215	456858.814	1200732.533	31.238	L		L	L	33	D		M	M		F	D	NW	1.5	C
216	456860.321	1200734.555	31.339	L		L	L	33	D		L	L		F	D	NW	1.5	C
217	456861.606	1200737.662	31.671	L		L	L	33	D		L	L		F	D	NW	1.5	C
218	456861.987	1200740.415	31.67	L		L	L	33	D		L	L		F	D	NW	1.5	C
219	456862.586	1200742.622	31.596	L		L	L	33	D		X	X		F	D	NW	1.5	C

220	456860.684	1200743.923	31.077	L	L	L	33	E		L	L		D	D	W	2	D
221	456861.591	1200746.363	31.119	L	L	L	33	E					D	D	W	2	D
222	456863.145	1200748.875	31.526	L	L	L	33	E		L	L		D	D	W	2	D
223	456864.66	1200752.045	31.672	L	L	L	33	E		L	L		D	D	W	2	D
224	456866.721	1200755.28	32.005	L	L	L	33	E		L	L		D	D	W	2	D
225	456866.703	1200758.851	31.935	L	L	L	33	E		X	X		D	D	SW	2	D
226	456866.09	1200760.929	31.792	L	L	L	33	E		M	M		D	D	SW	2	D
227	456864.511	1200764.169	31.17	L	L	L	33	E	B	L	L		F	N	SW	1	B
228	456861.965	1200767.356	30.581	L	L	L	33	D		L	L		F	N	SW	1	B
229	456858.209	1200772.837	29.882	L	L	L	33	C		M	L	L	C	N	SW	1	B
230	456855.329	1200775.952	29.468	L	L	L	33	B		M	L	L	C	N	SW	1	B
231	456853.009	1200780.345	29.047	L	L	L	33	B		M	M		F	N	SW	1	B
232	456853.032	1200780.341	29.034	L	L	L	33	B		L	L		F	N	SW	1	B
233	456850.016	1200783.895	28.077	L	L	L	33	B		S	L	L	F	N	SW	1	B
234	456845.93	1200787.076	27.563	L	L	L	33	B					C	N	SW	1	B
235	456843.255	1200789.497	27.054	L	L	L	33	B		M	M		C	N	SW	1	B
236	456841.321	1200792.917	26.515	L	L	L	33	C					C	N	SW	1	B
237	456838.498	1200795.72	25.695	L	L	L	33	C		M	M		C	N	S	1	B
238	456835.965	1200797.282	25.203	L	L	L	33	C					C	N	S	0.75	B
239	456834.246	1200797.892	24.839	D	D	D		C					C	N	S	0.75	B
240	456831.461	1200798.571	24.388	D	D	D		C		M	M		C	N	S	0.75	B
241	456828.903	1200798.332	23.928	D	D	D		C		M	M		C	N	S	0.75	B
242	456825.599	1200799.7	23.38	D	D	D		C		L	L		C	N	S	0.75	B
243	456823.924	1200799.672	23.098	D	D	D		C		M	M		C	N	S	0.75	B
244	456820.251	1200799.905	22.693	D	D	D		C		M	M		C	N	S	0.75	B
245	456835.84	1200797.093	25.167	D	D	D							N				
246	456837.336	1200796.445	25.455	D	D	D							N				
247	456838.064	1200795.131	25.597	D	D	D							N				
248	456837.616	1200793.995	25.455	D	D	D							N				

249	456836.447	1200793.945	25.181	D	D	D	N
250	456835.574	1200794.977	24.985	D	D	D	N
251	456835.07	1200796.932	25.09	D	D	D	N
252	456835.858	1200797.171	25.161	D	D	D	N
583	456803.06	1200740.3	26.866	D	D		
584	456803.884	1200741.553	26.84	D	D		
585	456805.484	1200742.392	27.041	D	D		
586	456806.372	1200743.597	26.973	D	D		
587	456808.711	1200747.14	26.909	D	D		
588	456810.735	1200749.298	27.374	D	D		
589	456811.601	1200751.467	27.451	D	D		
590	456812.224	1200754.066	27.259	D	D		
591	456812.718	1200759.515	26.589	D	D		
592	456811.986	1200762.423	26.135	D	D		
593	456813.416	1200763.937	25.569	D	D		
594	456813.563	1200768.224	25.239	D	D		
595	456813.981	1200774.906	24.56	D	D		
596	456813.701	1200779.32	24.038	D	D		
597	456813.782	1200784.008	23.588	D	D		
598	456813.523	1200789.18	23.239	D	D		
599	456814.193	1200791.641	23.044	D	D		
600	456815.057	1200795.443	22.792	D	D		

Appendix C.18 Gardie Norse Yards

Point Id	Eastings	Northings	Height	Type	Slope	F Ht In	F Ht Out	Max St	All max	Dense	Dir face	Face	Width	width
1-095	463498.8	1211540	18.938	L	33		M	L	L	L	N	T	0.6	B
1-096	463495.7	1211541	18.821	L	33		A			N	N	T	0.8	B
1-097	463492.2	1211541	18.664	L	33		A			N	N	T	1.5	C
1-098	463489.1	1211541	18.547	L	33		L	X	X	L	N	T	1.5	C
1-099	463486.3	1211542	18.513	L	33		L			N	N	T	1.7	D
1-100	463486.3	1211542	18.51	L	33		L			N	N	T	2	D
1-101	463482.8	1211541	18.454	L	33		L			N	N	T	1.7	D
1-102	463480.1	1211541	18.409	L	33		L			N	N	T	1.5	C
1-103	463477.4	1211541	18.196	L	33		A			N	N	T	1.2	C
1-104	463475.1	1211541	18.043	L	33		M	A	A	L	N	T	0.6	B
1-105	463473.6	1211541	17.966	L	33		M			N	W	T	0.6	B
1-106	463472.5	1211540	18.036	L	33		M	0	0	N	W	T	0.8	B
1-107	463471.6	1211538	18.235	L	33		A	L	L	L	W	T	1	B
1-108	463470.1	1211535	18.566	L	33		M			N	W	T	0.6	B
1-109	463470.2	1211535	18.572	L	33		M	A	A	L	W	T	0.6	B
1-110	463468.3	1211532	18.818	D			S	M	A	D	W	T		
1-111	463466.4	1211530	19.081	D				M	A	C	W	T		
1-112	463465.4	1211527	19.221	D				M	A	C				
1-113	463464.4	1211524	19.599	D				M	A	C				
1-114	463463.5	1211522	19.8	D				M	A	C				
1-115	463462.3	1211521	19.961	D				M	A	C				
1-116	463461.3	1211519	20.276	D				M	A	C				
1-117	463460.4	1211517	20.56	D				M	A	C				
1-118	463459.6	1211515	20.766	L						N				
1-119	463459	1211514	20.896	L						N				
1-120	463510.4	1211523	20.87	D				A	L	C			1.4	C
1-121	463510.3	1211523	20.861	D				L	L	C			1.4	C

1-122	463511.1	1211521	21.103	D				L	X		C		Q	1.4	C
1-123	463511.7	1211518	21.348	D	33	S	S				N		Q	1.4	C
1-124	463511.5	1211517	21.641	D	45	M	M				N		Q	1.1	C
1-125	463511.5	1211514	21.85	D	45	A	A	A	A		L		Q	1.1	C
1-126	463511.4	1211513	21.898	D	45	M	M	A	A		L		Q	0.9	B
1-127	463511	1211512	21.996	D	33	S	S				N		Q	0.9	B
1-128	463512.2	1211512	22.107	L	33	M					N	W	N	0.9	B
1-129	463512.5	1211509	22.523	L	33	M					N	W	N	0.6	B
1-130	463512.3	1211507	22.864	L	33	M					N	W	N	0.6	B
1-131	463511.6	1211504	23.16	L	33	M					N	W	N	0.6	B
1-132	463510.8	1211502	23.423	L	33	M					N	W	N	0.6	B
1-133	463510.6	1211500	23.639	L	33	M					N	W	N	0.6	B
1-134	463510.3	1211498	23.889	L	33	M					N	W	N	0.6	B
336	463509.9	1211497	24.001	D	33	M	S	M	A		C	N	N	1	B
337	463505.9	1211497	23.864	B	45	M	S	M	L		F	N	N	0.9	B
338	463500.8	1211498	23.442	B	45	M	S	M	A		F	N	N	1.1	C
339	463495.8	1211498	23.166	B	45	A	S	M	M		F	N	N	1.2	C
340	463492	1211498	23.029	B	45	A	S	M	A		F	N	N	1.2	C
341	463487.2	1211499	22.773	B	45	M	S	A		1	F	N	N	1	B
342	463483.7	1211499	22.667	B	45	M	S	M	L		F	N	N	1	B
343	463478.9	1211500	22.57	B	45	S	S				N	N	N	0.9	B
344	463474.9	1211501	22.485	B	45	S	S	M	X		D	N	N	1.1	C
345	463470.9	1211502	22.305	B	45	S	S				N	N	N	1.1	C
346	463467	1211502	22.124	B	45	S	S				N	N	N	1.3	C
347	463462.2	1211503	22.025	B	45	S	S	M	M		D	N	N	0.7	B
348	463459.1	1211504	22	B	45	S	S	M	M		D	N	N	0.7	B
349	463457.1	1211505	22.072	B	45	S	S				N	N	N	0.7	B
350	463455.7	1211506	22.1	B	45	M	M					N	N	1.1	C

Appendix C.19 Hamar Norse Yards

Point Id	EASTINGS	NORTHINGS	Height	Type	U Ham	L Ham	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir face	Face	Width	width
70	464668.721	1209414.079	37.385	B		B	33	B	B				N	N	S	2.20	E
71	464671.856	1209413.883	37.366	B		B	33	B	B				N	N	S	2.20	E
72	464675.691	1209412.896	37.372	B		B	33	B	B				N	N	S	2.20	E
73	464679.272	1209412.384	37.263	B		B	33	B	B				N	N	S	2.20	E
74	464682.716	1209411.988	37.108	B		B	33	B	B				N	N	SW	2.20	E
75	464683.231	1209409.332	36.835	B		B	33	B	C				N	T	E	3.20	G
76	464683.233	1209406.054	36.526	B		B	33	B	C				N	T	E	3.20	G
77	464682.956	1209401.265	36.166	B		B	33	B	C				N	T	E	3.20	G
78	464682.319	1209395.362	35.657	B		B	33		B				N	T	E	1.00	B
79	464681.809	1209393.368	35.382	B		B	33		B				N	T	E	1.00	B
80	464679.718	1209390.487	35.166	B		B	33		B				N	T	E	1.00	B
81	464675.684	1209388.409	35.359	B		B	33		B				N	T	E	1.00	B
225	464582.106	1209431.054	42.949	L		L	33	D		A	A		L	D	S	1.00	B
226	464586.486	1209430.970	42.400	L		L	33	D		A	A		L	D	S	1.00	B
227	464588.370	1209431.237	42.333	L		L	33	D		A	A		L	D	S	1.00	B
228	464593.876	1209434.336	42.115	L		L	33	D		A	A		L	D	SE	1.00	B
229	464593.952	1209435.842	42.432	L		L	33	D		A	A		L	D	SE	1.00	B
230	464593.944	1209436.657	42.594	L		L	33	D		A	A		L			1.00	B
231	464595.750	1209436.950	42.480	L		L	33	D		A	A		L			1.00	B
232	464598.646	1209437.708	42.195	L		L	33	D		A	A		L			1.00	B
233	464600.349	1209438.210	41.852	L		L	33	D		A	A		L			1.00	B
234	464600.222	1209439.648	42.002	L		L	33	D		A	A		L			1.00	B
235	464605.735	1209440.122	41.881	L	L		33		E	M	A	A	L	T	E	0.90	B
236	464607.008	1209442.155	42.072	L	L		33		E				N	T	E	1.10	C
237	464608.524	1209444.395	42.102	L	L		33		F				N	T	E	1.10	C
238	464609.740	1209447.616	42.491	L	L		33		D				N	T	E	0.80	B

239	464609.102	1209450.155	42.871	L	L	33	B	C				N	T	E	0.80	B
240	464608.026	1209452.941	43.388	L	L	33	B	C	M	M		L	T	E	1.40	C
241	464606.991	1209455.702	44.005	L	L	33	B	D	M	M		L	T	E	1.40	C
242	464605.864	1209458.712	44.421	L	L	33	B	C	M	M		L	T	E	1.40	C
243	464604.909	1209462.234	45.302	L	L	33	B	C	M	M		L	T	E	1.40	C
244	464604.753	1209462.396	45.306	L	L	45	B	C	M	M		L	T	E	1.40	C
245	464603.944	1209465.778	45.983	L	L	45	B	C	M	M		L	T	E	1.40	C
246	464603.282	1209468.415	46.613	L	L	45	C	C	M	M		L	Q		1.40	C
247	464602.175	1209469.548	46.986	L	L	45	C	C	M	M		L	Q		1.40	C
248	464602.140	1209469.528	46.995	L	L	45	C	C	M	M		L	Q		1.40	C
249	464599.622	1209469.252	47.437	L	L	90	D	B	A	A		L	N	S	1.00	B
250	464597.152	1209468.543	47.604	L	L	90	F		M	M		L	N	S	1.00	B
251	464594.106	1209466.816	47.749	L	L	90	F		M	M		L	N	SE	0.50	A
252	464590.763	1209465.490	47.923	L	L	45	F		M	M		L	N	SE	0.50	A
253	464588.862	1209463.449	47.576	L	L	45	F		M	M		L	N	SE	0.50	A
254	464588.894	1209463.248	47.389	L	L	45	E		A	A		L	N	SE	0.50	A
255	464586.700	1209460.263	46.959	L	L	45	E					N	N	SE	0.50	A
256	464584.863	1209458.216	46.659	L	L	33	F					N	N	SE	0.50	A
257	464582.663	1209455.984	46.525	L	L	33	F		A	A		L	N	SE	0.50	A
258	464581.115	1209454.656	46.221	L	L	33	F					N	N	SE	0.50	A
259	464579.859	1209453.477	46.343	L	L	33	F					N	N	SE	0.50	A
260	464575.324	1209452.977	47.083	L	L	33	F					N	D	SE	0.50	A
261	464573.134	1209453.488	47.596	L	L	33	F					N			0.50	A
262	464573.113	1209453.456	47.587	B	B	45	D	B	M	A	A	L	N	E	0.80	B
263	464572.742	1209451.979	47.071	B	B	45	D	B	M	A	A	L	N	E	1.40	C
264	464573.131	1209448.101	46.103	B	B	45	D	B	M	A	A	L	N	E	2.10	E
265	464574.107	1209444.193	45.388	B	B	45	D	B	M	A	A	L	N	E	1.40	C
266	464575.400	1209441.975	44.929	B	B	45	D	B	M	A	A	L	N	E	0.80	B
398	464601.748	1209466.842	46.183			45	B								0.50	A

399	464598.931	1209465.588	46.255		45	B	0.50	A
400	464595.510	1209463.547	46.258	L	45	B	0.50	A
401	464591.656	1209461.149	46.192	L	45	B	0.50	A
402	464589.472	1209458.490	45.764	L	45	B	0.50	A

Appendix C.20 Stove Norse Yards

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir face	face	Width	width
263	462025.939	1212467.711	33.712	B	33	D	E				N	D	NW	0.80	B
264	462025.006	1212467.272	33.604	B	33	D	E	M	M		D	D	N	0.80	B
265	462024.263	1212466.984	33.643	D		D	E	M	A	A	C	T	N	0.90	B
266	462021.274	1212466.745	33.599	D		D	E	M	L	L	C	T	N	0.90	B
267	462018.976	1212466.929	33.620	D		E	E	S	A	A	C	T	N	0.90	B
268	462017.738	1212466.914	33.584	D		D	E	S	M	M	C	T	N	0.90	B
269	462016.678	1212466.830	33.629	D		D	E	S	M	M	C	T	N	0.90	B
270	462015.457	1212466.229	33.621	D		D	E	S	M	M	C	T	N	0.90	B
271	462014.032	1212465.977	33.738	D		D	E	S	M	M	C	T	N	0.90	B
272	462012.950	1212465.616	33.739	D		D	E	S	A	A	C	T	N	0.90	B
273	462012.187	1212465.155	33.702	D		D	E	X	X		C	T	NW	0.90	B
274	462011.134	1212464.450	33.716	D		C	C	S	M	M	C	T	NW	0.90	B
275	462010.440	1212463.545	33.747	D		B	B	S	M	M	C	T	NW	0.90	B
276	462010.027	1212462.376	33.729	D		D	D	S	A	A	C	T	NW	0.60	B
277	462009.749	1212461.167	33.777	D		D	D	S	A	A	C	T	NW	0.60	B
278	462009.859	1212460.037	33.806	D		D	D	S	A	A	C	T	W	0.60	B
279	462009.962	1212458.573	33.765	D		D	D	S	A	A	C	T	W	0.60	B
280	462009.991	1212457.275	33.801	D		D	D	S	A	A	C	T	W	0.60	B
281	462010.100	1212455.925	33.842	D		D	D	S	A	A	C	T	W	0.60	B
282	462009.856	1212455.012	33.900	D		D	D	S	A	A	C	T	W	0.60	B
283	462010.085	1212453.572	33.896	D		E	E	S	A	A	C	T	W	0.90	B
284	462010.182	1212451.887	33.884	D		F	F	S	L	L	C	T	W	0.90	B
285	462010.262	1212450.508	33.959	D		D	D	S	M	M	C	T	W	0.60	B
286	462010.343	1212449.427	34.029	D		E	E	S	A	A	C	T	W	0.60	B
287	462010.358	1212447.858	33.994	D		E	E	S	A	A	C	T	W	0.60	B
288	462010.222	1212447.021	34.029	D		E	E	S	A	A	C	T	W	0.60	B

289	462010.904	1212445.939	34.006	D	C	C	S	A	A	C	T	W	2.10	E
290	462011.726	1212445.450	34.060	B	B	B	M	M		D	Q		1.20	C
291	462012.633	1212445.028	34.089	B	B	B				N	Q		1.20	C
292	462013.644	1212444.875	34.050	D	D	D	S	A	A	C	N	N	1.20	C
293	462014.721	1212444.632	34.021	D	E	E	S	A	A	C	N	N	1.20	C
294	462016.406	1212444.153	34.026	D	B	B	S	A	A	C	N	N	1.20	C
295	462017.638	1212443.791	34.052	B	B	B	S	M	M	C	N	N	0.80	B

Appendix C.21 Watlie Norse Yards

Point Id	EASTINGS	NORTHINGS	Height	Type	N YD	S YD	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir Face	face	Width	width
1	459604.637	1205176.641	50.359	L		L	90	D		A	L	L	C	D	NW		
2	459607.057	1205178.347	50.597	L		L	90	F		A	L	L	C	D	NW		
3	459610.007	1205181.004	50.008	L		L	90	F		L	L		C	D	NW		
4	459610.963	1205183.759	49.410	L		L	90	D					N	D	W		
5	459612.303	1205186.465	48.970	L		L	90	C					N	D	W		
6	459613.215	1205188.734	48.769	L		L	90	B					N	D	W		
7	459613.962	1205190.701	48.612	L		L	45	B		M	A	A	D	D	W		
8	459614.503	1205193.615	48.405	L		L	45	B		M	A	A	D	D	W		
9	459616.161	1205197.472	48.385	L		L	33	B					N	D	W		
10	459619.145	1205202.013	48.163	L		L	45	B					N	D	W		
11	459620.044	1205203.147	47.982	L		L	33	B					N	D	W		
20	459618.383	1205208.270	47.450	D	D	D	45	B	B				N	T	N	0.90	B
21	459615.034	1205209.778	47.087	D	D	D	45	B	B				N	T	N	0.90	B
22	459613.151	1205211.164	46.852	D	D	D	45	B	B				N	T	N	0.90	B
23	459611.275	1205213.002	46.499	D	D	D	45	B	B	S	S		L	T	N	0.75	B
75	459587.810	1205215.617	43.326	L		L	90		B	A	X	X	C	T	W		
76	459586.094	1205214.353	43.475	L		L	90		B	A	A		D	T	W		
77	459584.351	1205213.024	43.462	L		L	90		B	A	A		D	T	W		
78	459581.257	1205210.734	43.464	L		L	90		B	A	A		N	T	W		
79	459577.627	1205208.373	43.171	L		L	90		B	A	A		N	T	W		
80	459572.924	1205204.853	42.880	L		L	90		B	A	A		N	T	W		
81	459570.750	1205202.821	42.844	L		L	90		B	A	A		N	T	W		
82	459568.208	1205200.135	42.878	L		L	90		B	X	X		D	T	W		
83	459565.995	1205197.107	43.098	L		L	90		B	X	X		N	T	W		
84	459563.447	1205194.463	43.361	L		L	90		B	M	M		D	T	W		
85	459561.143	1205193.092	43.230	L		L	45		B				N	T	NW		

86	459559.691	1205191.499	43.329	L		L	45		C				D	T	NW		
87	459557.303	1205189.201	43.406	L		L	45		D	A	A		D	T	NW		
88	459555.672	1205187.588	43.524	L		L	45		D	A	A		D	T	NW		
89	459556.025	1205186.045	43.714	L		L	45		C	M	A	A	D	T	NW		
90	459557.323	1205184.030	44.204	L		L	45		B	M	M		D	D	SW		
196	459599.552	1205224.800	43.692	L	L		33		D	M	A	A	D	T	W	1.00	B
197	459601.198	1205229.208	43.758	L	L		45	A	D	M	L	L	D	T	W	1.20	C
198	459602.727	1205233.674	43.570	L	L		33		B				N	T	W	1.20	C
199	459605.991	1205240.630	43.466	L	L		33	B	D				N	T	W	1.40	C
200	459607.350	1205243.563	43.386	L	L		45	B	D	S	S		L	T	W	0.90	B
201	459608.886	1205245.630	43.393	L	L		45	B	B				N	D	NW	0.90	B
202	459610.329	1205246.531	43.519	L	L		45	B	B				N	T	NW	0.90	B
203	459611.470	1205246.591	43.659	L	L		45	B	B				N	T	NW	0.90	B
204	459614.139	1205245.509	43.958	B	B		33	B	B				N	Q		0.90	B
205	459617.636	1205242.558	44.077	B	B		33	B	B				N	Q		0.90	B
206	459621.954	1205239.797	44.479	B	B		33	B	B	S	S		D	Q		2.50	E
207	459624.675	1205237.533	45.213	B	B		33	B	B				N	Q		2.00	D
208	459630.070	1205233.190	46.350	B	B		33	C	C				N	T	N	1.20	C
209	459631.780	1205230.689	46.638	B	B		33	B	B				N	T	N	1.20	C
210	459631.467	1205229.499	46.653	B	B		33	A	B				N	T	N	1.20	C
211	459629.145	1205226.819	46.574	B	B		33	B	A				N	N	W	1.20	C
212	459626.723	1205223.942	46.705	B	B		33	B	A				N	N	W	1.20	C
213	459625.890	1205223.147	46.733	B	B		33	C	A				N	N	W	1.20	C
214	459626.492	1205220.816	46.975	L	L		45	A					N	N	W	0.60	B
215	459627.020	1205217.844	47.297	L	L		45	C					N	N	W	0.60	B
216	459626.734	1205215.910	47.522	L	L		33	C					N	N	W	0.60	B
217	459625.383	1205212.161	47.721	L	L		45	B					N	N	W	0.50	A
218	459625.639	1205210.640	47.958	L	L		45	B					N	N	W	0.50	A
219	459625.366	1205208.851	48.060	L	L		45	B					N	N	W	0.50	A

220	459625.523	1205208.284	48.103	L	L		45	B	N	N	W	0.50	A
364						R							
365						R							
366						R							
367						R							
368						R							
369						R							
370						R							
371						R							
372						R							

Appendix C.21 Belmont Norse Infields

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir face	face	Width	width
245	456835.840	1200797.093	25.167	D							N	Q			
246	456837.336	1200796.445	25.455	D							N	Q			
247	456838.064	1200795.131	25.597	D							N	Q			
248	456837.616	1200793.995	25.455	D							N	Q			
249	456836.447	1200793.945	25.181	D							N	Q			
250	456835.574	1200794.977	24.985	D							N	Q			
251	456835.070	1200796.932	25.090	D							N	Q			
252	456835.858	1200797.171	25.161	D							N	Q			
253	456825.995	1200885.550	17.552	D	33	B	B	M	L	L	C	Q		1.00	B
254	456829.765	1200885.716	17.803	D	45	D	D	M	M		C	Q		0.80	B
255	456833.192	1200884.686	18.570	D	33	B	B	M	M		C	Q		1.50	C
256	456837.899	1200884.319	19.266	D	45	D	D	M	M		C	Q		0.80	B
257	456842.111	1200884.179	20.079	D	45	F	E	M	M		C	N	S	1.20	C
258	456842.215	1200884.031	20.089	D	45	F	C	M	M		C	N	S	1.50	C
259	456844.822	1200884.070	21.226	D	45	F	E	M	M		C	N	S	1.50	C
260	456848.699	1200880.080	22.819	D	45	E	B	M	M		C	N	S	1.50	C
261	456852.027	1200877.799	24.090	D	45	E	F	M	M		C	N	S	2.00	D
262	456855.522	1200876.038	25.226	D	45	D	D	L	L		C	N	S	1.50	C
263	456857.952	1200876.353	25.982	D	45	D	D	L	L		C	N	S	1.20	C
264	456860.879	1200876.473	26.186	D	45	D	E	M	L	L	C	N	S	1.20	C
265	456864.562	1200876.372	26.814	D	45	D	C	M	M		C	N	S	1.20	C
266	456869.516	1200876.610	27.206	D	45	D	C	M	M		C	N	S	1.20	C
267	456875.031	1200877.088	28.257	D	45	D	C	M	M		C	N	S	1.20	C
268	456878.811	1200877.523	28.989	B	33	B	B				N	N	S	2.00	D
269	456882.363	1200878.185	29.261	B	33	B	B				N	N	S	2.00	D
270	456885.067	1200878.807	29.891	B	45	E	D	M	M		L	N	S	1.50	C
271	456887.996	1200879.180	30.208	B	45	E	D	M	M		L	N	S	1.50	C

272	456890.775	1200879.919	30.554	B	45	E	D	M	M		L	N	S	1.50	C
273	456894.413	1200880.256	31.057	B	45	E	D	M	M		L	N	S	1.50	C
274	456896.819	1200880.484	31.191	B	33	B	B	M	M		L	N	S	1.50	C
275	456898.391	1200880.388	31.085	B	90	D	D	M	M		L	N	S	1.50	C
276	456900.268	1200879.375	31.773	B	90	D	D	M	M		L	N	S	1.50	C
277	456902.668	1200880.537	31.449	B	90	D	D	M	M		L	N	S	1.50	C
278	456906.724	1200881.727	31.377	B	90	D	D	M	M		L	N	S	1.50	C
279	456910.664	1200882.655	31.584	B	90	F	F	M	M		L	T	N	1.50	C
280	456914.931	1200884.229	32.396	B	90	D	D	M	M		L	T	N	1.50	C
281	456900.089	1200878.726	31.630	B	45	E	B	M	M	M	F	N	W	1.80	D
282	456900.860	1200876.330	31.829	B	45	D	B	M	M	M	F	N	W	1.80	D
283	456901.861	1200872.623	32.246	B	45	D	B	M	M	M	F	N	W	1.80	D
284	456903.111	1200869.875	32.374	B	45	D	B	M	M	M	F	N	W	1.80	D
285	456904.169	1200866.682	33.090	B	45	D	D	M	M	M	F	T	E	1.80	D
286	456905.369	1200864.172	33.225	B	45	C	D	M	M	M	F	T	E	1.80	D
287	456906.414	1200862.191	33.459	B	45	C	D	M	M	M	F	T	E	1.80	D
288	456906.463	1200862.212	33.457	B	45	B	D				N	T	E	2.50	E
289	456907.968	1200860.706	33.689	B	45	B	D				N	T	E	2.50	E
290	456907.950	1200860.700	33.684	B	45	B	D				N	T	E	2.50	E
291	456908.503	1200857.640	34.193	B	45	Z	D				N	T	E	2.50	E
292	456909.517	1200855.673	34.339	B	45	Z	D				N	T	E	2.50	E
293	456909.360	1200853.317	34.687	B	45	Z	D				N	T	E	2.50	E
294	456910.559	1200848.868	35.118	B	45	Z	D				N	T	E	2.50	E
295	456911.209	1200846.414	35.352	B	45	Z	D	L	L		D	T	E	2.50	E
296	456911.094	1200844.669	35.580	B	45	Z	D	M	M		D	T	E	2.50	E
297	456912.039	1200842.714	35.782	B	45	Z	D	M	M		D	T	E	2.50	E
298	456913.333	1200839.583	36.220	B	45	Z	D	M	M		D	T	E	2.50	E
299	456913.962	1200836.709	36.626	B	45	Z	D	M	M		D	T	E	2.50	E
300	456914.392	1200834.158	37.191	B	45	B	B	M	M		D	Q		2.50	E

301	456915.067	1200831.911	37.599	B	33	B	B	M	M	D	Q		2.00	D
302	456915.630	1200830.245	37.868	B	33	B	B	M	M	D	Q		2.00	D
303	456918.461	1200824.990	38.642	B	33	B	B	M	M	D	Q		2.00	D
304	456919.355	1200822.782	39.119	B	33	B	B	M	M	D	Q		2.00	D
305	456921.456	1200818.905	40.293	B	33	B	B	M	M	D	Q		2.00	D
306	456922.811	1200815.815	40.876	B	33	B	B	M	M	D	Q		2.00	D
307	456923.691	1200814.039	41.083	B	33	B	B	M	M	D	Q		2.00	D
308	456924.715	1200812.051	41.384	B	33	B	B	M	M	D	Q		2.00	D
309	456924.642	1200811.989	41.394	B	45	D	B	M	M	D	N	W	2.20	E
310	456925.452	1200809.778	41.881	B	45	D	C	M	M	D	N	W	2.20	E
311	456926.345	1200806.812	41.970	B	45	C	B	M	M	D	N	W	2.20	E
312	456928.256	1200804.053	42.388	B	45		B	M	M	D	N	W	2.20	E
313	456929.189	1200800.959	42.695	B	45		B	M	M	D	N	W	2.20	E
314	456930.000	1200798.577	42.880	B	45	C	B	M	M	D	N	W	2.20	E
315	456930.473	1200795.855	43.030	B	45	D	B	M	M	D	N	W	2.20	E
316	456929.448	1200791.231	43.202	B	45		B	M	M	D	N	W	2.20	E
317	456928.501	1200785.975	43.500	B	45		B	M	M	D	N	W	2.20	E
318	456927.918	1200780.804	43.735	B	45	E	B	M	M	D	N	W	2.20	E
319	456926.366	1200773.036	44.027	B	45	D	B	M	M	D	N	W	2.20	E
320	456925.668	1200768.901	44.058	B	45	D	B	M	M	D	N	W	2.20	E
321	456925.761	1200768.930	44.065	B	45	D	B	M	M	D	N	W	2.20	E
322	456924.608	1200763.378	44.020	B	45	E	B	M	M	D	N	W	2.20	E
323	456923.423	1200758.273	44.002	B	45	F	B	M	M	D	N	W	3.20	G
324	456922.676	1200755.110	44.184	B	45	F	B	M	M	D	N	W	3.20	G
325	456922.492	1200753.066	44.171	B	45	F	B	M	M	D	N	W	3.20	G
326	456921.881	1200751.091	44.341	B	45	F	B	M	M	D	N	W	3.20	G
327	456920.212	1200748.034	44.305	B	45	F	B	M	M	D	N	W	3.20	G
328	456919.222	1200745.383	44.486	B	45	F	C	M	M	D	N	W	3.20	G
329	456918.119	1200742.098	44.521	B	45	F	C	M	M	D	N	W	3.20	G

330	456917.487	1200740.174	44.603	B	45	F	C	M	M		D	N	W	3.20	G
331	456916.277	1200736.439	44.447	B	45	F	B	M	L	L	F	N	W	3.20	G
332	456915.702	1200733.427	44.561	B	45	D	B	M	L	L	F	N	W	3.20	G
333	456914.988	1200729.914	44.570	B	45	F	B	M	L	L	F	N	W	3.20	G
334	456914.180	1200725.333	44.617	B	45	F	D	M	L	L	F	N	W	3.20	G
335	456913.462	1200719.616	44.847	B	45	F	D	M	L	L	F	N	W	3.20	G
336	456912.425	1200715.540	44.753	B	45	D	D	M	L	L	F	N	W	3.20	G
337	456911.523	1200713.302	44.700	B	45	D	D	M	L	L	F	N	W	3.20	G
338	456911.116	1200710.416	44.050	B	45	D	D	M	L	L	F	N	W	3.20	G
339	456909.545	1200706.403	43.532	B	45	D	D	M	L	L	F	N	W	3.20	G
340	456912.265	1200710.036	44.249	D				L	X	X	C	Q		1.00	B
341	456913.709	1200708.810	44.296	D	45			L	X	X	C	Q		1.00	B
342	456915.436	1200708.134	44.414	D	45			L	X	X	C	Q		1.00	B
343	456916.872	1200708.157	44.487	D	45			L	X	X	C	Q		1.00	B
344	456918.688	1200708.466	44.930	D	45			L	X	X	C	Q		1.00	B
345	456921.645	1200708.288	44.784	D	45			L	X	X	C	Q		1.00	B
346	456923.999	1200707.205	45.619	B	45	D	D	M	M		D	N	S	1.50	C
347	456925.698	1200706.894	46.098	B	45	E	E	M	M		D	N	S	1.50	C
348	456928.637	1200706.385	46.191	B	33	D	D	M	M		D	N	S	1.50	C
349	456931.511	1200705.761	46.253	B	45	D	D	M	M		D	N	S	1.50	C
350	456934.495	1200704.501	46.488	B	45	D	D	M	M		D	N	S	1.50	C
351	456937.754	1200703.603	46.252	B	45	D	D	M	M		D	N	S	2.50	E
352	456941.160	1200700.855	46.877	B	45	D	D	M	M		D	N	SW	2.50	E
353	456943.950	1200697.707	47.453	B	45	D	D	M	M		D	N	SW	2.50	E
354	456947.234	1200693.625	48.004	B	45	D	D	M	M		D	N	SW	2.50	E
355	456950.029	1200689.651	47.932	B	45	D	D	M	M		D	N	SW	2.50	E
356	456952.998	1200688.049	47.899	B	33	C	E	M	M		D	T	NE	3.50	G
357	456956.037	1200685.329	48.052	B	33	C	E	M	M		D	T	NE	3.50	G
358	456958.669	1200682.351	48.058	B	33	C	E	M	M		D	T	NE	3.50	G

359	456960.366	1200679.163	48.325	B	33	C	D	M	M		D	T	NE	3.50	G
360	456962.122	1200675.746	48.431	B	33	C	B				N	Q		3.50	G
361	456963.862	1200671.818	48.350	B	33	B	B				N	Q		3.50	G
362	456965.549	1200668.733	48.567	B	45	C	D				N	T	NE	2.50	E
363	456966.877	1200665.884	49.063	B	45	C	C	M	M	M	D	Q		2.50	E
364	456968.290	1200663.188	49.384	B	45	C	E	M	M	M	D	Q		2.50	E
365	456969.192	1200661.164	49.569	B	45	C	E	X	X		D	Q		2.50	E
366	45697V6	1200657.696	49.707	B	45	C	E				D	Q		2.50	E
367	456973.756	1200652.539	50.140	B	45	F	E	M	M		D	N	SW	2.50	E
368	456974.986	1200650.793	50.279	B	45	D	D	M	M		D	Q		2.50	E
369	456976.168	1200647.805	50.599	B	45	E	E	M	M		D	Q		2.50	E
370	456976.115	1200644.922	50.538	B	45	D	D	M	M		D	Q		2.50	E
371	456977.434	1200639.681	50.807	B	45	D	D	M	M		D	Q		2.50	E
372	456977.738	1200636.335	51.166	B	45	B		S	S		D	N	W		
373	456977.937	1200631.910	51.422	B	45	B		S	S		D	N	W		
374	456977.188	1200626.966	51.682	B	33	B					N	N	W		
375	456976.384	1200621.833	51.609	B	33	B					N	N	W		
376	456975.464	1200615.338	51.365	B	33	B					N	N	W		
377	456974.788	1200610.321	51.343	B	33	B					N	N	W		
378	456973.692	1200609.950	51.325	B	33	B					N	N	W		
379	456973.226	1200603.096	51.114	B	33	B					N	N	W		
380	456973.774	1200602.266	51.062	B	33		B	S	S		D	T	N		
381	456970.849	1200602.242	50.924	B	33		C	S	S		D	T	N		
382	456968.079	1200601.837	50.846	B	33		B				N	T	N		
383	456965.773	1200600.923	50.585	B	33		B				N	T	W		
384	456965.302	1200598.122	50.529	B	33		C				N	T	W		
385	456967.095	1200596.045	50.769	B	33		C				N	T	S		
386	456969.330	1200594.854	50.925	B	33		C				N	T	S		
387	456971.534	1200594.338	51.025	B	33		C				N	T	S		

388	456973.030	1200593.450	51.085	B	33		C			N	T	S		
389	456968.426	1200591.664	50.626	B	45	C	C			N	Q		2.50	E
390	456968.014	1200588.492	50.767	B	45	D	D	L	L	D	Q		2.50	E
391	456967.707	1200585.902	50.814	B	45	C	C			N	Q		2.50	E
392	456967.934	1200582.973	50.790	B	45	C	C			N	Q		2.50	E
393	456967.586	1200579.963	50.925	B	45	D	D			N	Q		2.50	E
394	456966.400	1200577.026	50.778	B	45	C	C			N	Q		2.50	E
395	456966.271	1200574.534	50.964	B	33	B	B			N	Q		0.60	B
396	456966.565	1200571.396	50.684	B	33	B	B			N	Q		0.60	B
397	456966.187	1200567.077	50.629	B	33	B	B			N	Q		0.60	B
398	456965.549	1200562.105	50.358	B	33	B	B			N	Q		0.60	B
399	456964.744	1200556.716	50.097	B	33	B	B			N	Q		0.60	B
400	456963.677	1200552.618	49.848	B	33	B	B			N	Q		0.60	B
401	456963.032	1200548.305	50.247	B	33	B	B			D	Q		1.00	B
402	456962.490	1200544.523	50.403	B	33	B	B			D	Q		1.00	B
403	456962.354	1200542.351	50.508	B	33	B	B			D	Q		1.00	B
404	456961.114	1200540.518	50.259	B	33	B	B			D	Q		1.00	B
405	456961.920	1200537.587	50.409	B	33	B	B			D	Q		1.00	B
406	456961.779	1200533.757	50.489	B	33	B	B			D	Q		1.00	B
407	456961.178	1200528.087	50.694	B	33	D	E	L	L	D	T	E	4.00	H
408	456960.448	1200521.709	51.000	B	33	C	B	S	S	D	N	W	4.00	H
409	456958.137	1200515.451	51.255	B	33	C	B	S	S	D	N	W	4.00	H
410	456954.420	1200499.785	50.969	B	33	C	B	S	S	D	N	W	4.00	H
411	456953.161	1200495.434	50.752	B	33	B	B			N	Q		2.00	D
412	456952.432	1200492.052	50.583	B	33	B	B			N	Q		2.00	D
413	456953.885	1200476.942	49.836	B	33	B	B			N	Q		2.00	D
414	456951.807	1200474.009	49.345	L	33	B				N	N	W	1.50	C
415	456949.726	1200469.772	49.085	L	33	C		L	L	D	N	W	1.50	C
416	456946.951	1200465.723	48.791	L	33	B				N	N	W	1.50	C

417	456944.689	1200461.693	48.736	L	33	B					N	N	W	1.50	C
418	456941.376	1200458.244	48.503	L	33	B					N	N	W	1.50	C
419	456937.403	1200455.121	48.431	L	33	B					N	N	W	1.50	C
420	456933.098	1200455.035	48.034	B	33	B	B	L	L		D	Q		3.00	F
421	456933.006	1200454.995	48.033	B				M	M	M	N	Q		1.50	C
422	456927.004	1200456.267	47.477	B							N	Q		1.00	B
423	456919.613	1200457.681	47.207	B	45	C	C				F	Q			
424	456913.454	1200458.897	46.951	B							N	Q			
425	456906.791	1200460.881	46.795	B							N	Q			
426	456901.210	1200462.300	46.386	B							N	Q			
427	456896.862	1200462.404	46.029	B							N	Q			
428	456893.440	1200464.589	45.692	B				M	L	L	C	Q		1.50	C
429	456890.774	1200466.249	45.386	B							N	Q			
430	456886.706	1200466.918	45.003	B							N	Q			
431	456881.760	1200466.500	44.923	B							N	Q			
432	456877.586	1200467.112	44.646	B							N	Q			
433	456871.753	1200468.124	44.573	B							N	Q			
434	456864.927	1200469.762	44.596	B							N	Q		1.00	B
435	456863.848	1200470.422	44.626	B							N	Q			
436	456859.198	1200470.406	44.914	B							N	Q			
437	456852.377	1200472.155	44.296	B							N	Q			
438	456847.063	1200473.253	43.366	B							N	Q			
439	456839.601	1200474.264	41.167	B							N	Q			
440	456835.887	1200474.502	40.709	B							N	Q		0.50	A
441	456831.471	1200476.049	40.090	B							N	Q			
442	456827.596	1200477.416	39.331	B							N	Q			
443	456824.008	1200478.969	38.868	D	45	D	E	S	M	M	C	Q		1.50	C
444	456820.749	1200481.193	38.601	D	45	D	D	S	M	M	C	Q		1.50	C
445	456818.708	1200483.561	38.202	D	45	B	D	S	L	L	C	Q		1.50	C

446	456815.172	1200487.358	37.764	D	45	B	D	S	M	M	C	T	SW	0.80	B
447	456812.112	1200490.891	37.600	D	33	C	C	S	M	M	C	T	SW	0.80	B
448	456809.459	1200493.889	37.396	D	33	B	B	S	M	M	C	T	SW	0.50	B
449	456806.374	1200498.281	37.318	D	33	C	B	S	M	M	C	T	SW	0.50	B
450	456803.730	1200503.974	37.343	D	33	C	B	S	M	M	C	T	SW	0.50	B
451	456801.121	1200508.571	37.371	D	33	B	C	S	M	M	C	T	SW	0.50	B
452	456797.528	1200513.460	37.323	D	33	B	C	S	M	M	C	T	SW	0.50	B
453	456793.061	1200518.089	37.069	D	45	B	C	S	M	M	C	T	SW	0.50	B
454	456787.643	1200523.590	36.382	D	45	B	C	S	M	M	C	T	SW	0.50	B
455	456784.777	1200527.124	35.731	D	45	B	C	S	M	M	C	T	SW	0.50	B
456	456782.598	1200529.641	35.390	D	45	B	C	S	M	M	C	T	SW	0.50	B
457	456781.686	1200532.970	34.587	D	45	B	C	S	M	M	C	T	W	0.50	B
458	456780.468	1200536.665	33.414	D	90	B	F	M	L	L	C	T	W	2.20	E
459	456774.917	1200537.273	32.283	D				L	X	X	C	Q		1.50	C
460	456765.956	1200537.831	31.089	D				S	L	L	C	Q		1.20	C
461	456758.837	1200539.381	30.046	D	45	D	D	S	L	L	C	Q		1.50	C
462	456752.700	1200540.555	29.179	D	45	B	D	S	L	L	C	T	S	1.50	C
463	456744.620	1200541.202	28.301	D	45		C	S	L	L	C	T	S	1.50	C
464	456743.203	1200541.516	28.208	D	45		D	S	L	L	C	T	S		
465	456742.266	1200541.452	28.080	D	45		D	S	L	L	C	T	S		
466	456739.879	1200542.746	27.704	D	45		D	S	L	L	C	T	S		
467	456738.935	1200543.887	27.416	D	45	B	D	S	L	L	C	T	S	0.80	B
468	456735.654	1200544.367	27.201	D	45	C	D	S	L	L	C	T	S	0.80	B
469	456732.920	1200546.082	26.912	D	45	D	E	S	L	L	C	T	S	0.80	B
470	456730.783	1200546.798	26.654	D	45	D	D	S	L	L	C	Q		0.80	B
471	456727.063	1200548.350	26.470	D	45	C	D	S	L	L	C	T	S	0.80	B
472	456725.413	1200549.232	26.541	D	45	B	C	S	L	L	C	T	S	0.80	B
473	456722.247	1200551.714	26.303	D	45	B	B	S	L	L	C	Q		0.80	B
474	456718.791	1200553.031	25.622	D	90	D	D	S	L	L	C	Q		0.80	B

475	456714.485	1200555.364	24.958	D	90	D	D	S	L	L	C	Q		0.80	B
476	456710.321	1200556.465	23.515	D	90	D	E	S	L	L	C	T	S	0.80	B
477	456707.452	1200557.215	22.743	D	45	D	E	S	L	L	C	T	S	0.80	B
478	456702.505	1200557.084	22.278	D	45	D	E	S	L	L	C	T	S	1.50	C
479	456697.405	1200556.321	20.903	D	33	C	F	S	L	L	C	T	S	2.00	D
480	456691.611	1200558.899	21.011	D	33	C	F	S	L	L	C	T	S	3.00	F
481	456687.457	1200560.401	19.786	D	45	D	F	S	L	L	C	T	S	1.50	C
482	456681.396	1200561.732	18.649	D	45	D	D	S	L	L	C	Q		1.50	C
483	456673.629	1200564.077	17.457	D	45	B	D	S	L	L	C	T	S	1.50	C
484	456669.294	1200566.658	16.682	D	45	B	D	S	L	L	C	T	S	1.50	C

Appendix C.22 Gardie Norse Infields

Point Id	Eastings	Northings	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir face	face	Width	width
23	463718.4	1211590.2	13.484	D	90		C	M	A	A	C	NE	Q		
24	463713.0	1211594.9	13.388	D	33		C	M	L	L	C	NE	Q	0.6	B
25	463712.6	1211595.8	13.156	D					B	B	B	NE	Q		
26	463707.4	1211598.2	13.815	D	33		E	M	L	L	C	NE	Q	0.8	B
27	463705.0	1211601.7	13.923	D	33		E	M	L	L	C	NE	Q	0.8	B
28	463702.6	1211603.9	13.942	D	33		E	M	L	L	C	NE	Q	0.8	B
29	463700.2	1211607.0	13.543	D	33		D	A	B	B	B	NE	Q	0.8	B
30	463698.7	1211609.5	13.387	D	33		D	M	A	A	C	NE	Q	0.8	B
31	463696.6	1211610.8	13.55	D	45		D	M	A	A	C	NE	Q	0.6	B
32	463695.0	1211611.7	13.297	D	45		D	B	B	B	B	NE	Q	0.6	B
53	463718.4	1211588.8	13.516	D				S	A	A	C		Q		
54	463714.0	1211583.0	14.012	D				A	A	A	C		Q		
55	463710.2	1211578.0	14.655	D				M	L	L	C		Q		
56	463706.1	1211573.2	15.162	D	45	D	D	M	L	L	C		Q		
57	463703.9	1211570.9	15.575	D		D	D	M	L	L	C		Q		
58	463700.9	1211568.3	16.151	D		C	C	M	L	L	C		Q		
59	463698.4	1211565.4	16.179	D				T	A	A	C		Q		
60	463694.4	1211562.0	16.659	D				S	A	A	C		Q		
61	463691.8	1211559.5	17.308	D				M	A	A	C		Q		
62	463690.7	1211558.1	17.628	D				M	L	L	C		Q		
63	463689.7	1211556.3	17.793	D				M	L	L	C		Q		
64	463689.2	1211555.0	17.561	W	90	D	D	M	B	B	B		Q		
65	463689.4	1211553.8	17.654	W	90	E	D	S	A	A	B	E	Q		
66	463688.9	1211552.9	17.664	W	90	D	C	S	A	A	B	E	Q		
67	463688.2	1211552.6	17.642	W	90	D	C	S	A	A	B	E	Q		
68	463687.9	1211552.6	17.609	W	90			S	L	L	B		Q		
69	463688.1	1211552.3	17.964	D				T	L	L	C		Q		

70	463686.5	1211550.5	17.943	D				S	1	1	C		Q		
71	463685.4	1211548.7	18.004	D				M	L	L	C		Q		
72	463683.5	1211546.0	18.19	D				S	L	L	C		Q		
73	463682.1	1211544.1	18.368	D				M	A	A	C		Q		
74	463679.3	1211540.6	18.934	W	90	D	D	S	L	L	B		Q		
75	463677.6	1211538.5	19.239	W	90	C	C	S	A	A	B		Q		
76	463675.1	1211534.6	19.23	W	90	C	D	S	A	A	B		Q		
77	463672.6	1211531.0	19.996	D				S	A	A	C		Q		
78	463671.0	1211528.5	20.335	W	90	D	D	S	A	A	B		Q		
79	463668.8	1211525.0	20.87	W	90	C	C	S	A	A	B		Q		
80	463666.4	1211519.8	21.683	W	90	B	B	S	A	A	B		Q		
81	463664.8	1211516.4	22.001	W	90	B	B	S	A	A	B		Q		
82	463662.9	1211513.0	22.503	D				S	A	A	C		Q		
83	463659.0	1211503.3	22.757	D				M	B	B	C		Q		
84	463657.2	1211497.7	23.434	D				S	M	M	C		Q		
85	463655.0	1211491.6	24.071	D				S	M	M	C		Q		
86	463653.3	1211487.0	24.11	D				S	A	A	C		Q		
87	463652.0	1211483.1	24.27	D				S	M	M	F		Q		
88	463650.9	1211480.3	24.585	D				S	A	A	F		Q		
89	463650.6	1211479.0	24.744	D				M	L	L	C		Q		
104	463648.6	1211471.5	25.205	D				S	M	M	F		Q		
105	463648.8	1211474.1	24.985	D				S	M	M	F		Q		
106	463649.6	1211476.8	24.837	D				S	A	A	F		Q		
287	463602.8	1211475.6	24.486	D	90	B	A	S	M	M	D	N	Q	0.8	B
288	463599.3	1211477.4	24.176	D	90	C	A	S	M	M	F	N	Q	0.8	B
289	463595.3	1211479.3	24.023	D	90	C	A	S	L	L	F	N	Q	0.8	B
290	463592.9	1211480.5	23.869	D	33				M	M	D		Q		
291	463592.3	1211481.3	23.692	D	33				A	A	L		Q		
314	463569.2	1211493.9	23.255	D	90	C		M	L	L	C	N	N		

315	463567.1	1211492.1	23.861	L	33	E	B	M	A	A	D	N	N	1.7	D
316	463564.9	1211491.3	24.2	L	33	E	C	M	A	A	D	N	N	1.9	D
317	463562.4	1211491.7	24.278	L	33	D	B	M	M		D	N	N	1.5	C
318	463561.1	1211492.0	24.152	L	33	E					N	N	N	1.7	D
319	463558.8	1211493.1	24.041	L	33	D	B				N	N	N	1.3	C
320	463556.7	1211494.1	23.947	L	33	D	B	M	M	M	D	N	N	1.3	C
321	463554.8	1211494.5	23.876	D	90	C	B	M	M	M	C	N	N	1.2	C
322	463553.0	1211495.2	23.862	D	90	C	B	M	L	L	C	N	N	0.9	B
323	463550.8	1211496.1	23.858	D	33	E	C	M	M	M	C	N	N	1.2	C
324	463548.3	1211496.3	23.954	D	33	D	C	M	A	A	C	N	N	1.2	C
325	463545.3	1211495.8	24.123	D	90	C	B	S	L	L	C	N	N	1.0	B
326	463542.0	1211495.4	24.172	D	33	D	C	S	M	M	C	N	N	1.2	C
327	463538.2	1211494.8	24.304	D	90	C	B	M	L	L	C	N	N	1.0	B
328	463535.0	1211494.3	24.327	D	33	D	B	M	A	A	C	N	N	1.0	B
329	463531.0	1211494.4	24.298	D	90	D	C	M	A	A	C	N	N	0.9	B
330	463528.1	1211494.5	24.5	D	90	D	B	M	L	L	C	N	N	0.9	B
331	463526.0	1211494.6	24.443	D	90	C	B	M	A	A	C	N	N	0.9	B
332	463522.9	1211495.2	24.324	D	33	D	C	M	L	L	C	N	N	0.8	B
333	463519.5	1211495.3	24.3	D	90	D	B	M	A	A	C	N	N	0.8	B
334	463516.9	1211496.4	24.266	D	90	C	B	M	M	M	C	N	N	0.7	B
335	463513.5	1211496.9	24.154	D	33	D	B	M	L	L	C	N	N	0.9	B
336	463509.9	1211496.9	24.001	D	33	C	B	M	A	A	C	N	N	1.0	B
337	463505.9	1211497.2	23.864	B	45	C	B	M	L	L	F	N	N	0.9	B
338	463500.8	1211497.5	23.442	B	45	C	B	M	A	A	F	N	N	1.1	C
339	463495.8	1211497.6	23.166	B	45	D	B	M	M	M	F	N	N	1.2	C
340	463492.0	1211498.2	23.029	B	45	D	B	M	A	A	F	N	N	1.2	C
341	463487.2	1211498.8	22.773	B	45	C	B	A	X	X	F	N	N	1.0	B
342	463483.7	1211499.0	22.667	B	45	C	B	M	L	L	F	N	N	1.0	B
343	463478.9	1211500.1	22.57	B	45	B	B				N	N	N	0.9	B

344	463474.9	1211500.5	22.485	B	45	B	B	M	X	X	D	N	N	1.1	C
345	463470.9	1211501.5	22.305	B	45	B	B				N	N	N	1.1	C
346	463467.0	1211501.8	22.124	B	45	B	B				N	N	N	1.3	C
347	463462.2	1211503.3	22.025	B	45	B	B	M	M		D	N	N	0.7	B
348	463459.1	1211504.3	22	B	45	B	B	M	M		D	N	N	0.7	B
349	463457.1	1211504.9	22.072	B	45	B	B				N	N	N	0.7	B
350	463455.7	1211505.6	22.1	B	45	C	C				N	N	N	1.1	C
351	463451.8	1211506.5	22.065	D	90	C	B	M	X	X	C	N	N	1.0	B
352	463449.8	1211507.0	22.085	D	33	C	B	M	L	L	C	N	N	1.0	B
353	463447.2	1211507.3	22.012	D	33	D	C	M	A	A	C	N	N	1.0	B
354	463447.5	1211507.4	22.18	D	33	D	C	M	L	L	C	N	N	1.0	B
355	463444.3	1211509.1	22.225	D	33	C	C	M	A	A	C	N	N	1.0	B
356	463441.9	1211510.8	22.279	D	33	C	C	M	A	A	C	N	N	0.9	B
357	463438.4	1211513.3	22.374	D	33	D	C	M	A	A	C	N	N	1.2	C
358	463435.7	1211515.6	22.427	D	33	C	C	M	L	L	C		Q	0.9	B
359	463433.0	1211518.3	22.471	D	33	D	B	M	L	L	C	S	T	0.9	B
360	463429.7	1211521.8	22.497	D	33	E	D	M	L	L	C	NE	N	0.9	B
361	463426.5	1211525.1	22.676	D	33	E	E	M	M	M	C	NE	N	0.9	B
362	463424.2	1211528.8	22.658	D	33	D	B	M	L	L	C	NE	N	0.9	B
363	463421.7	1211532.4	22.638	D	33	D	B	M	A	A	C	NE	N	0.8	B
364	463419.5	1211535.8	22.518	D	33	D	D	M	A	A	C		Q	0.7	B
365	463417.0	1211539.6	22.468	D	33	E	D	M	A	A	C	E	N	0.7	B
366	463416.2	1211542.1	22.414	D	33	D	C	M	M	M	C		Q	0.7	B
367	463414.1	1211547.9	22.126	D	33	D	D	M	A	A	C	E	N	0.7	B
368	463413.1	1211552.2	22.01	D	33	D	D	M	L	L	C		Q	0.7	B
369	463411.1	1211558.4	21.958	D	33	D	B	M	A	A	C	E	N	0.7	B
370	463409.8	1211563.4	21.534	D	33	D	B	M	L	L	C	E	N	0.7	B
371	463409.8	1211565.2	21.3	D	33	C	B	M	A	A	C	E	N	0.7	B
372	463408.4	1211568.4	21.246	D	33	D	D	M	A	A	C	E	N	1.1	C

373	463405.8	1211573.7	21.07	D	33	C	B	M	A	A	C	E	N	1.2	C
374	463403.9	1211578.1	20.994	D	33	C	B	M	X	X	C	E	N	0.9	B
375	463402.6	1211581.2	20.9	D	33	C	B	S	A	A	C	E	N	0.9	B
376	463402.4	1211581.0	20.84	D	33	D	C	M	A	A	C	E	N	0.9	B
377	463401.9	1211583.5	20.921	D				A	H	H	C		Q		
378	463400.2	1211587.9	20.505	D			C	M	X	X	C		Q		
379	463398.7	1211590.8	20.483	D	90		C	M	A	A	C	E	N		
380	463398.2	1211593.6	20.004	D	90		C	M	A	A	C	E	N		
381	463398.0	1211595.5	19.785	D	45		D	M	X	X	C	E	N		
382	463397.1	1211598.5	19.732	D	45		C	M	L	L	C	E	N		
383	463395.9	1211602.5	19.354	D	45		C	M	A	A	C	E	N		
384	463395.0	1211606.3	19.136	D	45		C	M	A	A	C	E	N		
385	463394.7	1211609.2	18.907	D	45		C	S	A	A	C	E	N		
386	463393.4	1211611.1	18.794	D	45		C	M	X	X	C	E	N		
387	463393.7	1211616.7	18.818	D				M	L	L	C		Q		
388	463394.6	1211622.3	18.038	D				M	L	L	C		Q		
389	463395.7	1211628.8	17.581	D				A	A	A	C		Q		
390	463397.0	1211633.5	16.891	D				M	L	L	C		Q		
391	463397.8	1211638.5	16.584	D				M	A	A	C		Q		
392	463398.9	1211643.2	16.456	D				M	G	G	C		Q		
393	463401.0	1211647.9	16.311	D				S	A	A	C		Q		
394	463403.8	1211656.8	15.537	D				M	L	L	C		Q		
395	463405.9	1211661.4	15.642	D				M	L	L	C		Q		
396	463406.8	1211665.4	15.404	D				M	L	L	C		Q		
397	463407.5	1211665.4	15.369	D				M	L	L	C		Q		
398	463409.2	1211667.0	15.157	D				A	X	X	C		Q		
399	463409.9	1211669.7	14.814	D				A	L	L	C		Q		
400	463410.3	1211670.7	14.477	D				B	B	B	C		Q		
401	463411.3	1211674.2	13.928	D				B	B	B	C		Q		

402	463412.0	1211677.9	13.403	D				B	B	B	C		Q		
403	463413.2	1211682.3	13.097	D				M	L	L	F		Q		
404	463415.2	1211685.6	13.167	D				M	L	L	F		Q		
405	463416.0	1211686.9	12.953	D				M	L	L	F		Q		
406	463416.1	1211690.4	12.547	D				M	A	A	C	E	N		
407	463416.7	1211694.6	12.064	D				M	A	A	C	E	N		
408	463418.3	1211698.7	11.551	D				M	F	F	C	E	N		
409	463420.6	1211703.6	11.157	D				A	L	L	F	E	N		
410	463422.0	1211708.1	11.007	D				A	L	L	F	E	N		
411	463424.7	1211713.4	10.728	D				M	X	X	F	E	N		
412	463426.8	1211717.8	10.59	D				M	L	L	F	E	N		
413	463427.7	1211720.0	10.551	D				S	A	A	F		Q		
414	463427.6	1211724.3	10.602	D				A	H	H	F		Q		
415	463427.5	1211724.5	10.605	D				M	X	X	F		Q		
416	463427.4	1211724.3	10.609	D				M	A	A	D		Q		
417	463431.1	1211722.8	10.156	D				A	A	A	D		Q		
418	463434.9	1211721.3	10.025	D				A	L	L	D		Q		
419	463437.8	1211719.0	9.946	D				A	X	X	D		Q		
420	463440.9	1211717.7	9.355	D				M	X	X	D		Q		
421	463444.9	1211715.6	8.618	D				M	A	A	D		Q		
422	463448.0	1211714.1	8.497	D				M	A	A	D		Q		
423	463451.7	1211711.7	8.088	D				M	M		D		Q		
424	463455.4	1211708.5	7.995	D				M	M		D		Q		
425	463459.0	1211706.2	7.738	D				M	A	A	D		Q		
426	463462.4	1211703.3	7.933	D				M	A	A	D		Q		
457	463399.2	1211581.8	20.962	D	33	B	B	M	A	A	C		Q	1.0	B
458	463396.1	1211581.6	21.118	D	33	B	B	M	L	L	C		Q	1.0	B
459	463392.2	1211581.4	21.082	D	33	B	B	M	M	M	C		Q	0.9	B
460	463378.8	1211582.0	21.485	D	33	B	B	M	L	L	C		Q	0.9	B

461	463371.4	1211582.7	21.482	D	33	B	B				N		Q	0.9	B
462	463361.4	1211583.5	21.899	D	33	C	C	M	A	A	C		Q	0.9	B
463	463355.0	1211585.0	22.45	D	33	C	C	M	A	A	C		Q	0.7	B
464	463350.9	1211585.8	22.668	D	33			M	X	X	C		Q	0.7	B
465	463341.1	1211587.6	22.909	D	33	C	B	M	L	L	C		Q	0.7	B
466	463333.6	1211590.6	22.906	D	33	D	D	M	A	A	C		Q	0.7	B
467	463330.5	1211591.2	22.849	D	33	E	D	M	A	A	C	N	D	0.7	B
468	463328.6	1211593.1	23.292	D	33	D	D	M	A	A	C	N	D	0.7	B
469	463327.8	1211594.1	23.345	D	33	D	D	M	A	A	C		Q	0.7	B
470	463324.2	1211595.0	23.305	D	33		D	M	A	A	C	S	U	0.7	B
471	463320.5	1211595.6	23.643	D	33		E	M	L	L	C	S	U	0.7	B
472	463315.9	1211594.8	24.665	D	33	D	F	M	L	L	C	S	U	0.7	B
473	463310.1	1211594.1	24.612	D	33	B	C	M	L	L	C	S	U	0.7	B
474	463303.7	1211595.3	24.094	D	33	B	C	M	A	A	C	S	U	0.6	B
475	463298.1	1211596.9	24.335	D	33	B	C	M	A	A	C	S	U	0.6	B
476	463296.1	1211599.0	24.166	D	33	B	C	M	A	A	C	S	U	1.0	B
477	463582.8	1211845.7	4.141	D	33	B	C	M	X	X	C	S	U	0.9	B

Appendix C.23 Stove Norse Infields

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Dir Face	face	Width	width
71	462057.602	1212527.541	29.853	L	33		B					Q		0.40	A
72	462061.519	1212528.026	29.802	L	33		B					Q		0.40	A
73	462065.704	1212529.028	29.746	L	33		C					Q		0.40	A
74	462069.779	1212529.777	29.620	L	33		D					Q		0.40	A
75	462074.709	1212530.579	29.457	L	33		D					Q		0.60	B
76	462079.637	1212531.243	29.241	L	33		C					Q		0.50	A
77	462083.440	1212531.882	29.226	L	33		C					Q		0.50	A
78	462086.847	1212533.053	28.916	L	33		C					Q		0.50	A
79	462090.427	1212534.014	28.702	L	45		D					Q		0.40	A
80	462090.451	1212534.070	28.693	B	33	B	D					Q		2.00	D
81	462092.724	1212534.382	28.488	B	33	B	D					Q		1.80	D
82	462096.638	1212535.971	28.295	B	33	B	D					Q		1.80	D
83	462100.583	1212537.026	28.079	B	33	B	D					Q		1.80	D
84	462103.397	1212537.836	27.977	B	33	B	D					Q		2.10	E
85	462105.062	1212537.458	27.884	B	33	B	D					Q		2.00	D
213	462040.285	1212464.949	33.117	B	33	A	D				N	T	NW	2.20	E
214	462042.415	1212466.301	33.157	B	33	A	D				N	T	NW	2.20	E
215	462042.923	1212468.447	32.976	B	33	A	D				N	T	NW	2.20	E
216	462043.833	1212470.958	32.946	L	33		E	S	A	A	C	T	N	0.90	B
217	462046.093	1212469.934	32.882	L	33		E				N	T	N	1.10	C
218	462049.504	1212469.086	32.742	L	33		D				N	T	N	1.10	C
219	462053.645	1212469.280	32.545	B	33	B	D				N	T	N	2.20	E
220	462058.077	1212470.054	32.270	B	33	B	D				N	T	N	2.20	E
221	462062.259	1212470.772	32.145	B	33	B	D				N	T	N	2.20	E
222	462068.375	1212470.029	32.038	B	33	B	E				N	T	N	2.20	E
223	462074.467	1212469.487	31.670	B	33	B	E				N	Q		2.20	E

224	462076.034	1212469.435	31.617	B	33	B	B	S	X	X	C	Q		1.10	C
225	462082.745	1212468.418	31.406	B	33	A	B	S	X	X	C	Q		1.10	C
226	462086.785	1212467.512	31.498	B	33	B	C	M	M		D	N	NE	1.30	C
227	462090.591	1212464.654	31.393	B	33	B	B	M	L	L	C	Q		1.10	C
228	462095.764	1212460.162	31.322	B	33	B	C	A	A		D	N	NE	1.10	C
229	462100.517	1212454.317	31.413	B	33	B	B	A	A		D	N	NE	1.10	C
230	462104.819	1212449.365	31.571	B	33	B	B	A	A		D	N	NE	1.10	C
231	462108.468	1212444.284	31.668	B	33	B	B	S	M	M	D	N	NE	1.10	C
232	462111.243	1212441.268	31.627	B	33	A	A	S	M	M	D	N	NE	0.80	B
233	462114.088	1212439.488	31.676	B	33	A	A				N	N	NE	0.80	B
234	462115.599	1212438.343	31.457	B	33	B	B				N	N	NE	0.80	B
235	462117.604	1212437.183	31.691	B	33	B	C	S	M	M	D	N	NE	2.50	E
236	462123.514	1212433.185	31.576	B	33	B	B	X	X		D	N	NE	1.30	C
237	462126.594	1212429.285	31.568	B	33	B	B				N	Q		0.80	B
238	462129.735	1212426.373	31.692	B	33	B	B				N	N	NE	1.10	C
239	462133.853	1212422.253	31.636	B	33	B	C				N	N	NE	1.10	C
240	462136.845	1212419.718	31.677	B	33	B	C				N	N	NE	1.10	C
241	462142.363	1212414.097	31.685	B	33	B	C				N	N	NE	1.10	C
242	462148.083	1212407.230	31.733	B	33	B	C				N	N	NE	1.10	C
243	462148.840	1212405.759	31.718	B	33	B	C				N	N	NE	1.10	C
244	462035.484	1212498.749	31.490	B	45	B	B	S	S		D	Q		1.20	C
245	462034.603	1212495.142	31.801	B	33	C	B	M	M		N	Q		0.80	B
246	462034.143	1212492.429	32.030	B	33	D	E	S	A	A	C	T	NW	1.20	C
247	462034.317	1212490.912	32.004	B	33	D	E	S	A	A	C	T	NW	1.20	C
248	462033.296	1212489.589	32.175	B	33	D	E	S	A	A	C	T	NW	1.20	C
249	462033.028	1212488.301	32.348	B	33	D	F	S	A	A	C	T	NW	1.40	C
250	462033.228	1212487.316	32.215	B	33	D	F	S	A	A	C	T	NW	1.40	C
251	462032.818	1212486.123	32.286	B	33	E	B	S	A	A	C	T	NW	1.60	D
252	462032.666	1212485.148	32.438	B	33	E	B	S	A	A	C	T	NW	1.40	C

253	462031.632	1212483.267	32.621	B	33	E	B	S	A	A	C	T	NW	1.60	D
254	462030.972	1212481.677	32.750	B	33	F	B	S	A	A	C	T	NW	1.60	D
255	462029.884	1212480.355	32.758	B	33	D	D	S	A	A	C	T	NW	1.80	D
256	462029.165	1212479.195	32.798	B	33	B	C	S	A	A	C	T	NW	1.20	C
257	462028.378	1212477.067	32.835	B	33	E	C	S	A	A	C	T	NW	0.80	B
258	462028.036	1212475.046	32.930	D		E	E	S	A	A	C	T	NW	0.80	B
259	462027.669	1212473.326	33.101	D		F	A	S	A	A	C	T	NW	0.80	B
260	462027.217	1212471.796	33.181	D		E	B	S	A	A	C	Q	SE	0.80	B
261	462026.279	1212470.507	33.359	D		D	E	S	A	A	C	Q	SE	0.80	B
262	462026.440	1212469.012	33.309	D		E	E	S	L	L	C	Q	SE	1.20	C

Appendix C.23 Watlie Norse Infields

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Face	Dir face	Width	width
143	459379.639	1205167.361	19.697	D		B	B	M	M		C	Q		0.80	B
144	459379.738	1205167.474	19.661	D		B	B	S	M	M	C	Q		0.80	B
145	459381.011	1205175.430	19.309	D		B	B	S	M	M	C	Q		0.70	B
146	459381.915	1205181.727	18.972	D		B	B	S	M	M	C	Q		0.70	B
147	459382.781	1205186.515	18.845	D		B	B	S	M	M	C	Q		0.70	B
223	459607.764	1205244.829	43.298	L	33	Z	D	L	L		D	N	W	1.80	D
224	459606.882	1205246.960	43.063	L	33	Z	D	M	M		D	N	W	1.80	D
225	459607.910	1205248.812	43.115	L	33	Z	C				N	N	W	1.80	D
226	459607.537	1205251.633	42.526	L	33	Z	C				N	N	W	1.80	D
227	459607.371	1205255.413	42.170	L	33	Z	C				N	N	W	1.80	D
228	459607.705	1205258.439	42.292	L	33	Z	C				N	N	W	1.80	D
229	459608.085	1205260.559	42.381	L	33	Z	D				N	N	W	1.00	B
230	459606.897	1205263.688	42.106	L	33	Z	D				N	N	W	1.00	B
231	459605.282	1205267.605	41.794	L	33	Z	B				N	N	W	0.40	A
232	459604.547	1205269.144	41.624	L	33	Z	B				N	N	S	0.40	A
233	459604.284	1205268.800	41.598	L	33	Z	B				N	N	S	0.40	A
234	459600.464	1205268.137	41.539	L	33	Z	B				N	N	S	0.40	A
235	459596.570	1205268.245	41.339	L	33	Z	B	M	M		D	N	S	0.30	A
236	459589.737	1205268.447	40.798	L	33	Z	B	S	S		D	N	S	0.30	A
242	459496.860	1205359.753	18.858	D	33	Z	C	M	A	A	C	N	S	1.20	C
243	459500.075	1205357.391	19.033	D	33	Z	C	M	M		C	N	S	1.00	B
244	459502.295	1205356.577	19.232	D	33	Z	C	M	M		D	N	S	1.00	B
245	459504.281	1205356.608	19.676	B	33	B	C				N	N	S	2.20	E
246	459506.344	1205353.465	21.105	B	33	B	C				N	N		2.20	E
247	459507.326	1205352.539	21.541	B	33	B	C				N	N		2.20	E
248	459508.461	1205350.490	22.177	B	33	B	C				N	N		2.20	E

249	459510.504	1205348.613	22.595	B	33	B	C				N	N		2.20	E
250	459512.707	1205346.704	22.994	B	33	B	C				N	N		2.20	E
251	459515.239	1205344.453	23.459	B	33	B	B	M	M		D	Q		1.40	C
252	459516.647	1205343.690	23.697	B	33	B	A	S	A	A	D	T	N	3.00	F
253	459517.527	1205341.169	24.243	B	33	A	A				N	Q		1.00	B
254	459519.688	1205338.029	24.960	L	33	B		S	M	M	D	N	S	1.20	C
255	459523.168	1205334.338	25.870	L	33	B		S	X	X	D	N	S	1.20	C
256	459525.317	1205331.785	26.428	B	33	B	A	S	A	A	D	N	S	1.20	C
257	459528.228	1205328.168	27.174	B	33	B	A	S	S		D	N	S	1.20	C
258	459531.433	1205325.956	27.798	B	33	B	B	S	M	M	D	Q		1.20	C
259	459534.478	1205323.536	28.456	B	33	B	B	S	M	M	FC	Q		1.20	C
260	459538.383	1205319.648	29.484	B	33	B	B	S	A	A	FC	Q		1.20	C
261	459541.269	1205317.528	30.028	B	33	B	C	S	A	A	FC	N	S	1.20	C
262	459544.319	1205314.556	30.731	B	33	B	C	S	M	M	C	N	S	1.50	C
263	459547.279	1205311.972	31.316	B	33	B	C	S	A	A	C	N	S	2.50	E
264	459550.104	1205309.164	32.212	B	33	B	C	S	M	M	C	N	S	1.50	C
265	459552.102	1205308.266	32.673	B	33	B	B	S	A	A	C	Q		0.90	B
266	459554.245	1205307.169	33.160	L	45	C		S	M	M	C	T	N	0.90	B
267	459557.276	1205304.934	33.641	L	45	C		S	X	X	C	T	N	0.90	B
268	459575.565	1205292.262	36.586	D				M	M	M	FC			0.60	B
269	459579.297	1205291.689	36.958	B	33	B	B				N			2.50	E

Appendix C.24 Belmont Reused TownshipDyke

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht In	Min St	All max	Max St	Dense	Face	Dir face	Width	width
486	456660.413	1200570.366	15.398	D	90	B	D	S	A	A	C	T	W	1.50	C
487	456634.328	1200520.973	13.128	D	33	C	E	S	A	A	F	D	W	1.90	C
488	456636.659	1200525.239	13.269	D	90	C	E	S	L	L	C	D	W	1.90	C
489	456637.861	1200528.959	13.379	D	90	E	E	S	A	A	C	U	E	1.90	C
490	456639.372	1200532.602	13.498	D	90	D	D	S	H	H	C	Q		1.90	C
491	456641.457	1200537.676	13.893	D	90	C	E	S	M	M	C	U	E	1.90	C
492	456646.222	1200546.313	14.333	D	45	E	E	S	M	M	C	U	E	2.50	E
493	456648.499	1200551.532	14.773	D	45	E	E	S	M	M	C	U	E	2.50	E
494	456650.342	1200554.890	14.968	D	45	D	C	S	M	M	C	U	E	2.50	E
495	456651.167	1200557.718	14.894	D	45	D	D	S	L	L	C	U	E	2.50	E
496	456652.500	1200560.903	14.921	D	45	D	B	S	M	M	C	U	E	2.50	E
497	456654.897	1200563.622	15.224	D	45	D	C	S	M	M	C	U	E	2.50	E
498	456655.780	1200566.536	15.503	D	45	E	D	S	M	M	C	U	E	2.50	E
499	456657.578	1200569.418	15.652	D	45	E	D	S	M	M	C	U	E	2.50	E
500	456659.384	1200570.645	15.864	D	45	E	D	S	M	M	C	U	E	2.50	E
501	456659.856	1200572.414	15.150	B	45	E	D	M	M		D	D	W	1.70	D
502	456661.595	1200576.597	15.239	B	45	E	D	M	M		D	D	W	1.30	C
503	456662.761	1200578.697	15.174	B	45	D	B	M	M		D	D	W	1.00	B
504	456664.565	1200579.908	15.190	B	45	D	B	M	M		D	D	W	1.00	B
505	456666.853	1200582.344	15.143	B	45	D	B	M	M		D	D	W	1.00	B
506	456667.655	1200585.219	15.037	B	45	D	B	M	M		D	D	W	1.00	B
507	456668.614	1200587.403	14.998	B	45	D	B	M	M		D	D	W	1.00	B
508	456670.423	1200589.258	15.036	B	45	D	B	M	M		D	D	W	1.00	B
509	456672.111	1200591.894	14.789	B	45	D	B	M	M		D	D	W	1.00	B
510	456674.433	1200593.637	15.017	B	45	D	B	M	M		D	D	W	1.00	B
511	456676.391	1200596.051	15.110	B	33	E	C	M	M		D	D	W	0.90	B

512	456677.628	1200598.654	14.765	B	45	E	D	M	M		D	D	W	0.90	B
513	456678.898	1200602.025	15.149	B	45	D	C	M	M		D	D	W	0.90	B
514	456680.300	1200604.315	15.327	B	45	D	C	M	M		D	D	W	0.90	B
515	456680.307	1200606.201	15.199	B	45	D	C	M	M		D	D	W	0.90	B
516	456680.983	1200607.763	15.003	B	45	D	C	M	M		D	D	W	0.90	B
517	456681.557	1200609.658	14.795	B	45	D	C	M	M		D	D	W	0.90	B
518	456683.473	1200612.192	15.110	B	45	D	C	M	M		D	D	W	0.90	B
519	456685.336	1200614.818	15.108	B	45	D	C				D	D	W	0.90	B
520	456686.984	1200617.552	15.342	B	33	E	B				D	D	W	2.00	D
521	456687.284	1200620.341	14.952	B	33	E	C				D	D	W	2.00	D
522	456686.320	1200623.980	15.063	B	45	E	C				D	D	W	1.10	C
523	456686.688	1200628.706	14.851	B	45	E	C				D	D	W	1.10	C
524	456687.094	1200634.218	14.166	B							D	D	W	0.90	B
525	456687.841	1200637.743	13.998	B							D	D	W	0.90	B
526	456689.733	1200641.602	14.026	B	33	D					D	D	W	2.00	D
527	456690.678	1200645.436	13.754	B							D	D	W	2.00	D
528	456691.377	1200649.199	13.624	B		E	E				D	D	W	2.00	D
529	456691.258	1200652.236	13.796	B		E					D	D	W	2.00	D
530	456690.658	1200656.009	13.250	B		E					D	D	W	2.00	D
531	456689.347	1200660.462	12.657	B		C	B				D	D	W	2.00	D
532	456688.799	1200663.743	12.506	B		B	B				D	D	W	2.00	D
533	456686.881	1200668.684	12.118	L	90	B	B	S	H	H	D	D	W	0.50	A
534	456685.396	1200672.154	11.917	L	45	B	B	S	M	M	D	D	W	0.50	A
535	456685.464	1200674.856	11.844	L	45	B	B	S	M	M	D	D	W	0.50	A
536	456685.200	1200678.441	11.793	L	45	B	B	S	M	M	D	D	W	0.50	A
537	456685.322	1200681.417	11.717	L	45	B	B	S	M	M	D	D	W	0.50	A
538	456685.980	1200684.468	11.623	L	45	C	B	S	M	M	D	D	W	1.00	B
539	456686.275	1200686.924	11.613	L	45	D	B	S	M	M	D	D	W	2.00	D
540	456685.971	1200689.256	11.775	B	33	B	B	M	M		D	Q		0.60	B

541	456687.689	1200692.294	11.606	B	33	B	B	M	M	D	Q		0.60	B
542	456690.677	1200691.654	11.674	B	33	B	B	M	M	D	Q		0.60	B
543	456695.457	1200692.489	12.344	B	33	B	B	M	M	D	Q		0.60	B
544	456700.428	1200693.729	13.314	B	33	B	B	M	M	D	Q		0.60	B
545	456704.629	1200696.717	13.842	B	33	B	B	M	M	D	Q		0.60	B
546	456709.218	1200698.467	14.913	B	33	B	B	M	M	D	Q		0.60	B
547	456713.741	1200697.698	15.623	B	33	B	B	M	M	D	Q		0.60	B
548	456716.473	1200698.431	16.264	B	33	B	B	M	M	D	Q		0.60	B
549	456719.150	1200698.636	16.557	B	33	B	B	A	A	D	Q		0.60	B
550	456719.288	1200698.640	16.551	B	33	B	B	M	M	D	Q		0.60	B
551	456721.953	1200698.697	17.193	D	33	B	B	M	M	F	Q		0.80	B
552	456723.569	1200699.543	17.417	D	33	B	B	M	M	F	Q		0.80	B
553	456724.487	1200702.781	17.442	D	33	B	B	M	M	F	Q		0.80	B
554	456723.756	1200706.616	17.133	D	33	B	B	M	M	F	Q		0.80	B
555	456726.571	1200701.486	17.972	B	33	B	B	M	M	D	Q		1.50	C
556	456728.821	1200703.592	18.491	B		A	A	M	M	D	Q		1.50	C
557	456730.904	1200706.002	18.815	D		A	A	S	S	F	Q		1.50	C
558	456732.513	1200707.615	19.345	B		A	C	S	S	D	D	NW	1.50	C
559	456735.540	1200708.859	20.001	D				M	M	F			0.50	A
560	456737.620	1200709.963	20.721	D				M	M	F			1.20	C
561	456740.154	1200710.171	21.338	D				L	L	F			1.20	C
562	456743.308	1200710.782	21.957	D				A	A	C			1.20	C
563	456746.305	1200711.870	22.499	D	90	D	E	M	M	C	U	SE	0.90	B
564	456750.643	1200714.199	22.933	D	90	B	C	M	M	C	D	NW	0.90	B
565	456754.310	1200715.754	24.603	D	90	D	D	M	M	C	Q		0.60	B
566	456758.490	1200717.067	25.002	D	90	E	E	M	M	C	Q		0.60	B
567	456762.503	1200718.278	25.797	D	33	B	B	M	M	C	Q		0.60	B
568	456767.196	1200720.030	26.196	D	90	B	B	M	M	C	Q		0.60	B
569	456770.922	1200719.362	27.569	D	33	C	B	M	M	C	U	S	0.60	B

570	456773.429	1200720.988	28.093	D	90	C	B	M	M		C	U	SE	0.60	B
571	456778.089	1200722.919	27.733	D	90	C	F	M	M		C	U	SE	0.60	B
572	456781.815	1200724.514	27.529	D	90	C	D	M	M		C	U	SE	0.60	B
573	456783.566	1200726.246	27.481	D	90	C	G	M	M		C	U	SE	0.60	B
574	456785.881	1200726.533	27.644	D	90	C	G	M	M		C	U	SE	0.60	B
575	456787.690	1200727.534	27.521	D	33	C	F	M	M		C	U	SE	0.60	B
576	456790.887	1200730.236	27.510	D	33	C	F	M	M		C	U	SE	0.60	B
577	456792.974	1200732.079	27.384	D	33	C	E	M	M		C	U	SE	0.60	B
578	456792.926	1200732.146	27.376	D	33	C	C	M	M		C	Q		0.60	B
579	456795.795	1200733.817	27.212	D	33	C	C	M	M		C	Q		0.60	B
580	456797.517	1200734.614	27.177	D	33	C	C	M	M		C	Q		0.60	B
581	456799.777	1200737.250	27.084	D	33	C	C	M	M		C	Q		0.60	B
582	456802.148	1200739.395	27.149	D	33	C	C	M	M		C	Q		0.60	B
583	456803.060	1200740.300	26.866	D	33	C	C	M	M		C	Q		0.60	B
584	456803.884	1200741.553	26.840	D	33	C	C	M	M		C	Q		0.60	B
585	456805.484	1200742.392	27.041	D	33	C	C	M	M		C	Q		0.60	B
586	456806.372	1200743.597	26.973	D	45	C	C	M	M		C	Q		1.50	C
587	456808.711	1200747.140	26.909	D	45	C	C	L	L		C	Q		1.50	C
588	456810.735	1200749.298	27.374	D	90	C	D	L	L		C	Q		1.50	C
589	456811.601	1200751.467	27.451	D	90	C	C	L	L		C	Q		1.50	C
590	456812.224	1200754.066	27.259	D	90	C	C	L	L		C	Q		1.50	C
591	456812.718	1200759.515	26.589	D	33	D	D	M	A	A	C	Q		1.50	C
592	456811.986	1200762.423	26.135	D	33	D	C	M	A	A	C	D	W	0.90	B
593	456813.416	1200763.937	25.569	D	33	D	C	M	A	A	C	D	W	0.90	B
594	456813.563	1200768.224	25.239	D	33	D	C	M	A	A	C	D	W	0.90	B
595	456813.981	1200774.906	24.560	D	33	C	C	M	A	A	C	Q		0.90	B
596	456813.701	1200779.320	24.038	D	33	C	C	M	A	A	C	Q		0.90	B
597	456813.782	1200784.008	23.588	D	33	C	C	M	A	A	C	Q		0.90	B
598	456813.523	1200789.180	23.239	D	33	C	C	M	A	A	C	Q		0.90	B

599	456814.193	1200791.641	23.044	D	33	C	C	M	A	A	C	Q		0.90	B
600	456815.057	1200795.443	22.792	D	33	C	C	M	A	A	C	Q		0.90	B
601	456815.551	1200798.663	22.589	D	90	B	A	S	A	A	C	D	W	0.50	A
602	456816.920	1200801.271	22.584	D	90	B	A	S	A	A	C	D	W	0.50	A
603	456817.163	1200804.068	22.351	D	90	B	A	S	A	A	C	D	W	0.50	A
604	456816.869	1200808.368	21.903	D	90	E	A	M	L	L	C	D	W	0.50	A
605	456816.518	1200812.005	21.647	D	45	C	B	M	A	A	C	D	W	0.80	A
606	456818.248	1200815.200	21.675	D	45	C	C	M	A	A	C	D	W	0.50	A
607	456819.581	1200820.685	21.488	D	45	D	C	S	S		C	D	W	0.50	A
608	456819.990	1200822.705	21.651	D	45	D	C	S	M	M	C	D	W	0.80	B
609	456820.265	1200826.125	21.347	D	45	D	C	S	M	M	C	D	W	0.80	B
610	456820.050	1200830.481	20.660	D	45	D	C	S	M	M	C	D	W	0.80	B
611	456819.623	1200834.341	20.317	D	45	D	C	S	M	M	C	D	W	0.80	B
612	456819.763	1200837.908	19.971	D	45	D	C	S	M	M	C	D	W	0.80	B
613	456819.347	1200840.195	20.010	D	45	C	C	S	A	A	C	Q		0.80	B
614	456819.379	1200842.426	19.747	D	45	D	C	S	A	A	C	D	W	0.80	B
615	456819.769	1200844.487	19.733	D	45	D	C	S	A	A	C	D	W	0.80	B
616	456819.475	1200848.548	19.275	D	45	C	C	S	A	A	C	Q		0.80	B
617	456820.403	1200851.097	19.317	D	33	B	B	M	A	A	C	Q		0.80	B
618	456820.841	1200854.445	18.962	D	33	D	B	M	A	A	C	D		0.80	B
619	456821.400	1200859.041	18.645	D	33	E	C	M	A	A	C	D	W	0.80	B
620	456822.237	1200864.807	18.405	D	33	E	B	M	A	A	C	D	W	0.80	B
621	456822.350	1200868.522	18.266	D	33	E	B	M	A	A	C	D	W	0.80	B
622	456821.899	1200872.888	18.023	D	33	E	B	M	A	A	C	D	W	0.80	B
623	456822.060	1200876.186	17.755	D	33	F	B	M	A	A	C	D	W	3.00	G
624	456823.140	1200881.167	17.877	D	33	F	B	M	A	A	C	D	W	3.00	G
625	456824.853	1200886.217	17.610	D	33		A	M	A	A	C	U		1.80	D
626	456825.795	1200890.030	17.156	D	45	C	B	M	A	A	C	D	W	1.80	D
627	456826.902	1200892.856	17.004	D	45	D	B	M	A	A	C	D	W	1.20	C

628	456828.358	1200896.930	16.941	D	45	D	B	M	A	A	C	D	W	1.00	B
629	456829.610	1200899.938	16.885	D	45	D	B	M	A	A	F	D	W	0.80	B
630	456828.811	1200905.727	16.401	B	33	D	B	M	A	A	F	D	W	0.80	B
631	456827.829	1200909.344	16.437	B	33	D	B	M	A	A	F	D	W	0.80	B
632	456827.186	1200911.768	16.130	B	33	D	B	M	A	A	D	D		0.80	B
633	456827.153	1200914.270	15.732	B	45	B	B	M	A	A	N			0.60	B
634	456829.567	1200917.412	16.233	B		C	C	M	A	A	N			1.20	C
635	456832.327	1200920.473	16.512	B		C	C	M	A	A	N			1.20	C
636	456834.013	1200921.641	16.708	B		C	C	M	A	A	N			1.20	C
637	456836.553	1200924.242	16.843	D				X	X		C			0.80	B
638	456840.228	1200926.620	17.135	D				X	X		C			0.80	B
639	456843.227	1200929.407	17.539	D				A	A		C			0.80	B
640	456845.749	1200930.918	17.694	B	45	E	C				N	D		0.80	B
641	456848.734	1200932.333	17.871	B	33	E	B	T	M	M	F	D		1.75	D
642	456852.066	1200936.489	18.332	B	33	E	B	M	M		F	D		1.25	C
643	456854.463	1200940.250	18.485	B	33	D	B	M	M		F	D		1.00	B
644	456855.450	1200942.186	18.512	B	33	B	B	M	M		F	Q		1.00	B

Appendix C.25 Belmont Reused Township Dyke

Point Id	EASTINGS	NORTHINGS	Height	Type	Slope	F Ht In	F Ht Out	Min St	All max	Max St	Dense	Face	Dir Face	Width	width
97	459557.243	1205182.772	45.149	D	90	D	B	M	A	A	C	D	N	1.30	C
98	459555.293	1205182.472	44.827	D	90	D	E	M	A	A	C	D	N	1.20	C
99	459553.434	1205181.732	44.884	D	90	E	E	M	A	A	C	D	N	1.20	C
100	459548.321	1205181.120	44.062	D	90	D	D	S	M	M	C	D	N	1.30	C
101	459545.577	1205179.689	44.084	D	90	D	D	S	A	A	C	D	N	0.95	B
102	459541.724	1205177.751	43.812	D	45	E	D	S	M	M	C	D	N	0.95	B
103	459538.901	1205177.101	43.332	D	90	F	E	S	S		D	D	N	1.00	B
104	459535.694	1205176.673	43.262	D		D	D	M	M		D	D	N	1.40	C
105	459533.134	1205176.065	43.279	D		F	E	M	M		D	D	N	1.40	C
106	459532.359	1205174.545	42.987	D		F	F	S	A	A	C	D	N	1.40	C
107	459530.545	1205171.410	43.166	D		D	F	S	M	M	D	U	E	1.60	D
108	459529.469	1205169.374	43.177	D		E	E	M	M		D	Q		1.20	C
109	459528.426	1205166.122	43.313	D		F	E	S	A	A	D	D	W	1.20	C
110	459527.138	1205163.134	43.701	D	45	F	B	S	A	A	D	D	W	2.00	D
111	459526.008	1205161.678	43.746	D	45	B	B				N	Q		1.60	D
112	459525.289	1205159.591	43.557	D	90	D	C	S	S		D	D	W	1.60	D
113	459522.903	1205154.486	44.561	D	90	E	D	S	S		D	D	W	1.20	C
114	459521.593	1205152.114	45.090	D	90	E	D	S	S		D	D	W	1.20	C
115	459520.523	1205149.454	45.265	D	90	E	D	M	M		D	D	W	1.20	C
116	459517.871	1205147.307	45.236	D	45	C	B	S	S		D	D	W	1.20	C
117	459515.877	1205145.536	45.049	D	90	F	F				N	U	E	1.20	C
118	459513.503	1205142.518	44.853	D	90	D	E				N	U	E	1.40	C
119	459511.922	1205138.924	45.022	D	90	D	D				N	Q		1.50	C
120	459509.885	1205135.819	45.033	D	45	B	B	S	S		D	D	W	1.50	C
121	459508.155	1205132.363	45.031	D	90	B	B	S	S		D	Q		0.90	B
122	459504.563	1205125.558	44.672	D	90	E	E				N	D	W	1.20	C

123	459502.612	1205122.480	44.652	D	90	F	F	S	M	M	D	D	W	1.60	D
124	459500.706	1205120.438	44.591	D	90	F	F				N	T	E	1.70	D
125	459497.213	1205120.188	43.631	D	45	D	D	S	S		D	T	S	1.90	D
126	459489.282	1205122.886	43.072	D	90	D	E				N	T	S	1.60	D
127	459480.813	1205125.844	41.193	D	90	E	E	M	M		D	T	S	1.80	D
128	459472.231	1205129.574	37.589	D	45	C	E	M	M		D	T	S	1.80	D
129	459460.296	1205135.630	33.443	D	45	D	D	M	M		D	T	S	1.80	D
130	459445.161	1205135.626	28.280	D	90	D	E	M	M		D	T	S	1.80	D
131	459431.902	1205141.218	26.642	D	90	F	F	S	A	A	D	T	S	1.80	D
132	459424.538	1205144.243	24.745	D	90	C	D	M			D	T	S	1.20	C
133	459417.402	1205146.852	23.811	D	90	D	E	S	M	M	D	T	S	1.40	C
134	459410.999	1205150.080	22.769	D	90	D	E	S	S		D	T	S	1.40	C
135	459406.695	1205152.323	21.775	D	90	D	E	S	S		D	T	S	1.70	D
136	459401.632	1205153.623	21.562	D	90	D	E	S	S		D	T	S	2.00	D
137	459399.179	1205153.983	21.265	D	33	D	E				N	T	S	3.00	F
138	459396.915	1205155.503	21.092	D	45	B	B				N	Q		2.50	E
139	459394.207	1205156.074	20.915	D	90	E	E				N	Q		2.50	E
140	459388.810	1205158.739	20.514	D		D	E				N	T	SW	1.20	C
141	459385.151	1205161.664	20.052	D		B	D				N	T	SW	1.10	C
142	459382.020	1205164.453	19.951	D		C	D				N	T	SW	0.90	B
143	459379.639	1205167.361	19.697	D		B	B	M	M		C	Q		0.80	B
362	459579.188	1205173.485	51.879	D	45	C	D	S	A	A	D	N	N	1.00	B
363	459581.817	1205173.394	52.087	D	45	D	D	S	A	A	D	Q		1.00	B
364	459582.986	1205172.762	51.805	D	45	E	D	S	A	A	D	N	N	1.00	B
365	459584.534	1205172.909	51.784	D	45	E	D	S	A	A	D	N	N	1.25	C
366	459586.362	1205173.543	51.835	D	45	D	E	A	A		D	T	S	1.25	C
367	459589.354	1205173.285	51.806	D	45	E	D	S	S		D	N	N	1.25	C
368	459592.104	1205175.220	51.313	D	45	E	D	S	M	M	D	N	N	1.50	C
369	459594.604	1205175.360	50.998	D	33	B	B	M	M		D	Q		2.00	D

370	459598.865	1205176.657	50.558	D				M	A	A	C			1.25	C
371	459601.663	1205175.934	50.599	D	45	A	D	S	M	M	D	T	S	1.40	C
372	459604.133	1205174.577	51.376	D	45	A	D	S	M	M	D	T	S	1.40	C
373	459605.764	1205174.243	51.524	D	45	A	D	S	M	M	D	T	S	1.40	C
374	459607.118	1205174.009	51.806	D	45	A	D	S	M	M	D	T	S	1.40	C
375	459608.654	1205173.654	52.020	D	45	A	D	S	M	M	D	T	S	1.40	C
376	459610.434	1205173.052	52.282	D	45	A	D	S	M	M	D	T	S	1.40	C
377	459617.503	1205170.853	53.796	D	45	A	D	S	M	M	D	T	S	1.40	C
378	459619.509	1205170.142	54.000	D	45	A	D	S	M	M	D	T	S	1.40	C
379	459626.310	1205168.382	54.205	D	45	A	D	S	M	M	D	T	S	1.40	C

Appendix D Sinuousity Data for Homestead Enclosures and Multiple Field Systems

H Encs	Croag	Exna	Hill Taing	Houlland	Newing	Vassa
A	1.061	1.037	1.038	1.016	1.087	1.017
B	1.008	1.015	1.013	1.013	1.001	1.04
C	1.025	1.005	1.035	1.04	1.085	1.047
D	1.004	1.004	1.084	1.075	1.044	1.54
E	1.007	1.074	1.007			
F	1.008		1.02			
G			1.132			
MFS	Brouster	Clev	Gallow	Gruting	Pinhoull	Sumburgh
A	1.041	1.035	1.069	1.043	1.041	1.089
B	1.116	1.125	1.027	1.05	1.022	1.037
C	1.277	1.014	1.009	1.042	1.074	1.115
D	1.655	1.015	1.027	1.022	1.06	1.112
E	1.043	1.153	1.064	1.03	1.02	1.008
F	1.188	1.09	1.036	1.109	1.027	1.049
G			1.067	1.013	1.06	1.011
H	1.04		1.156	1.062	1.106	1.098
I	1.393		1.017	1.018	1.017	
J	1.337		1.364	1.05	1.006	
K	1.007				1.012	
L	1.082					
M	1.041					
N	1.015					
O	1.064					
P	1.034					
Q	1.048					
R	1.022					

Appendix E Soil Field Descriptions

Old Scatness Q: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation (based on excavations and deposits adjacent)
OSB03 Q2	5709	*1779* *1780*	5YR 3/2 dark reddish brown; Lens 10YR 8/2 very pale brown		Top soil
	5710	*1780* *1781* *1778*	10YR 8/3 very pale brown 10YR 8/1 white	Light patchy sand	Sand blow
	5711		7.5YR 2.5/1 black, bone/fish bone, carbon flecking	Sandy loam	
	5712	1783	10YR 8/3 very pale brown 10YR 5/3 brown Base: 10YR 8/3 very pale brown	sandy	Sand blow
	5713	1802 1797	10YR 8/3 very pale brown 5YR 3/2 dark reddish brown	Sandy loam with fish bone	"Norse"cultivation
	5714	1809 1810 1782	5YR 3/2 dark reddish brown	Sandy silt loam with carbon flecking, bone	"Viking" cultivation
	5718	1799	7.5YR 3/1 very dark grey	Sandy silt with shell and carbon flecking	"Iron Age" cultivation
	5719	1801	7.5YR 3/2 brown	Sandy loam	"Iron Age" cultivation
	5720	1798	10YR 7/6 yellow		"Iron Age" cultivation
	5724	1798	7.5YR 4/5 brown		Spade marks
	5726	*1800*	10YR 4/1 dark grey mixed	"Blue sand"	6 layers of

			with 10YR 5/4 yellowish brown 10YR 5/6 dark yellowish brown	"Orange sand"	alternating blue and yellow sand
	5727	*1796*	10YR 5/1 grey 10YR 4/1 dark grey 10UR 2/2 very dark brown 10YR 2/1 black	"Purple sand"	Sand with traces of iron pan at base

Houlland Soils: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation
HN08/D	[HN101]		10YR 2/1 black	Organic, peaty	
	[HN102]	1	10YR 2/2 very dark brown	Sandy peaty silt	Worked?
	[HN103]	1&2	10YR 2/2 very dark brown 40% mottled 10YR 4/2 dark greyish brown	Sandy silt with stones up to 1cm, occasional stone 14cm	
	[HN104]		10YR 4/2 dark greyish brown	Gritty sandy silt, stones 1-3cm, occasionally 10cm, angular, including quartz	
HN08/E	[HN201]		10YR 2/1 black	Organic peat	
	[HN202]		10YR 2/1 black	Very peaty silt	
	[HN203]	1&2	10YR 2/2 very dark brown	Organic, peaty	Land surface?
	[HN204]	1	10YR 3/2 very dark greyish brown	Slightly clayey gritty peat containing either charcoal or manganese	
	[HN205]	1&2	10YR 4/3 brown	Sandy silt	
	[HN206]		10YR 5/2 greyish brown	Slightly sandy silt	
	[HN207]		Bedrock		

Clevigarth Soils: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation
CGB03/2	[2001]			Very organic	Topsoil
	[2002]	2i	10YR 2/2 very dark brown; mottles 10YR 2/1 black	Sandy clay loam (coarse sand) Mottles resulting from roots, organic	
	[2003]	2i & 2ii & 2iii	7.5YR ¾ dark brown	Slightly sandy loam, hard, firm. Flecks of charcoal and ash	amended
	[2004]	2ii & 2iii	7.5YR ¾ dark brown	Slightly sandy loam, hard, firm. Flecks of charcoal and ash	
	[2005]	2iii	7.5YR 4/6 strong brown	Loam, firm, fairly homogeneous with charcoal	
	[2006]		7.5YR 4/2 brown 7.5YR 7/8 reddish yellow	Clay with sandstone (rotting)	
CGB03/3	[3001]		10YR 2/2 very dark brown; mottles 10YR 2/1 black	Sandy clay loam (coarse sand) Mottles resulting from roots, organic	Topsoil
	[3002]	3i	10YR 3/2 very dark greyish brown, mottles 10YR 2/1 black	Coarse sandy loam, firm	
	[3003]	3i	10YR 3/2 very dark greyish brown, prominent mottles 5YR 2/1 black	Sandy loam, c.15% mottles	Unlike Profile 2
	[3004]	3i	5YR 4/1 dark grey	Silty clay loam, very firm	
	[3005]		5YR 4/1 dark grey	Silty clay loam, very firm	
	[3006]		5YR 5/3 reddish brown	Sandy silt loam, very hard	

Exnaboe Soils: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation
EXD08/C	[101]		7.5YR 2.5/1 black	Organic loam	topsoil
	[102]		7.5YR 2.5/1 black	Organic loam	topsoil
	[103]		10YR 2/1 black	Gritty silt, bleached stone rim, iron inside	Podzolisation & weathered bedrock
	[201]		7.5YR 2.5/1 black	Organic loam	topsoil
	[202]	1	7.5YR 2.5/1 black	Organic loam	Very organic
	[203]	1	10YR 2/1 black	Gritty silt, bleached stone rim, iron inside	Podzolisation & weathered parent material
	[204]				Parent material with stones up to 10cm

Pinhoulland Soils: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation
PHW08/H1	[1001]		2.5YR 2.5/2 very dusky red	Silty peat	80% vegetation
	[1002]		2.5YR 2.5/1 reddish black	Peaty silt	peaty
	[1003]	H1/1	5YR 2.5/1 black, mottles 5YR 3/1 very dark grey 30%	Peaty silt with charcoal or manganese	Peaty, amended?
	[1004]	H1/1	5YR 4/1 dark grey	Silty clay	
	[1005]				Parent material with small flat stones 2-5cm
PHW08/H2	[2001]		7.5YR 2.5/2 very dark brown	Organic sandy loam, some grit	
	[2002]	H2/1	7.5YR 2.5/2 very dark brown	Gritty loam matrix, stone up to 0.35m	Cairn matrix
	[2003]	H2/1 H2/2	7.5YR 3/2 dark reddish brown	Gritty silt	Early land surface
	[2004]	H2/2	7.5YR 2.5/1 black		
	[2005]	H2/2	7.5YR 2.5/1 black		Podzolised?
PHW08/C3	[3001]			Organic silt	Vegetation
	[3002]		10YR 3/1 very dark grey	Peaty silt	peat
	[3003]				Parent material
PHW08/D1	[4001]				Sphagnum
	[4002]	D1/1	7.5YR 2.5/1 black	Peaty silt	peat

	[4003]	D1/ 1	10YR 3/1/ very dark grey	Slightly gritty peaty silt	Charcoal - amended
	[4004]	D1/ 1	2.5YR 2.5/1 black	Peaty silt	Peaty
	[4005]	D2/ 2	5YR 2.5/1 black	Peaty silt	More peaty
	[4006]	D2/ 2	10YR 2/1 black	Silty clay	Lens
	[4007]	D2/ 2	10YR 4/1 dark grey	Silty clay	?worked
PHW0 8/D2	[6001]		7.5YR 2/1 black	Organic peaty loam	Topsoil
	[6002]		7.5 2/1 black	Gritty silty peat	Cairn matrix
	[6003]	D2/ 1	10YR 2/1 black	Silty clay	Surface?
	[6004]	D2/ 1	10YR 3/2 very dark brown	Gritty silt	Peaty podzol, disturbed
PHW0 8/J	[5001]				Sphagnum
	[5002]		2.5YR 2.5/1 reddish black	Peaty silt (10% root)	Peat
	[5003]	J1	5YR 2.5/1 reddish black, mottles 40% 2.5YR 2.5/1	Peaty silt	
	[5004]	J1	5YR 4/1 dark grey	Silty clay	Peaty
PHW0 8/J2	[7001]				
	[7002]		5YR 2.5/1 black	Firm peat	Peaty
	[7003]		10YR 2/1 black	Peaty silty clay	Peaty
	[7004]		10YR 3/2 very dark brown	Silty with irregular stone 1-2cm	

Hamar Soils: Field Descriptions

Site Code	Context	Sample	Field Description	Texture	Field Interpretation
HU08/1Y	[001]		7.5YR 2.5/2 Very dark brown	Organic loam and roots	Topsoil
	[002]	2601	10YR 4/3 brown Mottles:7.5YR 5/6 strong brown Iron staining: 5YR 4/6 yellowish brown	Slightly gritty silt loam	Organic
	[003]	2604	10YR 4/4 dark yellowish brown	Slightly gritty silty loam, a few stones up to 1.5cm	
	[004]	2604	10YR 3/4 dark yellowish brown	Gritty silty loam, 10% stones up to 2.5cm	Immediately above bedrock
HU08/2Q	[201]	2602	7.5YR 2.5/2 Very dark brown	Organic loam and roots	Topsoil
	[202]	2602 2622	10YR 4/4 dark yellowish brown. Mottles: 5%, 7.5YR 5/6 strong brown	Gritty silt loam, few stones up to 1cm	
	[203]		10YR 3/4 dark yellowish brown	Stone with silty loam	Subsoil/top of bedrock
HU08/4S	[401]	2603	10YR 3/3 dark brown	Silty loam and roots	Topsoil
	[402]	2603 2608	10YR 3/6 dark yellowish brown	Gritty silty loam	
	[403]	2608	10YR 4/4 dark yellowish brown	Silty loam, up to 10% stone up to 1cm	
	[404]		10YR 3/4 dark yellowish brown	Sitly loam with 50% stone and grit, up to 2cm	
HU08/5H	[501]	2607	10YR 3/3 dark brown, mottles: 7.5YR 5/4 strong brown	Silty loam	The only soil surviving, straight onto bedrock (area scalped)

Belmont Soils: Field Descriptions

Site Code	Context	Slide	Field Description	Texture	Field Interpretation
BU08/1	[B001]		5YR 2.5/2 dark reddish brown	Peaty/rooty loam	Topsoil
	[B002]	2606	10YR 3/2	Peaty gley	
	[B003]	2606	Chart 1 for gley 7/1 light greenish grey 30% mottles: 5YR 5/8 yellowish red	Peaty gley	In pockets within bedrock
BU08/2	[B201]	2610	10YR 2/1 black	Peaty loam, vegetation	Topsoil
	[B202]	2610	5YR 2.5/1 black	Silty peat-loam	Has [B203] within it, ard marks at base cutting [B204]
	[B203]	2610	7.5YR black	Silt	?early land surface
	[B204]		Chart 1 for gley 7/1 light greenish grey	Peaty gley	
BU08/3	[B301]	2605	10YR 2/1 black	Peaty loam, vegetation	Topsoil
	[B302]	2605	10YR 3/2 very dark brown	Peaty loam/peat	
	[B303]		Chart 1 for gley 7/2 light greenish grey	Peaty gley/bedrock	Bedrock with pockets of gley, quartz in bedrock

Underhoull Soils: Field Descriptions

Site Code	Context	Sample	Field Description	Texture	Field Interpretation
UH 10/A	[1001]	UH/A1			Topsoil
	[1002]	UH/A1	10 YR 3/3 Very dark brown	Humic silty loam	
	[1003]	UH/A2	10 YR 3/3 Very dark brown	Crumbly silty loam with orange (iron) mottles	
	[1004]	UH/A2	10 YR 3/ 4 Dark yellowish brown 50% iron pan	Crumbly gritty silt loam + iron pan	Includes iron pan
	[1005]	none	10YR 5/4 Yellowish brown Mottles: 10YR 6/2 light brownish grey	Very compact silty loam with some grit and stones up to 10cm	Subsoil/top of bedrock
UH10/B	[2001]	none			Rooty matter
	[2002]	none	10YR 3/3 Very dark brown	Humic loam	topsoil
	[2003]	UH/B1	7.5YR 2.5/2 Very dark brown	Sandy silt, damp with some charcoal	
	[2004]	UH/B1		Contains iron pan	Iron pan
	[2005]	UH/B2	10YR 5/3 Brown	Compact, crumbly and slightly sandy silt with iron mottles and stones up to 0.2m.	
	[2006]	UH/B2	10YR 5/4 Yellowish brown	Very compact, clayey with stones up to 0.15m	Subsoil/top of bedrock
UH10/C	[3001]	none	10YR 2/1 Black	Humic, compact loam, crumbly under pressure	Topsoil
	[3002]	UH/C1	10YR 2/2 Very dark brown	Crumbly silt loam	
	[3003]	UH/C1	7.5YR 2/1 Black	Crumbly silt loam	
	[3004]	UH/C1 UH/C2	7.5YR 3/2	Compact silty loam, gritty	
	[3005]	UH/C2			
	[3006]	UH/C2	2.5 YR 2.5/1	Wet peat	Wet peat

			Black		
	[3007]	UH/C2	2.5 YR 2.5/3 Dark reddish brown	Iron pan	Iron pan
	[3008]	UH/C2	10YR 4/4 Dark yellowish brown	Compact, very sandy. Very undisturbed/clean	Subsoil/top of bedrock "Natural"
UH10/D	[4000]		10YR 2/2very dark brown	Humic loam	Topsoil
	[4001]	UH/D1	7.5YR 4/2 brown	Humic, silty loam with root material	
	[4002]	UH/D1	7.5YR 2.5/1black	Silty loam/peat, slightly humic	
	[4003]	UH/D1	10 YR 2/1 black	Loamy/peaty sand	
	[4004]	UH/D1	7.5 YR 2.5/1 black	Silty loam/peat, forms crumbs	
	[4005]	UH/D2	10 YR 2/1 black	Silty peat. Crumb consistency	
	[4006]	UH/D2	10 YR 2/2 very dark brown	Slightly sandy silt loam	
	[4007]		5 YR 2.5/4 dark reddish brown	Iron pan	
	[4008]		10 YR 4/3 brown	Top of bedrock, contains gneiss/schist and some sand	Subsoil/top of bedrock "Natural"
UH10/E	[5000]				Topsoil - Ploughed up to 20 years ago
	[5001]	UH/E1	7.5 YR 3/2 Very dark brown	Dry sandy loam, crumbly Contains lot of charcoal	
	[5002]	UH/E2	7.5 YR 3/2 Dark brown	More compact sandy loam, slightly darker	
	[5003]	UH/E3	7.5 YR 4/1 Dark grey &7.5YR 5/8 Strong brown	Sandy, slightly silty clay loam Clay mottles	
	[5004]	UH/E3	7.5 YR 3/2 Dark brown	Sandy, slightly silty, clayey loam	
	[5005]	none	7.5 YR 4/2 brown	Sandy silty clay, stone up to 0.7cm	
	[5006]	none	7.5 YR 4/3 brown &.5YR 5/6 strong brown	Sandy silt	Subsoil/top of bedrock "Natural"
UH/F	[6001]	none	10 YR 2/2	Sandy loam, very humic. Includes quartz	Topsoil

			Very dark brown	and other stone up to 0.2cm compact	
	[6002]	none	7.5 YR 5/6 Strong brown	Sandy loam with rotting stone up to 0.5cm	Subsoil
	[6003]	none		Stone in rotting stone matrix	Glacial till?
UH10/G	[7001]	UH/G1	7.5YR 2.5/1, black	Loamy sand, humic, compact	Topsoil
	[7002]	UH/G1	7.5 YR 2.5/1 Black	Sandy clay loam, slightly humic, includes quartz and other stone, and possible crude ard point	
	[7003]	none	7.5 YR 5/6 Strong brown	Stone, rotted stone and sand	Subsoil
UH10/H	[8001]	UH/H1	10 YR 3/3 Dark brown	Humic sandy loam	Topsoil
	[8002]	UH/H1	10 YR 3/3 Dark brown	Compact sand, few rootlets	
	[8003]	none	7.5YR 5/6 Strong brown	Sand with stone and rotted stone	
UH10/I	[9001]	UH/G1	10 YR 3/3 Dark brown	Humic sandy loam	
	[9002]	UH/G2	10 YR 3/2 Very dark greyish brown	Sandy loam with charcoal flecks	
	[9003]	none	7.5YR 5/6 Strong brown	Sand with stone and rotted stone	Subsoil/Top of bedrock
UH10/J	[9501]	UH/J1	7.5 YR 3/1 Dark grey	Humic loamy sand	Topsoil
	[9502]	UH/J1	7.5YR 2.5/2 Very dark brown	Silt loam	
	[9503]	none	7.5 YR 4/6 Strong brown	Sand with small amounts of loam, mica flecks, stone up to 15cm	
	[9504]	none	10YR 5/1 Grey	(also white)Mottled clay with high mica content	Subsoil

Appendix F: Soils Recording Sheets

(graphics for all sheets by Bill Jamieson)

OLD SCATNESS
Area L

COARSE MINERAL

Context	Thin Section	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound
2059	2644		••		••					Rare	••
2060	2643		••							Very rare	•
2061	2641		•••							Very rare	Very rare
2062	2642		•••							Very rare	Rare
2063	2655		••								
2064	2654		••								

Context	Thin Section	Phytoliths	Diatoms
2059	2644	Rare	
2060	2643	Very few	
2061	2641	•	
2062	2642	•	
2063	2655	•	
2064	2654	•	Very rare

COARSE ORGANIC

Context	Thin Section	Parenchymatic	Lignified	Fungal spores	Pollen	Shell
2059	2644					Rare
2060	2643					Very rare
2061	2641		Very rare			Very rare
2062	2642		Very rare	Very rare		Very rare
2063	2655			Very rare		
2064	2654			Very rare		

FINE ORGANIC

Context	Thin Section	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Vivianite
2059	2644	Very few	•			
2060	2643	••	Very few			
2061	2641	•••	•		Very rare	Very rare
2062	2642	••	•••			
2063	2655	••	•			
2064	2654	•	Very few			

CULTURAL MATERIAL

Context	Thin Section	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Rubified Material
2059	2644		Very rare	Rare		Very rare
2060	2643		Very rare	Rare		Very rare
2061	2641		Rare	Very few		Very rare
2062	2642		Rare	Very few		Very rare
2063	2655		Very few	Very few		Rare
2064	2654		Rare	Rare		Very rare

PEDOFEATURES

Context	Thin Section	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic silt)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
2059	2644	Very rare					••				Very few		
2060	2643	Rare					•••				Rare		
2061	2641	Rare					•••				Very rare		
2062	2642	Rare					•••						
2063	2655	Very rare					••••						
2064	2654	Very rare					••••						

Frequency Very rare (<0.5%) Rare (0.5 - 2%) Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

OLD SCATNESS Q

Context	Thin Section	c/f ratio	COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL					PEDOFEATURES										
			Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Shell	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Rubified material	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental
5713	1802			•••							••					*			**	***			*	**			••	*						***		***		*
5713	1797			••		*					***		**		*	***			***		•	*	*	*	*		***	*						•		••		
5714	1809			•••			*				***		**	*	•	**			**	***		•	**	*			**	**						•		**		**
5714	1810			••							***		**		*	•			**	*	***	*			**			**							**	**		
5714i	1782			***															*									*						**				
5714ii	1782			***							**					**			**		**							**						***				
5718	1782			***							*		*			**			**		***							*						***				**
5715	1799			•••		**	*				••		**			•	*		•••	••	•	***	*	**	**			***					**	••	•			*
5719	1801			••		*					*		*		*	*			•	••	**	*		*	**								*	***	*	***		
5724	1798			•••		*							*			*			•	•	**				**			*					*	**		*		
5720	1798			••••		•	**												*	**															*			

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)

• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

EXNABOE B			COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES												
Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
E202	EXD/08/B	1:2-1:1	*	•	***	•					**	***	**		**	•	•		**	•	*	***		**			•		•	*	***	*				**		
E203	EXD/08/B	3:1		***	**	•					*	••••	**		**	***	***		**	**	*	*					••		*							***		

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

HOULLAND D&E			COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
102	HN08/D1	1:2-1.0		•		**					***	•	•	*	***	•	**	*	***	**	•	**					***		*					**		***		
103	HN08/D1 HN08/D2	4:1		***	*						***	••••	•	*	***	•	**	*	***	**	••	**					***		*			*		***				
203	2600/E1	1:1	*	••				***					***	**	•	••	**		•	*	•	**					•		**					**				
Lens	2600/E1	1:1	*	•	**	•		***			**	••	•	**	***	••	**	**	***	***	•	*			**		**	•	***					***				
204	2600/E1	2:1	*	••	**	**					**	•	**	*	**		*		***	*	•	*		** (Burnt)			**	••	**					**				
203	2611/E2	1:1		**		**		***				••																										
203/204	2611/E2	3:1		•		•					**	•••	***	*					***		•	***							*									
204	2611/E2	1:9		**		**					***		***								•••	***																

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

PINHOULLAND D1/1, D1/2, D2/1			COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
4002	2619	1:4											**		***	••••	***		**	•		•			**				**									
4003	2619	3:2		**		•							***	**	**	•	*		•	***	*	•			•		*		**									
4003B	2619	1:1											**	**	**	••••	***		***	***		•			*				***									
4004	2619	1:2											***	*	**	•	•			•		•							*									
4004B	2619	1:1											***	*	***	•	•		**	•	*	**					**		**									
4005	2633	1:4											*	•	**	•			***	***		**					*		*					*				
4006	2633	1:2		*									**	***	**	••	**		••	**	**	***			**		*		*									
4005B	2633	1:4											**	***	**	•	***		***	***	*	**							*					**				
4007A	2633	1:2		*			•						*	**	*	•••	**		••	•	**	**			•		*		*									
4007B	2633	1:1	**	**	**		•				**	*		*	*	•	**		***	***		**					**		*			*		*				
4008A	2633	3:2		•	*	***	•				**	**	•	**	**	•	**		**	•	**	**					***		*					***		**		
4008	2633	3:1		•	*		•				***	**	***	*	***	•			**	***	*	*					***		*					***		**		
6003	2609	1:2		•	**	**						•	••	**	***	•	***		***	•	***	**		*			***		**									
6004A	2609	1:3		**	***	**						•	***	*	**	•	*		***	***	**	**					•		***		•							
6004B	2609	1:1		***	**							•	***	*	**	•	**		***	***	*	**			*		**	***	*		**	*						

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

PINHOULLAND
H1 + H2

Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen
			COARSE MINERAL												COARSE ORGANIC			
1003i	HI/1												***		**	••	***	
1003ii	HI/1												**			•	**	*
1003iii	HI/1												*	*	**	••	***	
1003iv	HI/1												•	**	**	••	**	
1004v	HI/1												*		**		•	
1004vb	HI/1														•			
1004vi	HI/1	2:1		***								**	•	*	•	•	*	
2002	H2/1	1:1		***		**					*	•••	***		*	•••	**	
2003A	H2/1	2:1		**		*						••••	***		*	•	***	
2003B	H2/1	3:1		***								••••	***		*		***	
2003	H2/2	3:1		•		**						•••	**		**	•	*	
2004	H2/2	3:1		•		**						••	***		***	**	***	
2005	H2/2	2:1	***	•		**						••	***		**	•	***	

Context	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
	FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
1003i	•••	**	***	***							*							•		
1003ii	*		**	**			*				*							**		
1003iii		••	**	**							*									
1003iv	***	•	•	***			*		**		*									
1004v	••		**	***					**		*			•						
1004vb	**	**		***						**										
1004vi	**	**	**	•					***							•				
2002	**	••	***	**		*		*	•		**				**	**				
2003A	**	•	•	*					**	***	**				***	**		*		
2003B	*	•	**	*					••		**					**	**	*		
2003	**	•	•				*		•		***			**	**					
2004	**	**	**	***			*		***		**			***	•			*		
2005		**	***	**			**		•	••	*							**		

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

PINHOULLAND J1

Context	Thin Section	c/f ratio	COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
			Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
5003	J1	1:3											**		**	•••	***		•	**	•	•			**		*		**			***		**		*		
5004	J1	1:9		*		***						*	**		**	••	***		••	***	**	***			*		**		**			**		**				

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

CLEVIGARTH 2+3

Context	Thin Section	c/f ratio	COARSE MINERAL: Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms
2002	1792	1:1		••	**	**	••				***	**	***	
2003	1790	2:1		**	**	•	••				•		***	**
2004	1790	3:1		***	***	***	••				***	***	•	*
2003	1795	1:2			**	**	••				**	**	•	
2004	1795	2:1		*	*	*	•••				***	***	***	**
2005	1795	1:2			**	•	••				**	**	***	
3002	1793	2:11		•	**	••						•		
3003	1793	9:1		•	**	••						*		
3004	1793	4:1		**	***	••						••		

Context	Thin Section	COARSE ORGANIC: Parenchymatic	Lignified	Fungal spores	Pollen	FINE ORGANIC: Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Burnt Organic	CULTURAL MATERIAL: Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Rubified Material
2002	1792	**	•	**		**	*	***	**						*
2003	1790					***	*	**	**				*		
2004	1790					***	***	*	**	**					**
2003	1795	*	••			••	*	***	**	*					
2004	1795	*	•	*		•	•	**	**	**	?				
2005	1795	*				•	•	*	*	*					
3002	1793		***			***	*								
3003	1793		•			•									
3004	1793		**			**	**								

Context	Thin Section	PEDOFEATURES: Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
2002	1792	***		**			•		**				
2003	1790	**		*			***				**		
2004	1790	**		**			•	*					
2003	1795	***		***		**	*		•				
2004	1795	•		*		**	**		•		**		
2005	1795	**		**		**			**		***		
3002	1793								**				
3003	1793								**				
3004	1793	*							**				

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

BELMONT

Context	Thin Section	c/f ratio	COARSE MINERAL: Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms
B102	2606	1:9	•	***	*						**		••	*
B103	2606	1:4	**	••	*							*	•	
B201	2610	1:5	*	**									**	
B202/1	2610	1:1	**	*									••	
B202/2	2610	1:3		***									•••	
B202/3	2610	1:2	***	**	**								••	
B202/4	2610	1:9	**	*									**	
B202/5	2610	1:5	*	**									••	
B202/6	2610	1:9	*	**									•••	
B202B	2610	2:1	***	**	*	*							•	
B301	2605	1:3	*	**									••	*
B302	2605	1:1	*	***									•	*

Context	COARSE ORGANIC: Parenchymatic	Lignified	Fungal spores	Pollen	FINE ORGANIC: Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	CULTURAL MATERIAL: Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics
B102	***	**			**		*	*				
B103	**	**			**			*				
B201	***	•				**		**				
B202/1	**	***				***						
B202/2					*							
B202/3		**				*						
B202/4	***	**		*	**	*						
B202/5	**	***		*	*	***		*				
B202/6	***			*	**	***						
B202B	**	**	*		**		*	*				
B301	•••	•	*		**			•				
B302	••	**	*	*	*			**				

Context	PEDOFEATURES: Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
B102	***		*						•			
B103	•		*						***			
B201	••											
B202/1	***											
B202/2	**											
B202/3	•											
B202/4	•••											
B202/5		•••										
B202/6	•••							*				
B202B	*											
B301	*								*	*		
B302	**								**			

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

HAMAR			COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
Y1/1 002	2601	3:2	•••	**	*						*		**		***	••	*		•	••	•••			*	*		*					•••				**		
Y2/2 003	2604	1:4	**	*	*								•		**	••			**	•	••						*					**						
Y2/2 004A	2604	1:1	••••	*									***		**	••			•		••			**	**		*					•				*		
Y2/3 004	2604	1:4	•	**	•								**				**		***		•			*	**	*	*					••••						
Q1 201	2602	1:1	••	**											***	***			•	***	•			***		*	*					••••		**		*		
Q1 202	2602	2:3	•••	*									***		*	***	**		•					**		*	**		**			••••						
Q2 202	2622	1:4	**	*							***		•			••	•		•				***	**	*	**	***		*			••••			***	•		
S1 401	2603	4:1	***	**	*	**									**	•	**		**	*	*		**	**	*		**								*	*		
S1 402	2603	9:1 - 2:1	•••	*	*	*									**	***	***		***					*	*	*	•					••			•			
S2 402	2608	1:1	••	*	*								**		*	*	*		•	*	**				*	*	***		**		*	•••		**	**	*		
S2 403	2608	3:1	** ••••	*															***	*					*	**	*		*			••••		**	***			
H 501	2607	1:1 - 19:1	••••		*								**		•	*	***		**			***				**	***	**	**						••	**		

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

UNDERHOULL
Profiles A - C

			COARSE MINERAL												COARSE ORGANIC				FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
1001	A1	1:3	••	*	*	**			*				***		•	**	**		**		***	**					•		**			**						
1002	A1	1:1	•	*	•	•••			*				***		**	•	*		***		*						••		***	*								
1003	A2	2:1	•	*	***	••			*	**		**	***	*	*	***	*		***		***	*					••		***	**		••••		**				
1004	A2	2:1	•	*	**	•••			**		**		**	**	*	•	*		**		***	*			*		•••		•	*								
2003	B1	3:2	•	•	**	•••	**		*			••	**	*	**	•	**	*	•		***	*		*	**	*	•••			**		•••		**		***		
2004	B1	3:1	•	•	**	•	*		**		*				*	•	*		•	**	**	*					••					•••		**		•	•	
2005	B2	2:1	•	***	**	•	*			*		**	•		*	•	*		**	•		*		*			••		**					*	**	***		***
2006	B2	2:1	•	***	*	•	*					•	***		**	***			***	***				*			•		**						**	*		***
3002	C1	1:3	***	**		•	*		*			***	**	**	*	•	*		***		**	**			•		**					**				•		
3003	C1	1:2	***	**	•	***	*		*			••	**	***	*	***	**		***		*	*			*		**		**			*				•		
3003B	C1	2:1	•	**	**	•	*	*	*	**					*	•	*		***		•	*					••		*			**				•		
3004	C1	1:1	•	**	•	***		*		*			*		*	***	*		**	•							••				••					•••		
3005	C2	1:1	•	**	***	•	*			**		**	*						*	*	•			*			•••		•			•••				•		
3007A	C2	10:1		**		**		*								••••	*		*	*	••••						••••		*							•		
3007B	C2	10:1		*		**		*		**						•••	*		*		••••						••••											
3008	C2	3:1		•		**		*		*		•	**						**	**							•		*							••		

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

UNDERHOULL Profiles A - C

Context	Thin Section	c/f ratio	COARSE MINERAL: Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	COARSE ORGANIC: Parenchymatic	Lignified	Fungal spores	Pollen
1001	A1	1:3	••	∘	∘	∘∘			∘				∘∘∘		•	∘∘	∘∘	
1002	A1	1:1	•	∘	•	•••			∘				∘∘∘		∘∘	•	∘	
1003	A2	2:1	•	∘	∘∘∘	••			∘	∘∘		∘∘	∘∘∘	∘	∘	∘∘∘	∘	
1004	A2	2:1	•	∘	∘∘	•••			∘∘		∘∘		∘∘	∘∘	∘	•	∘	
2003	B1	3:2	•	•	∘∘	•••	∘∘		∘			••	∘∘	∘	∘∘	•	∘∘	∘
2004	B1	3:1	•	•	∘∘	•	∘		∘∘		∘				∘	•	∘	
2005	B2	2:1	•	∘∘∘	∘∘	•	∘			∘		∘∘	•		∘	•	∘	
2006	B2	2:1	•	∘∘∘	∘	•	∘					•	∘∘∘		∘∘	∘∘∘		
3002	C1	1:3	∘∘∘	∘∘		•	∘		∘			∘∘∘	∘∘	∘∘	∘	•	∘	
3003	C1	1:2	∘∘∘	∘∘	•	∘∘∘	∘		∘			••	∘∘	∘∘∘	∘	∘∘∘	∘∘	
3003B	C1	2:1	•	∘∘	∘∘	•	∘	∘	∘	∘∘					∘	•	∘	
3004	C1	1:1	•	∘∘	•	∘∘∘		∘		∘			∘		∘	∘∘∘	∘	
3005	C2	1:1	•	∘∘	∘∘∘	•	∘			∘∘		∘∘	∘					
3007A	C2	10:1		∘∘		∘∘		∘								••••	∘	
3007B	C2	10:1		∘		∘∘		∘		∘∘						•••	∘	
3008	C2	3:1		•		∘∘		∘		∘		•	∘∘					

Context	FINE ORGANIC: Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	CULTURAL MATERIAL: Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	PEDOFEATURES: Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
1001	∘∘		∘∘∘	∘∘					•		∘∘			∘∘						
1002	∘∘∘		∘						••		∘∘∘	∘								
1003	∘∘∘		∘∘∘	∘					••		∘∘∘	∘∘		••••		∘∘				
1004	∘∘		∘∘∘	∘			∘		•••		•	∘								
2003	•		∘∘∘	∘		∘	∘∘	∘	•••			∘∘		•••		∘∘		∘∘∘		
2004	•	∘∘	∘∘	∘					••					•••		∘∘		•	•	
2005	∘∘	•		∘		∘			••		∘∘					∘	∘∘	∘∘∘		∘∘∘
2006	∘∘∘	∘∘∘				∘			•		∘∘						∘∘	∘		∘∘∘
3002	∘∘∘		∘∘	∘∘			•		∘∘					∘∘				•		
3003	∘∘∘		∘	∘			∘		∘∘		∘∘			∘				•		
3003B	∘∘∘		•	∘					••		∘			∘∘				•		
3004	∘∘	•							••				••					•••		
3005	∘	∘	•			∘			•••		•			•••				•		
3007A	∘	∘	••••						••••		∘							•		
3007B	∘		••••						••••											
3008	∘∘	∘∘							•		∘							••		

Frequency ∘ Very rare (<0.5%) ∘∘ Rare (0.5 - 2%) ∘∘∘ Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

UNDERHOULL
Profiles D - G

Context	Thin Section	c/f ratio	Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms	Parenchymatic	Lignified	Fungal spores	Pollen
			COARSE MINERAL												COARSE ORGANIC			
4001	D1	2:3	•	•	**	••	*		*			***	*	**	**	•	**	
4002	D1	1:3	**	***		**			*		*	*	•	•	***	***	**	•
4003	D1	1:19 - 1:5	**	•	*	*	*				*	***	***	**	**	•	***	
4004	D2	1:1	**	**		***			**		**		•	**	*	***	**	
4005	D2	1:1	***	***	*				**		*		***	*	*	••••	*	*
4006	D2	3:2	**	***	*	**			**				•	**	*	•	*	
5001	E1	1:1 - 1:2	***	•	*	•	**		**		**		**		**	•	**	
5002	E2	1:2	***	•	**	•	**		**		**		**	**		•	*	
5004A	E3	1:1	•	*	*	•••			*	*	**		•	**	*	•	***	
5003A	E3	1:3	*	*	*			*		*				•••		•	**	
5004B	E3	2:1	•	*	**	••			*	*	*		**	*			**	
5003B	E3	2:3	***	***	*	••			**	*	*					•	**	
7001	G	1:3	***	*	*	••			*				***	*	***	•	**	*
7001B	G	1:3	*	*	*	••			*				*		*	***	*	**
7002	G	1:1	*	**	**	••••	***		*				•	*	***	•	***	***

Context	Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
	FINE ORGANIC				CULTURAL MATERIAL				PEDOFEATURES											
4001	***		*						••		*							*		
4002	*		*	*					••									***		
4003	***		***	*					**		**							•		
4004	**		*	*			**		•									••		
4005	•••		***	**		*	**		•									***		
4006	•		•	*			*		•									***		
5001	•	*	**	*			***		***		*			•				•		
5002	***	**	•			*		**			**			**				***		
5004A	•	*	***	*				*	***		**									
5003A	***	**	**						••											
5004B	***		**						**	*	*						***			
5003B	***		***						•		**				*	*	**			
7001	***	**	*	**					•		***									
7001B	***	*	*	*					**		*									
7002	***	***	•	**					•		***						•			

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)

UNDERHOULL
Profiles H - J

Context	Thin Section	c/f ratio	COARSE MINERAL: Serpentenite	Quartz	Olivine	Feldspar	Biotite	Muscovite	Garnet	Mica	Calcite	Compound	Phytoliths	Diatoms
8001	H	1:2	**		*	•		*		*	*		•	*
8002A	H	1:1	***		*	••	***	**		*	**	**	•	
8002	H	1:3 - 1:2	•		**	••	***	•	***		**		***	
9001	I1	1:1	***	**	•	••		**	*	*	**		***	
9002	I2	1:1	***	**	•	••		**	*	**	***		•	
9002B	I2	2:1	•						*		***		*	*
9501	J	1:4			*	•			*	*			•	***
9502	J	1:3 - 1:9				***		*	**	**			**	***

Context	COARSE ORGANIC: Parenchymatic	Lignified	Fungal spores	Pollen	FINE ORGANIC: Amorphous Black	Amorphous Brown	Amorphous Red-Brown	Cell Residue	CULTURAL MATERIAL: Fish Bone	Mammal/Bird Bone	Charcoals	Ceramics	PEDOFEATURES: Fe Accretion	Fe Depletion	Fe Nodules	Bleached Stone Rim	Iron Rim	Textural Coatings (organic clay)	Textural Coatings (clay)	Organic Coatings	Ca-Fe-P Infills	Excremental	Fe Coatings	Clay Accumulation
8001	***	•	***	**	**	***	**	**			*		**	**	***		•	**				**		
8002A	**	•	***	*	***	***	**	*		*					•		•	•••				**		
8002	***		***	**	***	***	**	**		**		*	•		•		•	•		*		••		
9001	***	•	**	*	•	***	**	**					•		**			***	*	*		••		
9002	***	•	**		•	***	***	**					**		***		**	••	***			•••		
9002B	***	•									**		***		***									
9501			***		***	**		*					•		*									
9502			*	*	**	**		•							**							***		

Frequency * Very rare (<0.5%) ** Rare (0.5 - 2%) *** Very few (2 - 5%)
• Few (5 - 15%) •• Frequent (15 - 25%) ••• Common (30 - 50%) •••• Dominant (over 50%)