Recognizing spatial and temporal relationships
between Neolithic earthen monuments, Earth, and sky
at Cranborne Chase, Southern Britain

SUBMITTED TO THE FACULTY OF THE
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BY

Paul D. Burley, PhD Candidate

Dr. Howard D. Mooers , Advisor
College of Science and Engineering
Department of Earth and Environmental Sciences
University of Minnesota

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Together we face the wind, heads up, and move forward.

DEDICATION

This study is dedicated to

Nancy Burley

who has encouraged me to do my best
throughout my career, academic endeavors, and all that life offers.

ABSTRACT

Cranborne Chase in southern England is a well-known area of Neolithic archaeology where a nexus of population growth, cultural evolution and resource extraction during the 4th millennium led to development of one of the highest densities of earthen monuments, including numerous long barrows, the largest and longest cursus in Britain, and many other structures. Some long mounds function as tumuli. However, reasons for siting monuments at certain locations within the complex chalkland landscape, the purpose of specific architectural forms and features of the earthen structures, and geographic relationships between the pattern of monuments and elements of the surrounding environment as a whole remain largely enigmatic. This multi-disciplinary geoarchaeological research project reviews local and regional geologic and paleoenvironmental characteristics of Cranborne Chase and the adjoining South Hampshire Lowlands, with specific interest in the physiographic setting of earthen long barrows and the Dorset Cursus. Locations, forms and architectural features of Early- to Middle-Neolithic earthen monuments are analyzed with regard to local and regional geologic, geomorphic, pedologic, topographic, paleoenvironmental, and astronomical conditions for the period of monument construction c. 3800 to 3200 BC. Data is developed from physical characteristics of the natural landscape, the skyscape, all known long barrows located in the study area, and the Dorset Cursus. Cultural development in southern Britain c. the 4th millennium is reviewed in tandem with descriptions of natural physiographic and paleoenvironmental conditions that are unique to Cranborne Chase and the lowland. Historical and ethnographical information provides analogies with respect to prehistoric cultural astronomy. Spatial and temporal relationships are identified between elements of the landscape, skyscape, and monuments. Based on results of our analysis, this study argues that:

- the pattern of monument sites on Cranborne Chase is related to a limited range of preferred subsurface conditions allowing ready access to chalk as a construction material and helping ensure a long-term lifespan for each monument;

- the set of long barrow sites near hilltops and ridge lines, oriented subparallel with local topographic contours toward the southeast, reflects the orientation of valleys and stream flow directions encountered across the Chase;

- long mound sites typically included an open viewshed featuring peripheral areas of the surrounding environment, most often including a level horizon in the up-barrow direction, toward the southeast and the English Channel;

- southeast-oriented long mounds are aligned with spatial and temporal relationships including local topographic contours, regional geomorphic and hydrologic features, and astronomical events highlighted by orientation toward the Belt stars of Orion perceived above the Channel between the Isle of Wight and the Purbeck Hills;

- an 'as above, so below' association between long barrows constructed on hilltops and interfluves and southeast-oriented stream valleys of the natural landscape could indicate a conceptual reciprocal relationship emphasizing orientation of the living and the dead toward the English Channel and skyscape above;

- the size, orientation, alignment and location of the Dorset Cursus is sympathetic to physiographic and topographic features of the landscape and temporal stellar events associated with Sirius, Belt stars of Orion, Aldebaran and the Pleiades when observed from upper elevations of the chalk plateau centered at Winklebury Hill, the Ox Drove alignment and environs possibly serving as a viewing platform;

- observed from the study area, the Pleiades (represented by Alcyone) crossed the south meridian at the same time Sirius appeared on the eastern horizon at 0.0° altitude c. 3365 BC. That time frame corresponds with the date of construction of the Dorset Cursus determined by radiocarbon analysis by others, indicating observation of those simultaneous astronomical events from Winklebury Hill – with the Belt Stars of Orion situated above the English Channel – may have been the purpose behind design, construction and use of the monument;

- the conjunction of risings of Sirius and the Sun (and Moon) during winter solstice c. 3365 BC might also be associated with positioning of the north end of Gussage Cursus as seen from Winklebury Hill; and

- the size, orientation and location of the Dorset Cursus are physically and symbolically related to long barrows exhibiting similar orientations of mound axes toward the southeast.

Results of this study demonstrate that spatial and temporal relationships between the earthen structures and elements of the surrounding landscape, seascape, and skyscape are key to recognizing and understanding the symbolism and signification expressed by the monumental architecture. The cultural landscape – including the pattern of both natural features and earthen monuments at Cranborne Chase, the South Hampshire Lowlands, and surrounding region – expresses spatial and temporal unification by alignment between Earth and sky, and the living and the dead. In that way, the cultural landscape is related to a Neolithic cosmology emphasizing certain elements of the observable landscape and skyscape, and belief in an astral afterlife.

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Chapter 1. Introduction

1.0 The Setting

Cranborne Chase (the Chase), located in southern England, is a well-known core area of Mesolithic and Neolithic cultural adaptation to the physical landscape (Barrett *et al*. 1991a; Barrett *et al*. 1991b; Green 2000; Field 2006, 2008; French *et al*. 2007). The study area extends across downland of the Chase and the South Hampshire Lowlands (SHL), from the Chalke Escarpment to the northwest to the English Channel to the southeast (Figure 1.1). The association of Early- to Middle-Neolithic long barrows, the Dorset Cursus, and additional earthen structures forms an integrated monument complex across the landscape. Traditions related to construction of each of those monumental earthen topologies ended by the 32nd century BC, bringing to an end 600 years of Neolithic traditions represented by the earliest, largest and most massive monuments emplaced upon the landscape (Tilley 1994; Barrett et al. 1991a; Bradley 1986; French 2007: 186; Mercer and Healy 2008).

There is a significant body of evidence for human activity across the Chase during the Mesolithic c. 10,000 to 4,000 BC (Green 2000:20-28; French *et al*. 2007:219-20). Archaeological evidence of Mesolithic activity in the study area is concentrated at several locations north of the crest of the Chalke Escarpment, numerous locations at lower elevations of open chalk downland, along tributaries of the Rivers Avon and Stour including the River Allen, and along the top of Pentridge Hill in the central portion of the Chase (Arnold *et al*. 1988; Green, 2000; Land Use Consultants 2003; French *et al*. 2007). Although palaeoecological records are few because of the lack of preservation of organics in the chalkland's karst environment, Mesolithic activity is believed to have substantially altered forest cover, creating regions of open country on downlands attractive to Neolithic agrarian and pastoral occupations (Collard *et al*. 2010; Woodbridge *et al.* 2014).

Far more intensive development and use of the landscape are evident during the Neolithic (Drew and Piggott 1936; Barrett *et al*. 1991a, 1991b; French *et al*. 2007; Mercer and Healy 2008; Green 2000). Earliest dates for Neolithic occupation of the upper Allen

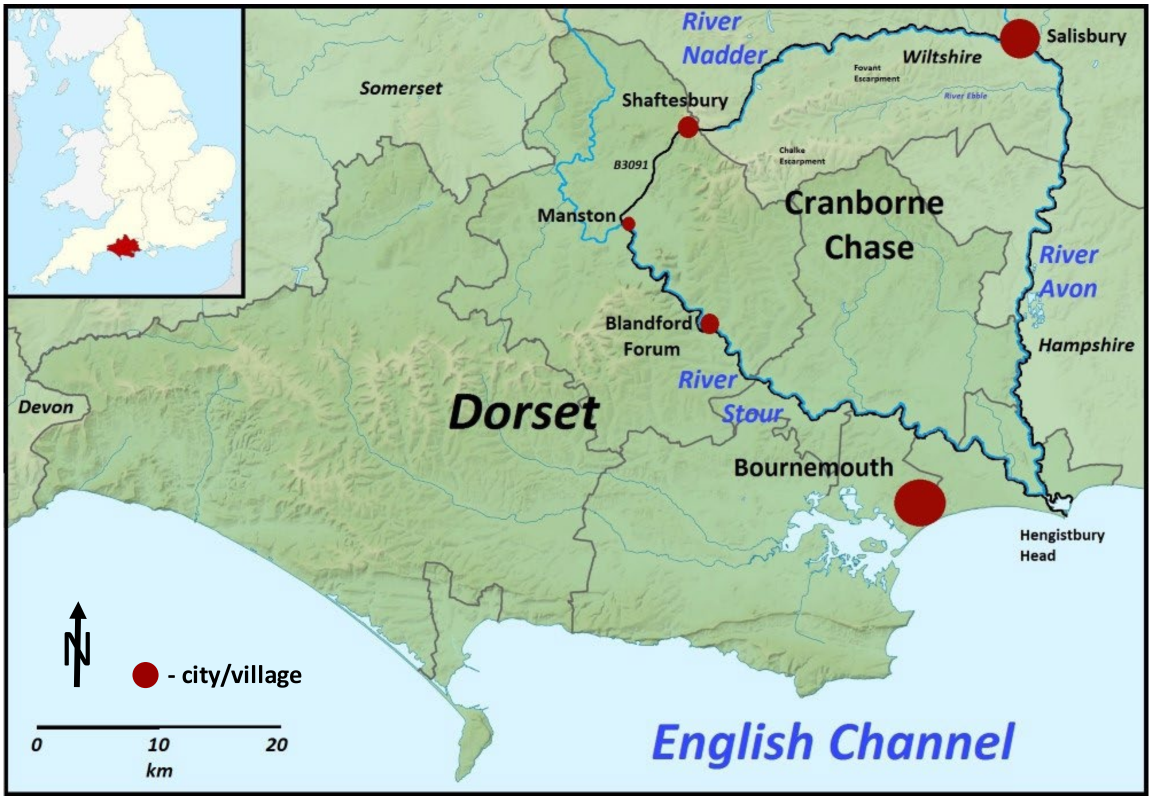


Figure 1.1: Location of the study area in portions of counties Dorset, Wiltshire and Hampshire. The study area, including Neolithic long barrows, the Dorset Cursus and Hambledon Hill causewayed enclosure are situated within an area bounded by the rivers Nadder, Avon and Stour, and south of the B3091 roadway between Shaftesbury and Manston. Inset: location of the study area in southern Britain. Base topographic relief map by Nilfanion, created using Ordnance Survey data.

valley in the central area of the Chase, are from one of the few preserved paleoenvironmental records at Fir Tree Field shaft at Down Farm, corresponding to a location that was culturally significant during the Mesolithic-Neolithic transition c. 4300-4000 BC (French *et al*. 2007; Green 2000).

The Chase has one of the highest densities of Neolithic earthen long barrows in southern England and, indeed, all of Britain (Ashbee 1970). Forty-two long mounds, including 41 long barrows confirmed during previous archaeological investigations (Ashbee 1970; Kinnes 1992; Damerham Archaeology Project 2011), and one potential long mound investigated during archaeological excavation by the University of Southampton during 2016 are located in the study area. Locations of the 42 known earthen long barrows in the subject area (38 long mounds on the downs of the Chase, two barrows on Hambledon Hill, and 2 mounds on Paleogene formations in the South Hampshire Lowlands) and the

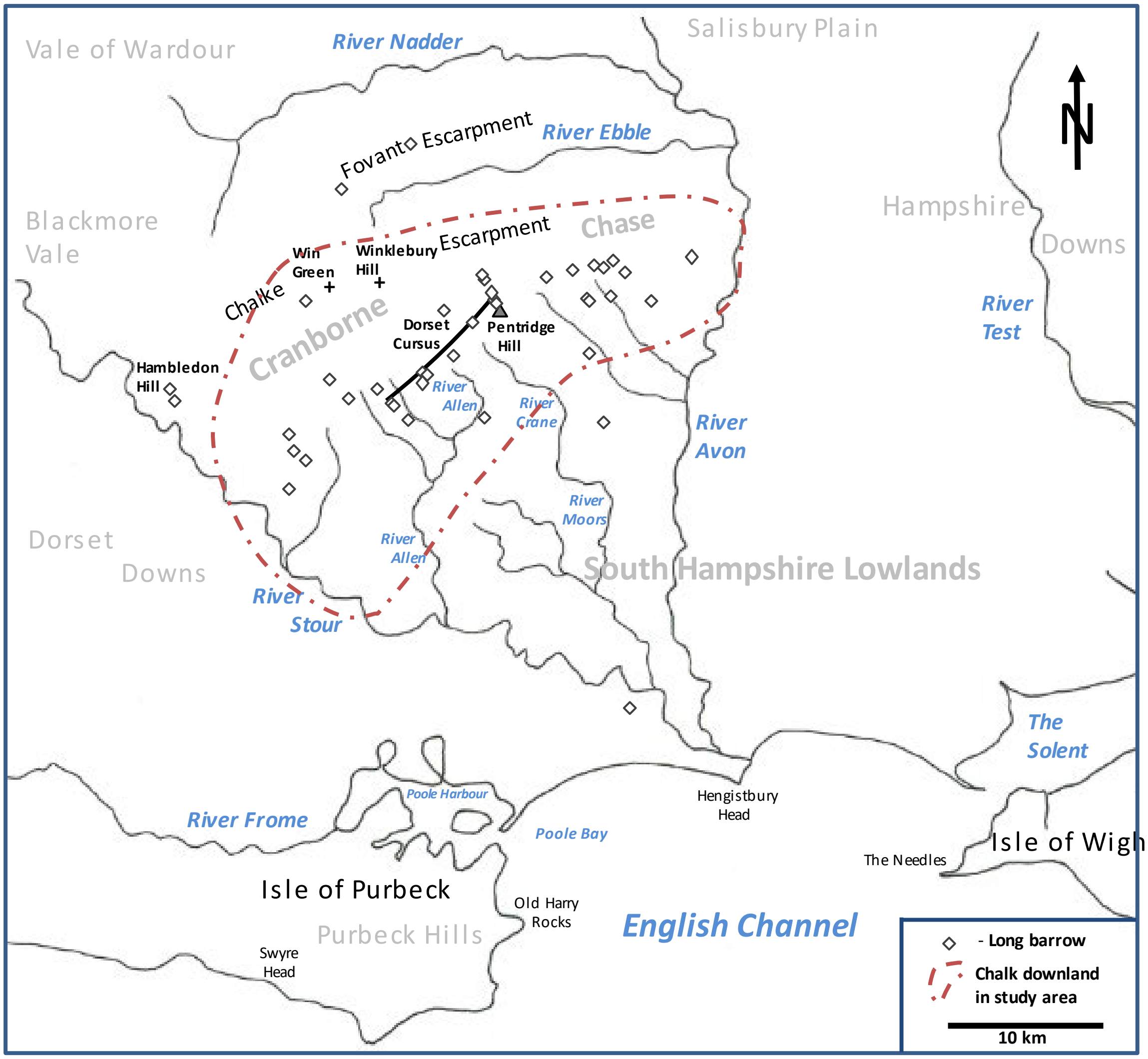


Figure 1.2: Map showing location of long barrows and the Dorset Cursus situated between the valleys of the Avon and Stour rivers, and geographic features of the study area and surrounding region. The Chalk downland of the Chase occupies a kidney-shaped landscape southeast of the Chalke Escarpment.

Dorset Cursus are shown in Figure 1.2. The core area of Neolithic earthen long barrow construction is located on the chalk downs. Most long mounds in the study area remain unexcavated by modern archaeological methods. Few long barrows on the Chase have been dated, although construction of long barrows and similar structures in southern Britain likely did not occur prior to the second half of the thirty-eighth century BC, and the tradition ended by 3300 BC (Whittle *et al*., 2007; Allen *et al*., 2016).

The Early-to Mid-Neolithic landscape of the Chase was a product of human behaviors and the natural paleoenvironment. Carl Sauer (1925) defines cultural landscapes as effects of culture enacted upon the natural environment. The natural environment is the medium. Culture is the agent. Further, Denham (2017) suggests that the term ‘landscape’ “encapsulates the environmental and human aspects of a bounded area of land. The environmental aspects include the combined effects of climate, hydrology, landforms, vegetation, and fauna. . . In addition to the physical aspects of past landscapes – in terms of both environmental and human processes – a landscape is explicitly or implicitly associated with layers of human meaning and value.” Darvill *et al.* (1993) proposes that relict cultural landscapes be defined on the basis of the pattern of archaeological remains, noting that relationships between sites, the environment, and cultural use of space are relevant to understanding history.

Landscapes with their many and varied shapes, elements, and patterns of elements, have a degree of uniformity of structure in which the details of each element and place are part of, but not necessarily essential to perception and comprehension of the landscape at micro-, meso-, or macro-scales (Ode *et al*. 2010). For example, Gebauer (2015) describes a model of Neolithic tombs in landscape in which distance is created between the living and the dead by placement of tombs at the margins of everyday, and in some instances overlooking the inhabited landscape. Barrie (2010) acknowledges that “intangible, ephemeral, and immaterial aspects of sacred architecture” need to be understood to unveil the full extent of its meaning. However, recognizing the means of designing and constructing long barrows, cursuses and other earthen monumental Neolithic architecture – focusing on the process of design and construction, materials of construction and their properties of import to the purpose of the construction, and ontological relationships between humans and their environment – can help us understand the purpose behind social and cultural organization of temporal and spatial aspects of experiencing the Neolithic environment, or “the organization of the cosmos and society” (Fowler 2021; Richards 1996).

Fleming (1999) suggests “landscape is a cultural code . . . a means of conceptual ordering that stresses relations.” In other words, the architecture (and therefore the symbolism) of monuments is in some ways the product of sensorial relationships people have with physical and/or biological characteristics of the surrounding environment and the conception of meaning derived from those relationships. It is the interplay of elements in a landscape that define its relevance to culture. Therefore, relict components of prehistoric cultural landscapes are studied in terms of relationships between the cultural elements (barren of text) and facets of the surrounding environment. Those relationships are both temporal and spatial.

1.1 The Problem

Unravelling the purpose, design, cultural significance and meaning of the large Early- to Mid-Neolithic cultural landscape of the study area, including the long barrows and cursus, is complicated. Was the resulting landscape simply a random collection of monumental elements constructed over several hundred years, or was there *intent* in the design and layout of those cultural features? While natural physiography had a significant role in development of ritual landscapes, site-specific reasons for constructing large – in some cases apparently over-sized – earthen monuments during the Neolithic remain in question. Archaeological evidence is often fragmentary, incomplete, and mute, making it difficult to arrive at a definitive conclusion regarding social interpretations and, therefore, there is often the need to broaden the scope of analysis using historical, ethnographical and anthropological data as means to provide analogies to prehistoric context (Mackie 2002).

The purpose and meaning of prehistoric architectural achievements, while not accompanied by texts, were often associated with links not only to culture and the natural landscape, but the celestial sphere, as well (Magli 2009). Celestial cycles have been shown to be a key interest of builders of Neolithic stone and earthen monuments, with those materials expressing through architectural signs and symbols the importance of astronomy in the function of the structures. Suggested alignments between Neolithic cultural elements of the Chase, natural features of the landscape, and events related to the skyscape above, have generally lacked quantitative analysis. This problem is compounded by the lagging question of purpose for constructing not only individual earthen monuments, but an entire prehistoric cultural landscape that required expending tremendous amounts of time and energy for burial or entombment of the dead, of which only a limited portion of the population appear to be represented.

1.2 Purpose of this Research

Extant archaeological and physiographic conditions associated with relict monumental architecture at the Chase and SHL provide an ideal opportunity to study relationships between natural and cultural elements of the Early- to Middle-Neolithic landscape. The pattern of archaeological residues in the form of the known set of long barrows and the Dorset Cursus provide evidence related to the former state of the landscape, physical and social processes that contributed to the cultural pattern, and its use. In addition, given the discrepancy between qualitative orientations of earthen long barrows at the study area compared to orientations of long mounds in general across Britain, it may be possible to identify aspects of the Chase environment that might have contributed to the predominant NW- SE long mound orientation exhibited at the study area, as well as the siting, size and SW-NE orientation of the Dorset Cursus.

This multi-disciplinary geoarchaeological study identifies and quantifies spatial and temporal relationships between Neolithic earthen monuments and the surrounding chalkland environment at Cranborne Chase (the Chase) and adjoining South Hampshire Lowlands (SHL) in southern England. The timeframe of monument construction related to this study is restricted to the British Early- to Middle Neolithic, c. 3800 to 3200 BC. This was the period during construction of long barrows, the Dorset Cursus and hilltop causewayed enclosures that, aside of numerous round barrows situated across the Chase, represent the earliest, largest and most massive monuments emplaced upon the landscape.

The purpose of the study is to develop an understanding of the relationships among siting and construction of the massive earthen long barrows and the Dorset Cursus within the context of the geomorphology, hydrology, viewshed, and skyscape of the Chase and SHL. Given the unresolved relationships between earthen Early- to Middle-Neolithic monumental architecture (i.e. long barrows and the Dorset Cursus) and surrounding environment of the Chase, the aim of this study is to address the following questions.

- What are the spatial relationships between the monumental architecture and bedrock stratigraphy, geomorphology, pedology, karst elements, periglacial features, topography, and paleoenvironmental conditions (climate and vegetation) of the study area?

- Identify and quantify orientations (azimuths) of elements of the cultural landscape and skyscape, and evaluate them for statistically significant, common orientations.

- What natural features of the Chase and SHL differentiate the study area from elements encountered at other British landscapes, and how did those differences develop?

- What influence did astronomical events (e.g., solar, lunar, stellar) have on the siting and architecture of those monuments?

- Does the spatial pattern and orientation of monuments reflect a process of purposeful long-term development of the landscape? If so, are the patterns of monument siting and architectural elements related to ritual functions of the landscape?

Specific aspects of the natural environment considered in this analysis include:

- physical and chemical characteristics of bedrock (lithology, structure, stratigraphy);

- physical and chemical characteristics of unconsolidated sediments and soil (type, location);

- geomorphic processes in the development of local and regional geomorphological, topographical and hydrological conditions, leading to access to earthen resources for monument construction, an extensive viewshed, and other features of the cultural landscape;

- surface hydrology with particular interest in runoff, springs and streams;

- paleoenvironmental conditions during the Holocene, with emphasis on native vegetation and modification resulting from Mesolithic and Neolithic land use activities; and,

- observable astronomical events within the context of physiographic characteristics of the Chase and SHL during the Neolithic period.

If a necessary and sufficient number, type and location of cultural elements of the landscape were constructed on the Chase and recognized within the defined geologic, paleoenvironmental and geographical setting, it may be possible to decipher the architectural symbolism built into the landscape by the designers/builders, residual as it may be. Given that a number of earthen monuments in that landscape involved conceiving and then constructing earthen tumuli, and accepting that those structures and the landscape as a whole had social or cultural meaning, the resulting landscape may be seen as integral with the pattern of Neolithic life and death within the study area. Further, improving our understanding of the relationship between long barrows and the natural environment of the Chase has the potential to help focus the scope of analysis of long barrow-landscape relationships at other environments. For example, identifying and quantifying relationships between long barrow orientations and geomorphological features at the Chase might point the way forward for 1) analyzing other landscapes for similar relationships, and 2) using those relationships as a tool to predict locations and orientations of long barrows at other landscapes.

Chapter 2. The Study Area

2.0 Location of the Study Area

The study area is defined by the pattern of earthen long barrows delimited by a set of geomorphological and hydrological features of northeast County Dorset and surrounding portions of County Wiltshire and County Hampshire (Figure 1.1). Specifically, the study area is bound on the north by the ridgeline of the southwest-northeast trending Chalke Escarpment between Melbury and Knowle Hill at Mead End, and the similar trending ridgeline of the Fovant escarpment between White Sheet Hill east of Donhead St. Andrew and Hare Warren south of Wilton, then along the valley of the River Nadder to Salisbury. To the east, the study area is bound by the valley of the River Avon between the river's confluence with the River Nadder at Salisbury and the mouth of the Avon discharging to the Solent Basin on the north side of the English Channel at Hengistbury Head. The study area is bound to the west and southwest by the valley of the River Stour from its confluence with the River Avon northwest of Hengistbury Head to its upper reach at Melbury.

2.1 Geological Setting

The geology of central southern Britain has been a focus of study for many decades, and the structure and stratigraphy of the region are well-defined (Arkell 1933; Chatwin 1960; Mottram 1961; Lake & Karner 1987; Bristow *et al*. 1997; Mortimore & Pomerol 1997; Wray & Gale 2006). The study area is situated in the west-central portion of Hampshire Basin, a sub-basin of the Wessex Basin, and consists of two distinct landscapes including downlands of the Chase in the northwest and the lowlying coastal plain of the SHL in the southeast. Most of Cranborne Chase is located in the South Wessex Downs Natural Area (Natural England, 1997). Bedrock immediately underlying surficial soils and Quaternary sediments at the Chase consists of the Upper Cretaceous White Chalk Subgroup (the Chalk) (Figure 2.1). The downs are dominated by karst features of the chalklands. Here, the landscape is characterized by chalk plateaus, escarpments, dip slopes, combe valleys (dry hollows), and tributary valleys occupied by winterbournes (intermittent streams) or perennial streams. The crest of the WSW-ENE trending Chalke Escarpment rises to 277 m above mean sea level (Ordnance Datum Newlyn) at Win Green (British National Grid

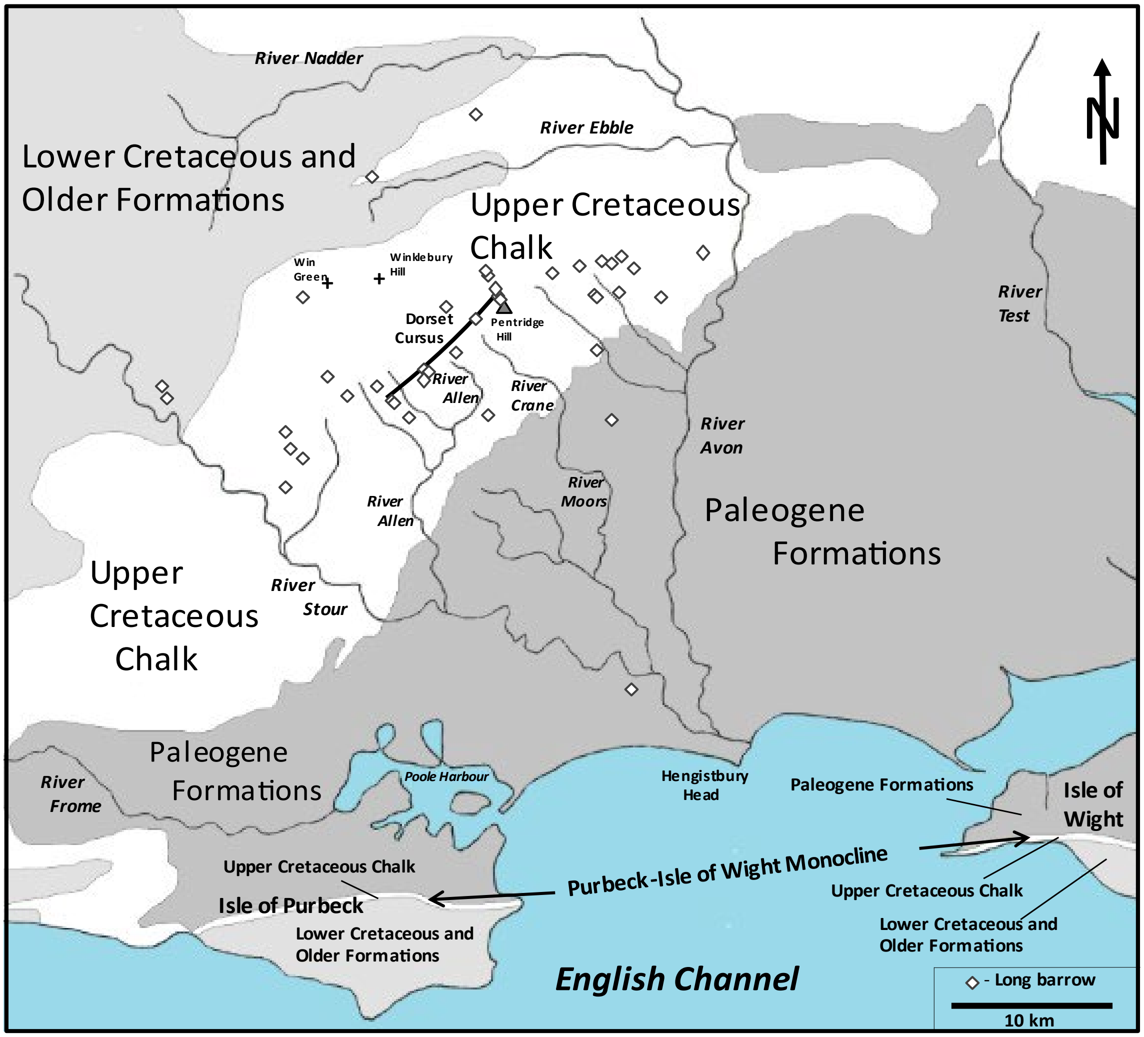


Figure 2.1: Map showing locations of long barrows, Dorset Cursus, general areal extent of sedimentary rocks (including Paleogene and Upper Cretaceous formations in the study area) in the region, and geographic features in and around the study area.

Reference ST 925 206), falling to the southwest and northeast. High points along the ridgeline to the northeast include 260 m at Winklebury Hill (ST 952 213), 243 m at Trow Down (ST 972 217), and 230 m at South Down (ST 988 215). Eighteen hundred meters southwest of Win Green, the crestline falls to an elevation of 252 m on Ashmore Down (ST 913 194). The north limb of the Hampshire syncline formed by the White Chalk dips beneath the study area at about 4 degrees toward the southeast.

Heads of combes are located on the east side of the Chalke Escarpment ridgeline. The combes incise the Seaford and Lewes chalk formations and extend southeastward to broad dry valleys. Springs occur where the water table in the Chalk intersects the dry valleys. The springline is variably encountered at elevations of 70 to 100 m, at which streams begin their southeasterly flow toward the Channel. The area is drained by perennial streams forming a trellis drainage network common to much of the British chalklands (Jung *et al*. 2015), with numerous perennial and intermittent tributaries (Figure 4.2, and Figure 4.9). Those waterbodies southwest of Pentridge Hill include the River Tarrant, Crichel Brook, Gussage Stream, River Allen, and River Cranborne flowing southeasterly down the chalk dip slope of Hampshire Basin before encountering the broken topography of the SHL, where the streams are directed south or southwestward before joining the River Stour. Southeasterly-flowing streams northeast of Pentridge Hill include Ashford Water (River Allen) and Sweatsford Water, both flowing into the River Avon at Fordingbridge.

The SE dip slope and trellis drainage pattern divide the Chase into roughly evenly spaced NW-SE oriented low ridges and interfluves upon which most of the long barrows are situated. Pleistocene sands and gravels overlie extensive upland areas of the chalk-cored interfluves and plateaus such as Penbury Knoll on Pentridge Hill. Bedded sands and gravels are also encountered in terraces and modern river channels, and extend into the English Channel (Allen and Gibbard, 1993). The Chalk is overlain by Tertiary (Paleocene) fluviatile and brackish-marine sands and clays in the South Hampshire Lowlands southeast of the downs. The sedimentary formations are eroded by rivers to produce an undulating topography of shallow wooded valleys, low hills and plateaus between the downs and the English Channel.

Interfluves encountered on the Chase are generally oriented NW-SE and separate stream valleys northwest of the SHL. Ridge crests of interfluves rise to as much as 60 m above nearby streams. However, lower elevations of interfluve ridge crests between Pentridge Hill (elev. 185 m) to the northeast and Ashmore Down to the southwest (Ashmore el. 224 m) provide an unobstructed southeasterly sightline across the South Hampshire Lowlands to the English Channel (Figure 2.2). On clear days, the southeasterly view includes the Isle of Wight, the English Channel and the Isle of Purbeck, up to 60 km southeast of the cuesta. The Channel waters are apparent between landward portions of the Isle of Wight – Purbeck Monocline.

Figure 2.2: View toward the southeast from the Chalke Escarpment. The telephoto view was taken along the upland east of the crest of Winklebury Hill. The South Hampshire Lowlands are apparent in the background, beyond the line of trees. Sunlight reflecting off the water of the English Channel between the Isle of Wight and Isle of Purbeck is apparent along the horizon. Photo © P. Burley.

2.2 Geoarchaeological Setting

2.2.1 Long Barrows

Table 2.1 lists the 42 long barrow sites included for this study. Many of the long barrows retain an extant but degraded chalk mound with adjoining subparallel quarry side ditches or are of the ‘Cranborne Chase’ type barrow with an ovate mound and a peripheral ditch extending around one or both ends of the mound (Ashbee 1970; Barrett *et al.* 1991a; Allen *et al*. 2016) (Figure 2.3 and Figure 2.4). Many long barrows are believed to be remnant burial structures containing articulated or disarticulated human bones. However, the contents of most long mounds at the Chase, including the potential for encountering human remains or artifacts related to interment, generally remains undocumented or unknown.

Table 2.1 Name, Monument Number and Remarks for Long Barrows at Cranborne Chase and the SHL

Ashbee (1970)	**Tilley (1994)**	**This Study**	**Historic England Monument Number**	**Remarks**
Chettle 1	Chettle House (Bar)	Chettle 1 (Thickthorn Bar)	210199	Extant mound
Chettle 2	Chettle Wood	Chettle 2	210068	Extant mound
Child Okeford 1	Hambledon Hill, North	Hambledon Hill North	206237	Extant mound
Child Okeford 2	Hambledon Hill, South	Hambledon Hill South	206260	Extant mound
Gillingham 1*	- - - - - - - - -	- - - - - - - - -	202314	Outside of study area
Gussage St Michael 1 (Thickthorn Down)	Thickthorn Down, North	Gussage St Michael 1, North	210031	Extant mound
Gussage St Michael 2 (Thickthorn Down)	Thickthorn Down, South	Gussage St Michael 2, South	210037	Extant mound
Gussage St Michael 3 (Gussage Down)	Gussage Cow Down, North	Gussage Down 3, North	210013	Extant mound
Gussage St Michael 4 (Gussage Down)	Gussage Cow Down, South	Gussage Down 4, Center	210019	Extant mound
Gussage St Michael 5 (Gussage Down)	Gussage South-East	Gussage Down 5, South	210023	Slight extant mound
Gussage St Michael 6 (Gussage Down)	Gussage, Parsonage Hill	Gussage Down 6*	210041	No extant mound
Handley 1 ((Wor Barrow)	Wor Barrow	Handley 1 (Wor Barrow)	213497	Extant mound
Pentridge 1	Martin Down, South	Pentridge 1 (Bokerley 1)	213535	Extant mound
Pentridge 2a	Martin Down, Central	Pentridge 2 (Bokerley 2a)	213531	Extant mound
Pentridge 2b	Martin Down, Central	Pentridge 2b (Bokerley 2b)	213531	Extant mound
Pentridge 3	Martin Down, North	Pentridge 3 (Bokerley 3)	213530	Extant mound
- - - - - - - - -	Martin, Long Barrow Lane	Martin 1 (Long Barrow Lane)	214154	Extant mound
Pentridge 4 (Cursus)	Salisbury Plantation	Pentridge 4 (Cursus)	213548	Extant mound
Pimperne 1	Pimperne	Pimperne 1	210178	Extant mound
Tarrant Hinton 1	Thickthorn Farm	Tarrant Hinton 1, Thickthorn Farm	210069	Extant mound
Tarrant Hinton 2	Telegraph Clump	Tarrant Hinton 2, Telegraph Clump	209324	Extant mound

(continued next page)

Table 2.1 Name, Monument Number and Remarks for Long Barrows at Cranborne Chase and the SHL (continued)

Ashbee (1970)	Tilley (1994)	This Study	Historic England Monument Number	Remarks
Tarrant Launceston 1	Race Down	Tarrant Launceston 1, Race Down	209377	Extant mound
Tarrant Rawston 1	Little Down	Tarrant Rawston 1	209347	Extant mound
- - - - - - - - -	Tollard Farnham*	- - - - - - - - -	N/A	No extant mound
Verwood 1 (Pistle Down)	Pistle Down	Verwood 1 (Pistle Down)	651276	Extant mound
- - - - - - - - -	Furze Down	Furze Down 1	214148	Low extant mound
Wimborne St Giles 1	Drive Plantation	Wimborne St Giles 1	213773	Extant mound
Ansty 1 (Whitesheet Hill)	Whitesheet Hill, Ansty	Ansty	210660	Extant mound
Broadchalke 2	Vernditch Chase, North	Broadchalke 2	214286	Extant mound
Coombe Bissett 2	Coombe Bissett	Coombe Bissett 2	214099	Extant mound
- - - - - - - - -	Whitsbury Down	Whitsbury Down 1	N/A	Extant mound
Donhead St Mary 4	Donhead St Mary	Donhead St Mary 4	209842	Extant mound
Downton 2	Giant’s Grave	Downton 2, Giant’s Grave	217890	Extant mound
- - - - - - - - -	Sutton Down	Sutton Down	N/A	Extant mound
Martin 1 (Woodyates)	Vernditch Chase, South	Martin Woodyates 1 (Vernditch SW)	214358	Extant mound
Martin 2 (Knap Barrow)	Toyd Down, Knap Barrow	Martin 2 (Knap Barrow)	213385	Extant mound
Martin 3 (Grans Barrow)	Toyd Down, Grans Barrow	Martin 3 (Grans Barrow)	213390	Extant mound
Rockbourne 1 (Duck’s Nest)	Duck’s Nest	Rockbourne 1 (Duck’s Nest)	218031	Extant mound
Rockbourne 2 (Round Clump)	Round Clump	Round Clump 2	218000	Extant mound
Rockbourne 3 (Giant’s Grave)	Giant’s Grave, Braemore	Giant’s Grave Braemore	218118	Extant mound
Rockbourne 4 (Rockbourne Down)	Rockbourne Down	Rockbourne Down 4	218007	Slight extant mound
Holdenhurst	- - - - - - - - -	Holdenhurst	MDO8435	No extant mound
- - - - - - - - -	- - - - - - - - -	Dampney	1497087	Slight extant mound
- - - - - - - - -	- - - - - - - - -	Knowle Hill Farm	N/A	No extant mound

Notes: N/A - not available
*not included in long barrow orientation analysis for this study

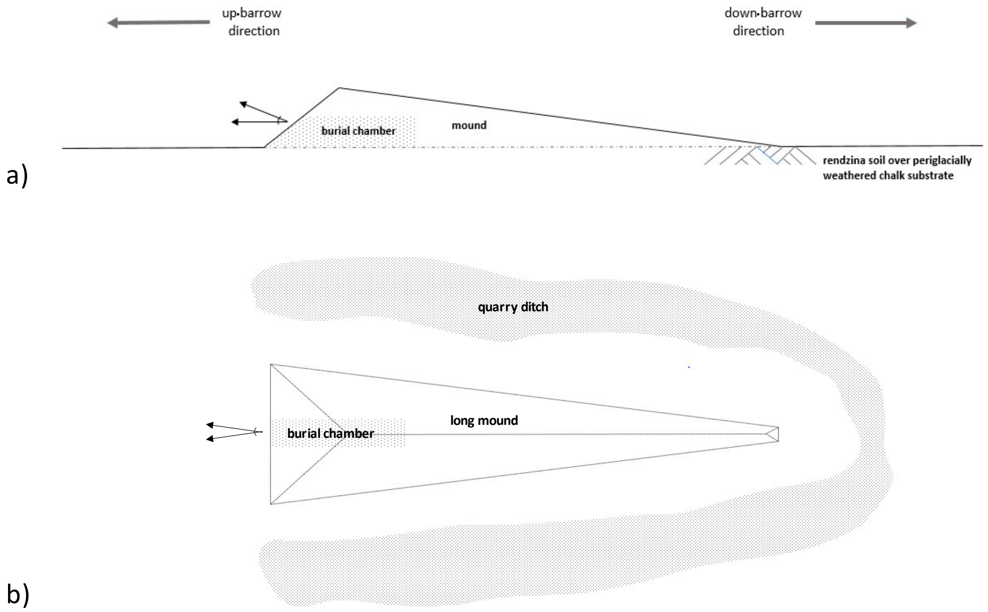


Figure 2.3: Schematic illustration of typical long mound longitudinal profile (a) and ground plan (b). Location of the burial chamber and former ground line are indicated, in addition to up barrow and down barrow directions along the spine of the mound. Internal and external structures and forms vary between mounds. Heighth:length:width ratios are variable between mounds. The 'Cranborne type' quarry ditch (Ashbee 1970; Kinnes 1992) extends subparallel to the length around the down-barrow end of the mound, as depicted. In some instances the quarry ditch extends along the length on both sides of the mound but does not connect along the down barrow end.

a)

b)

Figure 2.4: Long barrow Donhead St Mary 4 (ST 917 196), an example of the extant but degraded condition of chalk-cored long mounds located on Cranborne Chase. a) lateral profile of the grass-covered mound with view toward the southeast; b) up-barrow view along the spine of the mound toward the crest of the Chalke Escarpment at the horizon. Photos by P. Burley.

2.2.2 The Dorset Cursus

Of the more than 150 known Neolithic cursus monuments in England, the longest and largest by far is the Dorset Cursus (Loveday 2006:11). The cursus is nearly 100 m wide and trends SW-NE across almost 10 km of downland from Thickthorn Down in the south-central area of the Chase to Martin Down just north of Pentridge in the north-central portion of the Chase (Barrett *et al*., 1991a; Tilley, 1994; French *et al*., 2007) (Figure 2.1, Figure 2.5, Figure 2.6). Table 2.2 provides a summary of the location and topographic variability of the cursus. Few surface expressions of the cursus' peripheral bank and ditch remain, the most prominent being chalk-filled berms delineating the south terminus of the cursus on Thickthorn Down. An apparent intention to relate the Dorset Cursus to long barrows that are proximal to, or incorporated into, the bank of the structure has been mentioned by a number of archaeologists (e.g. Atkinson 1955; Penny and Wood 1973; Barrett et al. 1991a: 46-47; Bradley 1993; Loveday 2006; Brophy 2016: 138).

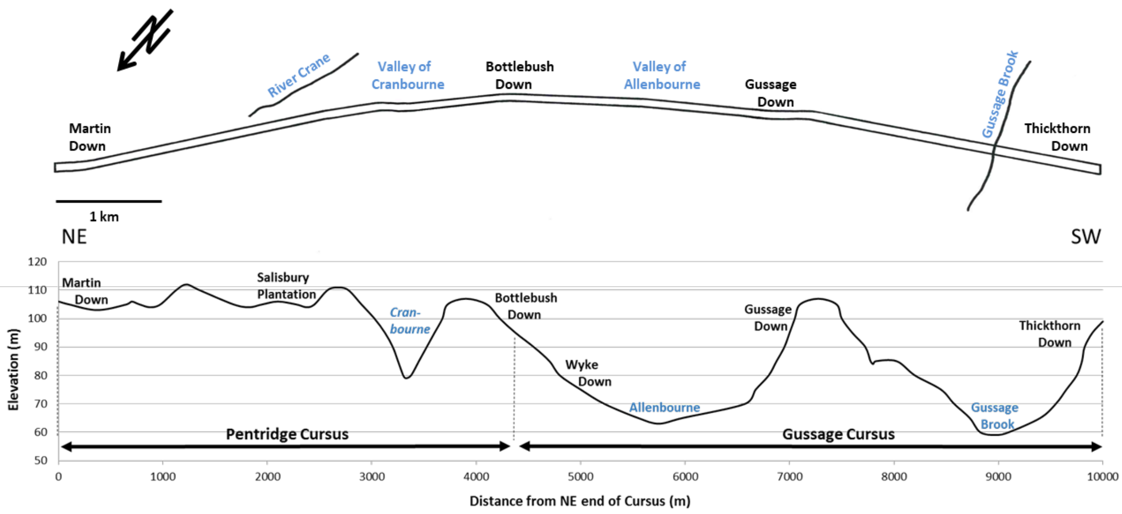


Figure 2.5: Plan view and longitudinal ground surface profile of the Dorset Cursus. a) plan view; b) ground surface profile, vertical exaggeration:10

Figure 2.6: Curvilinear alignment of the Dorset Cursus coursing across the Allen River valley from Gussage Down to Salisbury Plantation. Length of the alignment shown is approximately 4000 m. The common termini between the Gussage Cursus and Pentridge Cursus is indicated by crop marks on Bottlebrush Down below Salisbury Plantation. View is toward the northeast. (Photo by P. Burley)

Table 2.2 Dorset Cursus Location and Elevation Data

Item	Location (Nat. Grid Ref.)	Elevation (m.)
Pentridge Cursus: North End	SU 040 192	106
South End	SU 016 156	95
Gussage Cursus: North End	SU 016 156	95
South End	ST 969 124	99
Dorset Cursus, maximum elevation	SU 026 169	112
Dorset Cursus, minimum elevation	SU 005 147	63

The cursus is constructed of two substructures linked on Wyke Down. Gussage Cursus comprises the southern 5600 m of Dorset Cursus between Thickthorn Down and Wyke Down. The south end of the Gussage Cursus is located at the ridge top of Thickthorn Down (elev. 99 m). To the northeast, the cursus crosses the valleys of Gussage Brook, the Allenbourne, a bourne of the River Crane, and a broad swale near the north end of the monument. Pentridge Cursus extends 4400 m between Wyke Down and Martin Down to the north, and is slightly younger than Gussage Cursus (Barrett et al. 1991a). The relationship between the Dorset Cursus and topographic and geomorphic elements of the Chase might have been intended to effect certain physical and visual experiences between persons inside and along the confines of the cursus and long barrows proximal to the monument, or serving to divide the natural landscape while also inherently part of the cultural landscape (Barrett *et al*. 1991a: 46-7; Bradley, 1993; Tilley 1994; Brophy 2016).

2.2.3 Dating the Monuments

Radiocarbon analyses of organic remains retrieved from and presumed to indicate the approximate date and use of three long barrows in the study area, and a trench of the Dorset Cursus, provide the following dates (Table 2.3). Allen and Gardiner (2009) outline results of analyses of three long barrows in the study area - Thickthorn, Gussage Cow Down 78, and Gussage Cow Down 294 - interpreted to have been constructed in open dry or scrubby grassland during the 37th century BC (Entwistle 1985; French *et al*. 2007: 153-8).

Table 2.3: Cranborne Chase Long Barrow and Dorset Cursus Dates

Long Barrow	Date	Source
Hambledon Hill South	3689-3640 cal BC (95%)	Mercer *et al*. (2008)
Wor Barrow	3720-3640 cal BC (95%) 3735-3645 cal BC (95%)	Allen *et al*. (2016) Allen *et al*. (2016)
Thickthorn Down	3255-3165 cal BC (95%)	Allen, M.J. (2007)
Dorset Cursus	3500-3200 cal BC	French *et al*. (2007:186)
“	3342-3042 cal BC	Entwistle and Bowden (1991:22-23)
“	3650-3000 cal BC	Omish and Tuck (2002)
“	3360-3030 cal BC (91%)	Barclay and Bayliss (1999:23)

The dates listed above for long mounds agree with the generally accepted period for construction of British long barrows between the 3750 BC and 3300 BC, and that period is assumed herein to be representative of the period during construction of long barrows for this study. The estimated date of 3360-3030 cal BC (91% confidence level) (Barclay and Bayliss, 1999:23) for construction of the cursus is based on radiocarbon dating of animal bone samples retrieved from the lower portion of the peripheral ditch in a southern section of the monument. Construction of long barrows encountered across the Chase and SHL, and earthworks at Hambledon Hill (British National grid reference ST 848 123) located at the southwestern edge of Cranborne Chase, while beginning during the first half of the fourth millennium, are believed to have been developed in concert with construction and use of the Dorset Cursus during the second half of the 4th millennium (Tilley, 1994; Barrett *et al*., 1991a; Bradley, 1986; French, 2007: 186; Mercer and Healy, 2008).

2.2.4 Other Earthen Structures

Additional Neolithic earthen structures located on the Chase include mortuary enclosures found particularly in the vicinity of the Dorset Cursus and long barrows, as well as henges and hengi-form constructions, groups of pits, and numerous artifact scatters (French *et al*., 2007, Green, 2000). The top of Hambledon Hill includes remnants of a pair of Neolithic causewayed enclosures, numerous inhumations, and two long barrows (Mercer and Healy, 2008).

Physiogeographical, geometrical and astronomical relationships between long barrows, cursus monuments and other Neolithic monumental earthen and megalithic structures have been either identified or suspected at British ritual landscapes (e.g., Penny and Wood 1973; Tilley 1994; Chapman 2003; Harding *et al*. 2006; Loveday 2006). French *et al*. (2007) recognizes a significant relationship between geomorphology and prehistoric development in the central portion of the Chase. Tilley (1994:156-167) evaluates the pattern of intervisibility between long barrows and notes the contrast between readily apparent intervisibility of monuments situated in the central area of Cranborne Chase and lack of visibility of monuments in peripheral portions of the landscape (Tilley 1994, Figure 5.5). Tilley (1994) concludes the process of siting each long barrow in the central portion of the Chase was related to geographic relationships with proximal monuments (i.e. other long barrows and Dorset Cursus), while topography played a greater role in the siting of barrows in peripheral areas of the landscape.

Qualitative relationships between orientations of primary axes of long barrows and the Dorset Cursus with respect to landforms and drainage features of the Chase have been noted (e.g. Tilley 1994; Loveday 2006; French *et al*. 2007; Manley *et al*. 2017). Qualified long axis orientations (ex. SE, ENE) of most long barrows located on the Chase and the SHL are listed by Ashbee (1970) and Kinnes (1992). Ashbee (1970) and Kinnes (1992) note the majority of long barrows on the Chase exhibit a NW-SE axial orientation that is contrary to the predominantly W-E orientation of most British long barrows. That finding accords with conclusions by Field (2006:69) and Ahlers (2018:246) who note that the higher, wider end of British long barrows is typically located at the east end. They propose a cosmological implication associated with solar or lunar observations.

2.3 Role of Cosmology in Neolithic Ritual Landscapes

An important part of the environment, although often neglected with regard to archaeological landscape analysis, is situated above the horizon – the cosmic dome. The dearth of analysis of potential celestial alignments in Neolithic culture is surprising given the extensive documentation of celestial alignments of Egyptian monuments with astronomical events by 3700 BC and possibly much earlier (*e.g.* Lockyer, 1894). Its importance is demonstrated by an increasing number of studies finding direct relationships between ancient and indigenous ritual architecture and astronomical events (e.g., Pauketat 2012; Silva 2014; Ruggles 2015; Henty 2016; Higginbottom 2020). An increasing number of studies identify potential relationships between British Neolithic ritual architecture, landscape and skyscape (Penny and Wood 1973; Barrett *et al*. 1991a:50-51; Ruggles, 2015; Henty 2016). Over the last 40 years cosmology has been recognized as playing a central role in Neolithic architecture of Britain, and of import to understanding how Neolithic ritual landscapes were organized and experienced by their builders (e.g., Harding *et al*. 2006; Tilley 1994). Darvill (1997) proposes that orientation of long barrows toward the east might have been intended to link the east direction with sunrise, birth and fertility. Burl (1981) and Kinnes (1992) suggest emphasis on the easterly orientation might be associated with solar and lunar cycles and in conjunction with an agricultural calendar.

Natural features of the environment can have symbolic value evidenced by relationships between humans and the world expressed in many ancient and indigenous cultures. Purposeful architectural design and construction of Neolithic earthen monuments integrated with a natural or previously modified landscape may be likened to the process of creating artworks and decorative artifacts in many ancient and native cultures. Cajete (2000:48-49) identifies a general pattern in that process. The first step is the creator's preparation for the journey through creation. That is followed by attention toward the location and quality of natural sources of raw materials to be used (particularly with regard to ceremonial purposes), how they will be obtained, and an adherence to patterns of form, time and place. Relationships between monumental architecture and the environment may be dictated in part by local physiographic conditions and astronomical events (e.g. proximity to steep slopes or surface water, observation of solar, lunar or stellar phenomena, etc.) of which spatial forms and patterns may be perceived to have value in terms of significance of place, particularly in the context of temporal frames of reference. Those relationships can effect symbolic value at specific places such as individual monumental sites, as well as the landscape in toto.

Chapter 3. Methods

3.0 General

Relationships have been identified between architectural features of Neolithic earthen and megalithic monuments located across the European Atlantic façade and spatial and temporal elements of the natural environment as part of human experience of landscape (e.g. Scarre 2002c; Murrieta-Flores 2013; Noble and Brophy 2014; Higginbottom and Mom 2021). However, those relationships are complex and not consistent across time and space. Previous investigations of the study area have identified significant differences in architectural details of Neolithic earthen monuments compared to similar structures located at other landscapes of southern Britain and elsewhere (e.g. Ashbee 1970; Kinnes 1992; Loveday 2006; Darvill 2010). Those differences are both materially and visually complex. They include a breadth of source materials for earthen constructions, contrasting densities of monuments between landscapes, variability in siting monuments with respect to topographical and geomorphological settings within each landscape, and the breadth of type, size and orientation of architectural elements, such as primary axes of earthen long barrow mounds and configurations of banks and ditches constructed to form cursuses and causewayed enclosures.

Understanding relationships between human experience and the inherent complexity of landscape requires recognizing links between elements of the landscape, analysis of actual visual relationships that account for variation of elements across space, and identifying objectively measurable, independent dimensions of landscapes in which interactions between human behaviors and features of the landscape are expressed (Ode *et al*. (2010). In turn, Ode *et al*. (2010) suggests models may be developed for linking specific features of landscape with preferences in terms of human behavior and development of cultural elements across landscapes.

Methods applied for this study address spatial and temporal relationships between earthen monuments in the study area; geological and environmental conditions at micro- (on-site), meso- (local) and macro- (regional) scales; variability of geological processes that might be responsible for differences in monument architectures in contrasting British landscapes; and archaeoastronomical analysis of alignments between the monuments (long barrows and the Dorset Cursus) and astronomical phenomena during the time of long barrow and cursus construction and use during the 4th millennium.

3.1 Field Data and Analytical Methods

On-site data gathering was conducted between January 2015 and October 2018. Geomorphological and topographical features of the natural landscape were observed in the study area and surrounding region, including areas of chalk uplands and lowlands underlain by Eocene sediments and Quaternary deposits. Locations, orientations and viewsheds associated with escarpments, hill crests and slopes, river and stream valleys, dry valleys, and topographic and surface drainage patterns were noted. Shallow bedrock, surficial sediments and soils observed across the study area, including the location of each monument of interest, were identified based on readily available digital surface geology and soil maps (BGS 2018; NSRI 2017a-d, 2018a-h, 2021a-b).

Site visits were conducted to observe and document site conditions (including location, size and orientation of visible earthen mound, ditches, exposed soils, vegetation) at each of 39 extant long barrows on Cranborne Chase and adjoining downs, and one long barrow (Verwood 1 on Pistle Down) situated on Eocene sediments about 6 km southeast of the main body of long barrows on the Chase. Observed long barrow locations included thirty-five barrows of the Cranborne Chase Group identified by Ashbee (1970) (the exception being the Gillingham long barrow locate in Blackmore Vale) and four additional barrows located on the Chase: Sutton Down (984 264) located along Fovant Escarpment south of Swallowcliff; Furze 1 (1079 219) and Whitsbury Down 1 (1122 220), located 2.5 km and 6 km northeast, respectively, of the village of Martin; and Dampney (SU 0927 1493) located about 1.5 km west of the village of Damerham. Extant features of each long barrow were viewed and described with respect to mapped monument locations indicated on Ordinance Survey topographic maps (1:25000 scale) and descriptions and axial orientations provided in the archaeological literature (Ashbee 1970; Kinnes 1992; Tilley 1994; Damerham Archaeology Project 2011). Locations of Gussage Down 6 and Dampney long barrows were observed and plotted based on information provided on OS maps and archaeological literature. Readily apparent conditions of each long barrow mound and adjoining quarry ditches, and local topographic and surface hydrogeologic features of the landscape surrounding each monument was reviewed with respect to earthen monument locations and orientations indicated on Ordinance Survey maps (1:25000 scale) of the landscape and information regarding those features provided by Ashbee (1970), Kinnes (1992) and Tilley (1994).

Most extant long barrows on the Chase remain unexcavated by modern archaeological techniques, and are in various states of condition with a number of barrows suffering from historic and/or ongoing plowing. The original height, length and width of the barrows is difficult to determine without intrusive and detailed archaeological investigation. Nonetheless, most mounds exhibit sufficient topographical characteristics to provide visual indications of the general orientation and areal and vertical extent of the remnant earthen structures. We assume the long barrows are in suitable condition to approximate original primary axis orientation with field measurements made within an error of about 2 degrees of arc. The form of each extant long barrow indicates the original mound was trapezoidal or wedge shaped, with most mounds constructed higher and wider at one end. The larger (higher/wider) end of the respective long mound was noted where apparent, and the bearing of the long axis of each extant mound was measured using a Brunton® pocket transit compass. To record the bearing, two measurements were made of the long axis of each barrow, one sighting up-barrow (from smaller end to larger end) along the apparent spine of the mound, and one sighting down-barrow (Figure 1.5); both measurements were recorded to the nearest degree of arc, and the orientation of each mound was determined as the average of the two measurements. Natural topographic features of the surrounding landscape were observed with particular interest in the up-barrow and down-barrow directions. Orientation of the long axis of each long barrow was evaluated with respect to natural geomorphic features of the surrounding landscape, such as readily apparent topographic highs and stream valleys situated up-barrow or down-barrow. For this study, twenty-nine long barrows with extant mounds were observed for which the orientation (bearing toward the higher end) could be measured along the spine of the mound during field observations. Orientations of nine additional long barrows were measured using the 'Ruler' tool provided in the Google Earth Pro (Google Earth) software program, and orientations of two other long mounds (Holdenhurst barrow and Knowle Hill Farm) completely excavated during historic archaeological excavations were estimated based on scaled site plans included in the respective investigators reports (Piggott 1937b; Delbarre *et al*. 2019).

A quantitative evaluation (Davis, 2002:316) was made of the measured long barrow orientations reflecting the circular nature (bearings measured from North) of the data. The bearing of each primary long barrow orientation was plotted on a rose diagram and analyzed statistically to evaluate the dominant direction. The analysis provided a measure of the average direction of the long barrows and the distribution of the bearings about that average. The resulting mean direction and distribution of mound orientations were tested for randomness using the von Mises distribution. Results of the analysis were then used to assist identifying up-barrow and down-barrow topographic or geomorphic features aligned with the respective long barrow orientation.

On-site observation and recording of local geomorphic and topographic conditions, and viewshed along the length of the Dorset Cursus - from the north end of Pentridge Cursus to the south end of Gussage Cursus - were performed during a walking survey in August 2016. Readily apparent conditions of the cursus' banks and ditches, local topographic and surface hydrogeologic features were noted along the alignment. Latitudes and longitudes of thirty-three point locations (average spacing 300 m) were recorded along the cursus' alignment, and the landscape surrounding the monument were compared with topographic and hydrologic features indicated on OS maps (1:25000 scale), a digital elevation model (DEM) of the project area as described below, and digitized aerial photographs provided on Google Earth. Geographic coordinates (latitude and longitude) of Dorset Cursus were plotted and a best fit line was drawn through the resulting alignment based on regression analysis of the real data points.

3.2 Spatial Analysis of Landscape and Earthen Monuments

3.2.1 Digital Elevation Model of Study Area

A geographic information system (GIS) including all existing topographic and geologic data and available map coverage was developed for the study area. High-resolution (30 m pixel spacing) topographic data generated from NASA's Shuttle Radar Topography Mission (SRTM) was used to create a 30x30 m digital elevation model (DEM) of the project area and environs. Digitized geological map units were overlain onto the topography. Mapped units in digital form including bedrock geology, superficial deposits, artificial ground, mass movements, and linear features (1:50,000 scale) were provided by the British Geological Survey (BGS 2018) in ESRI.shp format and applied as layers on the base map. Locations of the Dorset Cursus, earthen long barrows, and other features of the study area were identified using latitude and longitude coordinates provided on Google Earth, and cross-referenced with National Grid reference data provided on Ordinance Survey topographic maps (1:25000 scale), information provided by Ashbee (1970) and Tilley (1994), and global positioning system (GPS) locations recorded in the field. Latitudes and longitudes of thirty-three point locations were recorded along the alignment of the Dorset Cursus. Locations along the length of the cursus include points between the east and west longitudinal ditches of the cursus, including the monument's north and south termini, along tangent sections of the alignment, at two reverse curves, and the slight right-hand bend near the north end of the cursus. The locations were then digitized, and OS maps were scanned and registered to the GIS coverage. The locations were then plotted as a layer onto the DEM using ArcGISPro 1.4.1. The DEM was used to develop ground surface profiles along the length of the Dorset Cursus and across the Chase, between the crest of the Chalke Escarpment and the English Channel.

3.2.2 Soil Information

Area-specific Soil Site Reports each covering 25 km^2 of the subject area were requested and provided by Cranfield University's National Soil Resources Institute between August 2017 and May 2021. The reports are based on the National Soil Map (1:50000 scale) for England and Wales, and include maps and data regarding spatial distribution, parent material, typical habitats, hydrogeological rock type and profile descriptions of soil types (or soil series) encountered at Cranborne Chase and the SHL.

3.2.3 Viewshed and Intervisibility Analysis

Geomorphometric study of the cultural landscape included landscape visibility and cumulative viewshed analyses. Spatial relationships among earthen monuments, bedrock and superficial geology, and geomorphology were evaluated using ArcGISPro 1.4.1. The spatial analysis included cumulative viewshed and intervisibility analyses to identify visible areas of the landscape from the Dorset Cursus, 38 long barrows located on the chalk downs, and locations proximal to the ridgeline of the Chalke Escarpment that provide extensive views across the study area. The monument intervisibility and cumulative viewshed analyses assume the landscape was open (e.g. grassland) with generally unobstructed visibility between barrow locations at the time of development during the Early- to Middle-Neolithic (French *et al*., 2007; French 2012). The cumulative viewshed analysis identifies visible areas of the landscape from four points along the brow of the Chalke Escarpment (Win Green, Winklebury Hill, Trow Down and South Down). Orientations of sightlines between the escarpment and terminal ditches and banks of Gussage Cursus and Pentridge Cursus were measured using the Ruler Tool provided in the Google Earth software program.

The intervisibility analysis applied the ArcGISPro ‘Visibility’ tool to numerically evaluate intervisibility and concurrent frequency between 38 actual long barrow sites located on the downs. The ‘Minimum Bounding’ tool was used around the barrow locations to specify minimum bounding geometry enclosing each input feature, and a 1 km buffer was created using the ‘Buffer’ tool to delineate the areal extent of the spatial analysis. The ‘Visibility’ tool was set to the buffer zone within the bounded area using the DEM without additional elevation related to long barrow height or potential visibility of the landscape as might be seen by a human standing at the respective barrow locations. The ‘Line of Sight’ tool was used to identify visibility from point to point between the 38 long barrows located across the downland landscape. The output produced an attribute table with integer fields (unique ObjectID values) related to the long barrow locations, and listing the number of long barrow sites visible from the respective ObjectID. Those values were used to construct a histogram for each data set.

The intervisibility of long barrow sites was compared to intervisibility of random locations within the natural landscape by applying a stratified random sampling method using the ArcGISPro ‘Create Random Points’ tool to develop ten sets of 38 random locations distributed within the study area. The ten sets of 38 randomly-chosen points were created within the buffer, sight lines were created using each unique data layer, and then the “Line of Sight” tool was applied. The output produced lines from each point to every other point (no repeating) with a visible/not visible (binary) code produced in the attribute table.

Thirty-seven documented long barrows and the site of the potential long barrow or mortuary-related mound at Knowle Hill Farm (SU 403062 110415) (Delbarre 2019) were included in the intervisibility analysis. The analysis did not include long barrows Gussage 6 and Dampney, of which no mound is readily apparent at each site. In addition, Verwood 1 is located in the SHL on a southeast-sloping plateau that faces away from the core area of barrows 6 km to the northwest. Holdenhurst is located in the SHL on a terrace of the Stour River near the coast and about 23 km southeast of the core area of long mounds, and situated at a low elevation preventing the mound location from being observed from long barrows situated on the Chase. Dampney long barrow is located at least 5 km from, and behind low hills of the rolling downland that prevent it from being visible with other long barrows on the Chase.

3.2.4 Spatial Analysis of Valley and Ridge Orientations

Orientations of the largest downland stream valleys and ridges were determined from measurements using ArcGIS cross-referenced with topographic (5-meter contour interval) and geographic information provided on OS maps (1:25000) of the Chase. From southwest to northeast the streams include (1) The Tarrant, (2) Crichel Brook, (3) Gussage Brook, (4) River Allen, and (5) River Crane. Bearings of stream reaches and ridgelines were measured between the crest of the Chalke Escarpment and the contact between the Chalk and overlying Eocene deposits, generally corresponding to the area within which the Dorset Cursus and long barrows on the downland are located. Measured lengths of mapped valleys and ridges range from 3.75 to 12.25 km, with bearings accurate within 2 degrees of arc. Bearings of The Tarrant and River Allen, the two largest surface waters coursing across Cranborne Chase, were determined between the crest of the Chalke Escarpment and the location where each stream has a sharp bend westward at the southeast perimeter of the chalk downland. The orientation of Crichel Brook was measured between the spring at Chettle to the location where the stream bends westward and flows into Crichel Lake near the south end of the Chase. The orientation of Gussage Brook was measured between the crest of the Chalke Escarpment and Gussage All Saints where the channel bends eastward and the flow discharges to the River Allen. The bearing of the River Crane was determined between the confluence of two bournes located east of Bottlebrush Down and the village of Cranborne at the east limit of the downland.

Ridges measured for orientation during this study are situated between valley pairs. Bearings of the ridgeline situated between The Tarrant and Crichel Brook, and between the River Allen and River Crane, were measured between topographic high points along the respective ridge in the central portion of the Chase. Orientations of ridges situated between Crichel Brook and Gussage Brook, and between Gussage Brook and the River Allen, were measured from the crest of the Chalke Escarpment to high points of ridgelines between the respective streams in the east portion of the downland.

3.3 Archaeoastronomy Methods

3.3.1 Adjustment of Stellar Position for Precession and Proper Motion

Archaeoastronomical analyses were conducted to evaluate the potential for alignments between earthen monuments (long barrows and the Dorset Cursus) and astronomical phenomena during the time of long barrow and cursus construction and use c. 3800 – 3200 BC. The analyses applied astronomical modeling software (Starry Night Enthusiast, version 4.5) (SNE) to identify solar, lunar and stellar events along and above the horizon. Accuracy of celestial coordinates (right ascension and declination) of stars provided by SNE (adjusted for precession and proper motion) was checked using a rigorous method of calculation (Meeus 1998, pp. 134-135). The method for determining stellar positions corrected for precession and proper motion during past epochs is detailed in Appendix C. The method converts right ascension (α) and declination (δ) of a star for a given epoch and equinox to corresponding mean values for another epoch and equinox by considering effects of precession of the equinoxes (the vernal equinox defined by the intersection of the celestial equator and ecliptic, regressing along the ecliptic approximately 50" per year) and proper motion of the star. The obliquity of the ecliptic c. 3800 – 3200 BC was calculated based on Jet Propulsion Laboratory's DE2000 Series (1984) computer-generated emphemerides.

3.3.2 Identifying Locations for Archaeoastronomical Analysis

Given the well-known predominantly SE up-barrow orientation of long barrows located in the study area, the archaeoastronomical analysis focused on evaluating astronomical events in the SE quadrant of the skyscape. Evaluation of potential solar and lunar targets of long barrow orientations was based on results of the statistical analysis of the set of mound orientations with respect to azimuths of the solar equinox, solstices and lunar standstills for the referenced time period.

Archaeoastronomical analysis related to the Dorset Cursus is complicated by the gargantuan size of the earthen monument, extending 10 km along a curvilinear alignment across interfluves and valleys of the Chase (Figure 1.3 and Figure 1.4), not to mention that the cursus is comprised of two cursuses – the 5.6 km long Gussage Cursus and 4.4 km long Pentridge Cursus – bound together by a common terminus on Bottlebrush Down. The breadth of topographic variation along the alignment prevents observation of the entire cursus from any location within the confines of the monument. Therefore, potential locations of c. 4th millennium archaeoastronomical observations related to the cursuses were determined based on the monument's size and shape as a whole, and developing a model of the cursus' geometry to identify 1) places (i.e. focus locations) referenced by the curvilinear geometry of the constructed monument within the context of Cranborne Chase, and 2) lines of sight allowing as much of the cursus and skyscape to be observed as possible from the focus location(s).

A virtual skyscape above the Chase was analyzed using Starry Night Enthusiast, version 4.5 to evaluate the spatial and temporal conditions. The analysis included documenting the calculated azimuth and altitude of stars during the years 4000 BC, 3800 BD, 3500 BC, 3350 BD, 3200 BC and 3000 BC. Those years correspond generally to the beginning of the British Neolithic, the estimated beginning of British long barrow construction, the middle of the 4th millennium, the mean date of construction of the Dorset Cursus, the estimated end date of long barrow construction, and the end of the British Middle-Neolithic, respectively.

Movements of the Sun, Moon, and stars were evaluated with respect to spatial and temporal alignment with geometrical configuration of the Dorset Cursus, and local and regional geographic points of interest such as prominent hilltops and hydrologic features of the study area and surrounding environment. Of the 100 brightest stars viewed from Earth today, 87 were visible from the latitude of the study area during the referenced time frame. Analyses of potential stellar observations were limited to identification of spatial and temporal alignments related to the geometrical configuration of the Dorset Cursus and the 39 brightest stars with magnitude less than +2.50 (determined by the maximum visual magnitudes as viewed from Earth) during the referenced time frame.

Chapter 4. Results

4.0. Long Barrows

4.0.1 Locations and Elevations

Long barrow locations in the study area are shown in Figure 1.2. Table 4.1 summarizes data and information concerning each long barrow, including name, location (National Grid reference), elevation (m), length, width, height, bearing of the long axis, and geographic relationships with the surrounding apparent landscape. Thirty-three (92%) of the 36 long barrows on the Chase southeast of the Fovant Escarpment and northeast of Hambledon Hill are located within a SW-NE trending corridor of monuments overlying the dip slope southeast of the Chalke Escarpment. The corridor extends for about 23 km along a 4 km wide swath across the central portion of the Chase, from about 3 km east of Blandford Forum overlooking the River Stour, northeastward to about 1.5 km northwest of Downton, overlooking the River Avon. Of the three other long mounds on the Chase, Donhead St. Mary 4 is located near the crest of the Chalke escarpment northwest of the corridor, while the Dampney and Knowle Hill Farm mounds are located southeast of the main corridor.

Ground surface elevations at long barrows on the Chase range from 251 m at Donhead St. Mary 4 to 58 m at Dampney (Figure 4.1), with a mean elevation of 116 m. Five barrows are located on chalk upland at elevations between 251 m and 165 m. The areal extent of thirty-five long barrows on chalk below an elevation of 165 m forms an arcuate pattern trending southwest-northeast, reflecting the lateral extent of Seaford, Newhaven and Culver Chalk formations across the central portion of the Chase. Those long barrows comprise the central corridor of mounds across the dip slope of the downs. Long barrows within the corridor are situated at elevations between 150 m and 59 m. A sharp break in the trend line of long barrow elevations occurs between mounds situated above elevation 120 m and those at or below 120 m. Thirty-one of the thirty-three long mounds were constructed over Seaford, Newhaven or Culver Chalk at elevations between 120 m and 82 m (mean 102 m); the set of elevations is nearly linearly-distributed (R^2= 0.9741). Similarly, the remaining set of seven barrows situated on Lewes or Seaford Chalk above 120 m (range 131-251 m, mean 192 m) approaches a linear-distribution (R^2= 0.9873).

Table 4.1
List of Study Area Long Barrows

Name of Long Barrow	Long Barrow Number	Location (Nat. Grid ref.)	Elev. (m)	Long Axis Bearing (deg)	Remarks	View of Channel Horizon	View of Win Green - Winklebury Hill
Ansty	1	SU 942 242	244	60	Subparallel with and on ridgeline of SW-NE trending Fovant Escarpment		✓
Sutton Down (Sutton Mandeville)	2	SU 984 264	211	210	On nose of SW-NE trending Fovant escarpment, subparallel with north-side slope, 8 m below ridgetop		✓
Hambledon Hill North (Child Okeford 1)	3	ST 845 127	190	161	On top of and subparallel to N-S trending ridgeline of hill, north-central portion of hilltop	✓	✓
Hambledon Hill South (Child Okeford 2)	4	ST 849 121	165	160	On top of and subparallel to N-S trending, south-facing ridgeline of hill, central portion of hilltop	✓	✓
Tarrant Rawston 1 (Luton Down)	5	ST 915 067	104	144	On east side of and 1 m below ridgeline, subparallel with strike of sideslope	✓	✓
Donhead St Mary 4	6	ST 917 196	251	67	Subparallel with strike of south-facing sideslope and subparallel with Chalke escarpment	✓	✓
Pimperne 1	7	ST 917 105	114	157	East of ridgeline on near level ground, subparallel with strike of sideslope	✓	✓
Tarrant Hinton 2 (Telegraph Clump)	8	ST 922 093	120	122	On and subparallel with low ridgeline	✓	✓
Tarrant Launceston 1 (Race Down)	9	ST 929 088	108	146	On and subparallel with low ridgeline	✓	✓
Chettle 2	10	ST 937 136	115	160	East of low ridgeline, subparallel with strike of sideslope	✓	✓
Chettle 1 (Thickthorn Bar)	11	ST 951 128	85	84	On east-facing nose of low ridgeline, subparallel with strike of sideslope	✓	✓
Tarrant Hinton 1 (Thickthorn Farm)	12	ST 964 132	87	146	On and subparallel with ridgeline	✓	✓
Gussage St Michael 1 (Thickthorn)	13	ST 971 123	100	141	On and subparallel with ridgeline	✓	✓
Gussage St Michael 2 (Thickthorn Long)	14	ST 970 124	101	132	On and subparallel with ridgeline	✓	✓

Table 4.1 (continued)
List of Study Area Long Barrows

Name of Long Barrow	Long Barrow Number	Location (Nat. Grid ref.)	Elev. (m)	Long Axis Bearing (deg)	Remarks	View of Channel Horizon	View of Win Green - Winklebury Hill
Gussage Down 6 (Parsonage Hill)	15	ST 982 114	88	ND	Slightly east of ridgeline, subparallel with strike of sideslope	✓	✓
Gussage Down 5 (Gussage Down South)	16	ST 993 131	103	107	West of and about 14 m below ridgeline, subparallel with strike of sideslope	✓	✓
Gussage Down 3 (Gussage Down North)	17	ST 993 138	110	150	On and subparallel with ridgeline	✓	✓
Gussage Down 4 (Gussage Down Center)	18	ST 994 136	113	154	On and subparallel with ridgeline	✓	✓
Handley 1 (Wor Barrow)	19	ST 012 173	109	150	East of and about 2 m below low ridgeline, subparallel with strike of sideslope	✓	✓
Wimborne St Giles 1* (Drive Plantation)	20	ST 015 148	82	ND	On shallow northwest-facing slope east of the Allenbourne, subparallel with dip of sideslope		✓
Pentridge 4 (Cursus)	21	ST 026 169	112	48	Slightly south of and 1 m below ridgeline, subparallel with strike of sideslope	✓	✓
Knowle Hill Farm	22	SU 403062 110415	57	148	On broad shallow slope falling to the northwest		✓
Broadchalke 2	23	SU 034 211	150	256	Subparallel with strike of sideslope and Chalke Escarpment	✓	
Martin Woodyates 1 (Vernditch)	24	SU 035 204	131	164	Subparallel with strike of sideslope east of low ridgeline		✓
Pentridge 1 (Bokerley 1)	25	ST 040 187	120	153	Subparallel and on nose of ridgeline northeast and below east summit of Pentridge Hill		✓
Pentridge 2a (Bokerley 2a)	26	ST 041 191	111	150	On ridgeline north of Pentridge Hill, subparallel with ridgeline and strike of sideslope		✓
Pentridge 2b (Bokerley 2b)	27	ST 040 191	111	150	On ridgeline north of Pentridge Hill, subparallel with ridgeline and strike of sideslope		✓
Pentridge 3 (Bokerley 3)	28	ST 042 188	111	170	On ridgeline north of Pentridge Hill, subparallel with ridgeline and strike of sideslope		✓

Table 4.1 (continued)
List of Study Area Long Barrows

Name of Long Barrow	Long Barrow Number	Location (Nat. Grid ref.)	Elev. (m)	Long Axis Bearing (deg)	Remarks	View of Channel Horizon	View of Win Green - Winklebury Hill
Martin 1 (Long Barrow Lane)	29	SU 064 206	90	288	On nose of low ridgeline northeast of Pentridge Hill, subparallel with south-facing slope		
Furze Down 1	30	SU 079 219	106	86	On nose of nearly level ridgeline northeast of Pentridge Hill, slight southerly slope		
Martin 2 (Knap Barrow)	31	SU 088 198	94	133	On and subparallel with ridgeline northeast of Pentridge Hill, nearly level ground		✓
Martin 3 (Grans Barrow)	32	SU 1090 198	93	174	On and subparallel with ridgeline northeast of Pentridge Hill, nearly level ground		✓
Dampney	33	SU 091 151	59	60	On very shallow, broad, hill sloping down to the northwest		
Coombe Bissett 2	34	SU 095 223	119	85	South and about 7 m below top of nose of low ridgeline, subparallel with strike of sideslope	✓	✓
Rockbourne Down 4	35	SU 102 222	104	159	On and subparallel with rather level nose of shallow ridgeline	✓	✓
Rockbourne 1 (Duck's Nest)	36	SU 104 204	83	153	On and subparallel with rather level ridgeline	✓	✓
Round Clump 2	37	SU 113 227	109	131	Subparallel with strike of southwest-facing nearly level side slope	✓	✓
Whitsbury Down 1	38	SU 122 220	95	150	Slightly west of nearly level nose of ridgeline, subparallel to strike of sideslope	✓	✓
Giants Grave Braemore Giants Grave (B)	39	SU 139 200	90	39	Slightly south of ridgeline and below hilltop to the northeast, subparallel with nose of ridge	✓	✓
Downton 2 Giants Grave (D)	40	SU 161 230	85	193	On east-facing slope about 10 m below ridge top, subparallel with strike of sideslope	✓	✓
Verwood 1 (Pistle Down)	41	ST 097 105	95	148	On shallow, broad, sandy plateau sloping toward the southeast	✓	✓
Holdenhurst	42	SZ 116 946	12	155	On gravel terrace subparallel with local contours		✓

*ND – Not deternined, long barrow orientation given as N-S (Casteldon 1992), E (Kinnes (1992), and SW-NE (RCHME 1975a)

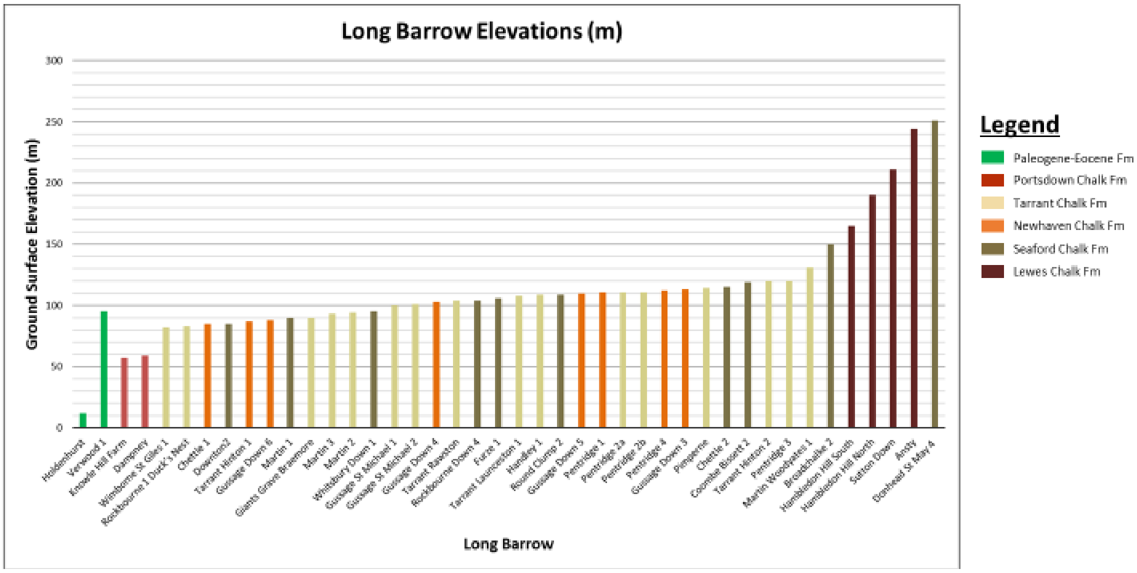


Figure 4.1: Chart of Long Barrow Elevations and underlying bedrock formations

Of the four other mounds in the study area, two were constructed over Portsdown Chalk at elevations of 59 m and 57 m and less than 0.5 km from the contact with Eocene sediments that overlie the Chalk to the southeast. Two (5%) long barrows in the study area are located in the South Hampshire Lowlands. Verwood 1 (SU 409784 110404) is situated at an elevation of 95 m on a dissected terrace plateau of Eocene Branksome sands (BGS 2018) at Boveridge Heath, about 7 km southeast of the main barrow group. Holdenhurst (SZ 411594 94594) was constructed on Quaternary terrace gravel of the River Stour at an elevation of 12 m, about 5 km upstream from the river's confluence with the Avon near Hengistbury Head (Field 2008; BGS 2018).

4.0.2 Subgrade Materials

Table 4.2 and Table 4.3 provide summaries of soil associations/descriptions and elevations related to long barrow locations. All 38 long mounds on the Chase and the two long barrows on Hambledon Hill (Hambledon Hill North and Hambledon Hill South)

Table 4.2
Long Barrow Name, Location, Elevation, and Soil Association/Description

Long Barrow Name	Location (Nat. Grid ref.)	Elevation (m)	Soil Association	Soil Description (per NSRI 2017, 2018, 2021)
Ansty	SU 942 242	244	341 - Icknield	Shallow, mostly humose, well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops
Sutton Down	SU 984 264	211	343i – Andover 2	Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk
Hambledon Hill N. (Child Okeford 1)	ST 845 127	190	341 - Icknield	Shallow, mostly humose, well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops
Hambledon Hill S. (Child Okeford 2)	ST 849 121	165	341 - Icknield	Shallow, mostly humose, loamy well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops
Tarrant Rawston 1	ST 915 006	251	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk on slopes and crests
Donhead St Mary 4	ST 916 196	251	343h – Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pimperne 1	ST917 105	114	343h – Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Tarrant Hinton 2	ST 922 093	120	343h - Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Tarrant Launceston 1	ST 929 088	108	343h – Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Chettle 2	ST 937 135	115	581D –Carstens and 343h – Andover 1	Well-drained fine silty over clayey, clayey and fine silty soils, often very flinty, over relatively high permeability chalk; shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk on slopes and crests

Table 4.2, continued
Long Barrow Name, Location, Elevation, and Soil Association/Description

Long Barrow Name	Location (Nat. Grid ref.)	Elevation (m)	Soil Association	Soil Description (per NSRI 2017, 2018, 2021)
Chettle 1	ST 950 128	85	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Tarrant Hinton 1	ST 964 131	87	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage St Michael 1	ST 971 122	100	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage St Michael 2	ST 970 124	101	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage Down 6	ST 982 114	88	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage Down 4	ST 994 136	103	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage Down 5	ST 922 131	110	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Gussage Down 3	ST 933 138	113	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Handley 1 (Wor Barrow)	ST 012 172	109	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Wimborne St Giles 1	ST 014 147	82	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pentridge 4	ST 025 169	112	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Knowle Hill Farm	SU 062 0415	57	Upton 1	Shallow, well-drained calcareous silty soils over chalk, deeper fine silty calcareous soils in coombes and dry valleys

Table 4.2, continued
Long Barrow Name, Location, Elevation, and Soil Association/Description

Long Barrow Name	Location (Nat. Grid ref.)	Elevation (m)	Soil Association	Soil Description (per NSRI 2017, 2018, 2021)
Broadchalke 2	SU 034 211	150	343i – Andover 2	Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk
Martin Woodyates 1	SU 035 204	131	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pentridge 1	ST 041 191	120	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pentridge 2a	SU 041 191	111	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pentridge 2b	SU 040 191	111	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Pentridge 3	SU 042 188	111	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Martin 1	SU 064 206	90	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Furze 1	SU 079 219	106	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Martin 2	SU 088 198	94	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Martin 3	SU 090 197	93	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Dampney	SU 091 151	59	571j – Frilsham	Well drained mainly fine loamy soils over chalk, somecalcareous; hallow calcareous fine loamy and fine silty soils in places
Coombe Bissett 2	SU 095 223	119	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests

Table 4.2, continued
Long Barrow Name, Location, Elevation, and Soil Association/Description

Long Barrow Name	Location (Nat. Grid ref.)	Elevation (m)	Soil Association	Soil Description (per NSRI 2017, 2018, 2021)
Rockbourne Down 4	SU 102 222	104	343i – Andover 2	Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk
Rockbourne 1 (Duck's Nest)	SU 104 203	83	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Round Clump 2	SU 112 227	109	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Whitsbury Down 1	SU 122 220	95	341 - Icknield	Shallow, mostly humose, well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops
Giants Grave Braemore	SU 138 200	90	343h- Andover 1	Shallow, well-drained, calcareous silty, loamy soils overrelatively high permeability chalk on slopes and crests
Downton 2	SU 161 230	85	343i – Andover 2	Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk
Verwood 1 Pistle Down	SU 097 105	95	634 – Southampton and 641b – Sollom 2	Well-drained, very permeable and very acid, very flinty soils with bleached subsurface horizon and derived from plateau gravel and river terrace drift; and deep often stoneless and very acid, humose sandy soils with bleached subsurface horizon, derived from Tertiary sand, affected by groundwater
Holdenhurst	SZ 594 594	12	571w – Hucklesbrook	Well drained coarse loamy and some sandy soils, commonly over gravel; some similar permeable soils affected by groundwater

Table 4.3 Summary of Soil Types at Long Barrows		
Soil Association/Description	Number of Long Barrows	Elevation
341 – Icknield: Shallow, mostly humose, well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops	4	95-165
342a – Upton 1: Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk	1	57
343i – Andover 2: Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk	3	85 - 211
343h – Andover 1: Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk on slopes and crests	30	82 - 251
581D –Carstens (adjoining 343h – Andover 1): Well-drained fine silty over clayey, clayey and fine silty soils, often very flinty, over relatively high permeability chalk	1	115
571j – Frilsham: Well drained mainly fine loamy soils over chalk, some calcareous; shallow calcareous fine loamy and fine silty soils in places	1	59
634 – Southampton and 641b – Sollom 2: Well-drained, very permeable and very acid, very flinty soils with bleached subsurface horizon and derived from plateau gravel and river terrace drift; and deep often stoneless and very acid, humose sandy soils with bleached subsurface horizon, derived from Tertiary sand, affected by groundwater	1	95
571w – Hucklesbrook: Well drained coarse loamy and some sandy soils, commonly over gravel; some similar permeable soils affected bygroundwater	1	12

Table 4. 4

Summary of Soil Associations and Bedrock at Long Barrow Locations

(soil associations based on NSRI 2017, 2018, 2021); bedrock based on BGS 2018)

Soil Association	Soil Type	Bedrock Formation	Number of Barrows	Total Number of Barrows
341 – Icknield	Humic rendzinas	Lewes Chalk	**3**	
		Seaford Chalk	**1**	**4**
342a – Upton 1	Grey rendzinas	Portsdown Chalk	**1**	**1**
343h – Andover	Brown rendzinas	Newhaven Chalk	**18**	
		Seaford Chalk	**6**	
		Culver Chalk	**6**	**30**
353i – Andover 2	Brown rendzinas	Lewes Chalk	**1**	
		Seaford Chalk	**2**	**3**
581d – Carstens	Paleo-argillic brown earths	Seaford Chalk	**1**	**1**
571j – Frilsham	Chromic endoleptic luvisols	Portsdown Chalk	**1**	**1**
634 – Southampton & 641b – Sollum2	Episkeletic ruptic umbric albic podzols;	Branksome Sand	**1**	**1**
571w – Hucklesbrook	Gley podzols	Branksome Sand	**1**	**<u>1</u>**
				42

overlie shallow chalk of the White Chalk Group (Table 4.4 and Table 4.5). Five long barrows are located on Lewes Chalk that forms a convex slope at the top of the Fovant and Chalke escarpments and upper elevations of Hambledon Hill. Of the five long mounds located at elevations at or exceeding 165 m, Ansty and Sutton Down are located on and subparallel to the ridgeline of the Fovant Escarpment and overlie the Lewes Nodular Chalk, while the two long barrows on Hambledon Hill are located on Lewes Chalk along the ridgeline of the hill (Figure 4.2).

Of the long mounds in the corridor, nine (27%) overlie Seaford Formation, eighteen (55%) are constructed on Newhaven Chalk, and six (18%) overlie the Tarrant Member of the Culver Chalk. White chalks used for long barrow construction at those locations (in addition to Donhead St. Mary 1) are characterized as generally soft to medium hard, permeable, containing marl seams and bands of flints, and are likely frost-shattered to some depth as a result of paleo-periglacial conditions (Bristow *et al.*, 1997). One (3%) barrow (Wimborne St. Giles 1) is constructed on a broad, low gradient slope underlain by Newhaven Chalk.

The Lewes Chalk at each of the four long barrow locations on the Fovant Esacarpment and at Hambledon Hill underlies a veneer of humic rendzinas (leptosols) of the Icknield soil association (BGS 2018c; NSRI, 2018; Avery, 1990). The soils are shallow, mostly humose, well-drained, loamy and calcareous, and are common over relatively high-permeability chalk (NSRI 2018). The fifth long barrow underlain by Lewes Chalk, Donhead St. Mary 4 located on Ashmore Down near the crest of the Chalke Escarpment, is underlain by thin, brown rendzinas of the Andover 1 soil association encountered above Seaford Chalk.

Long barrows located along hill crests and upper elevations of interfluves on the Chalk are situated where the predominant soils consist of shallow (< 30 cm) calcareous and non-calcareous, well-drained, fine silty rendzinas related to Andover 1 and Andover 2 soil associations (NSRI 2017) (Table 3.2 and Table 3.3). Discovery of undisturbed pre-monument soils consisting of thin rendzina soils characteristic of well-established short-turfed grassland beneath long barrows Gussage St. Michael 2 (Thickthorn Down), Gussage Down 5 (Gussage Cow Down 78), and Gussage Down 4 (Gussage Cow Down 294) (Barrett

Table 4.5

Bedrock underlying Long Barrows at Study Area*

Formation	Typical Composition	Characteristic Brash (Chalk)	Typical Associated Topography	Number of Long Barrows
Branksome Sand underlying alluvium	Sand and gravel, locally with lenses of silt, clay or peat overlying mainly interbedded cross-bedded fine- to coarse-grained sand and heterolithic (mixed grain-size) sediments, with subordinate kaolinitic clay, organic-rich clay and rooted lignites	not applicable	North of Verwood the formation forms low, rolling terrain and flat-topped hills above the London Clay. Overlain by podzols consisting of freely draining very acid sandy and loamy soils*	1
Branksome Sand underlying terrace gravel	Sand and gravel, locally with lenses of silt, clay or peat overlying mainly interbedded cross-bedded fine- to coarse-grained sand and heterolithic sediments, with subordinate kaolinitic clay, organic-rich clay and rooted lignites, mainly as lenticular units	not applicable	Well drained coarse loamy and some sandy soils, commonly over terrace gravels; some similar permeable soils affected by groundwater	1
Portsdown Chalk	White flinty chalk with common marl seams and some flint bands	Brash cannot be reliably distinguished from that of Culver Chalk on lithological grounds alone	Outcrop includes face and dip slope of the fourth escarpment; base at a negative break of slope	2
Culver Chalk – Spetisbury Mem.	Soft white chalks without significant marl seams, but with some very strongly developed nodular, horn and semi-tabular flints	Tends to be blockier than that from the Newhaven Chalk, but most cannot be reliably distinguished on lithological grounds alone	Outcrop occupies the dip slope behind the secondary escarpment. Base just below a strong positive break of slope at top of that escarpment; locally divided by a third escarpment	0
Culver Chalk – Tarrant Member				11
Newhaven Chalk	Soft-to medium hard, block smooth white chalks with numerous marl seams and bands of flint nodules	Angular slabby fragments of smooth white chalk very similar in appearance to that of the Seaford Chalk but commonly voluminous with in smaller fragments	Forms steep ground in the face of the secondary escarpment. Base at a negative break of slope at the foot of the escarpment	13

Table 4.5 (continued)

Bedrock underlying Long Barrows at Study Area*

Formation	Typical Composition	Characteristic Brash	Typical Associated Topography	No. of Long Barrows
Seaford Chalk	Soft blocky smooth white chalk with abundant seams of large nodular and semi-tabular flint, with thin beds of harder nodular chalk near the base	Volume of flint and frequency of large flint nodules is generally much greater than on the Newhaven Chalk	Forms extensive dip slopes between primary and secondary escarpments. Base at a very slight negative feature in front of, or at, or behind the crest of that escarpment	10
Lewes Chalk	Hard to very hard, white to creamy or yellowish white nodular chalks and chalkstones, with interbedded soft to hard gritty white chalks and common seams of clay-rich chalk (marl seams). Regular bands of nodular flint, some large, occur more commonly than in the underlying beds	Rubbly, hard nodular chalk fragments and large nodular flints. Rough-textured and rather flaggy in appearance	Forms a convex slope at the top of the primary escarpment, commonly including the crest. Base at a positive break of slope	4
New Pit Chalk	Smooth-textured, rather blocky, massively bedded, firm white chalks, with regular thin beds of clay-rich chalk (‘marl seams’) and sparse smallish flints	Fragments tend to be of very uniform, smooth, brittle white chalk of medium hardness. These break readily under the plough and so the brash commonly shows numerous clean broken surfaces	Forms the steepest ground in the face of the primary escarpment, typically with a uniform gradient. Base at a negative break of slope with underlying Holywell Nodular Chalk	0

*Information based on http://www.landis.org.uk/services/soilsguide/soilscapes.cfm?ssid=14 and http://mapapps2.bgs.ac.uk/ukso/home.html?

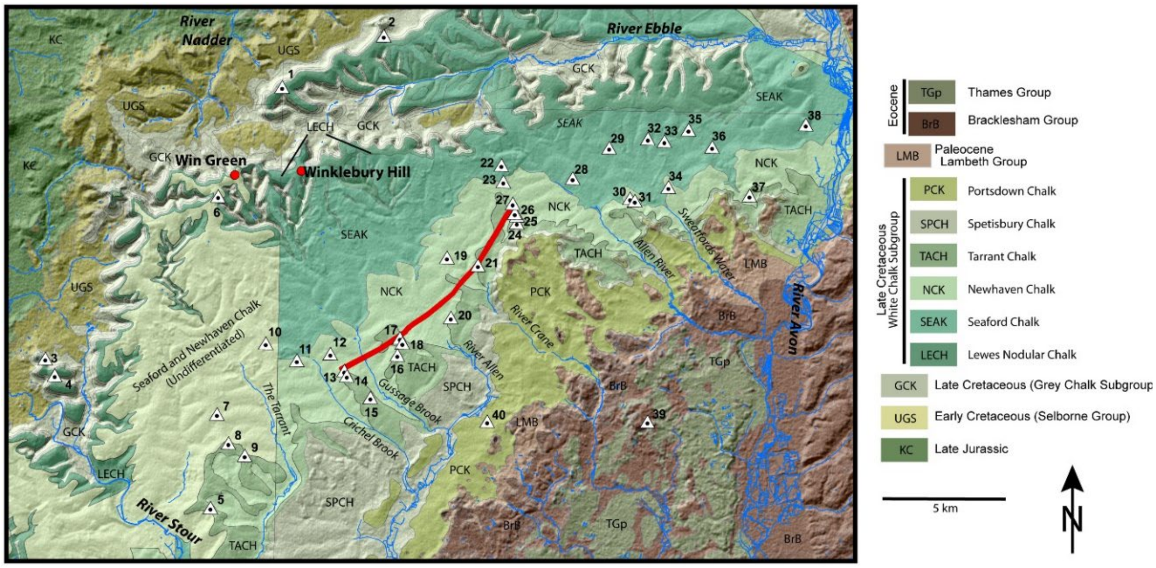


Figure 4.2: Geologic map showing locations of the Dorset Cursus (red) and long barrows (triangles) with local topography and locations of surface streams, near-surface bedrock and Eocene sediments indicated across the Chae and adjoining SHL. Long barrows on Hambledon Hill and the Fovant Escarpment were constructed on Lewes Chalk. Earthen monuments southeast of the Chalke Escarpment occupy an area underlain by the Chalk formations including Seaford, Newhaven and Tarrant Formations. (Geologic base map courtesy BGS, 2018a)

et al. 1991a, 1991b; French *et al*. 2007) is consistent with the type and areal extent of soils mapped on Gussage Down and Thickthorn Down by NSRI. Those soils also reflect soil types mapped at long barrow locations across the central corridor of long mounds. Deeper brown earths are encountered on upper to- mid-slopes of the downs, particularly in areas underlain by Clay-with-flints northwest of the central corridor, and locations farther southeast where Reading Beds are situated (French *et al*. 2005; NSRI 2017). Brown earths overlying Clay-with-flints are common in upper portions of the chalk dip slope and on southeast-facing hillsides in the Knowlton area, about 6 km southeast of the Dorset Cursus, where Clay-with-flints and Reading Beds are encountered.

Of the ten long barrows located on Seaford Chalk, eight (80%) are located where soils primarily consist of brown rendzinas (leptosols) of either the Andover 1 or Andover 2 soil association (NSRI 2018; Avery, 1990) (Table 4.4). Of the other two barrows overlying Seaford Chalk, one (Whitsbury Down 1) is located in an area of Icknield humic rendzinas (leptosol); the other (Chettle 2) is in an area of well-drained, silty and clayey paleo-argillic brown earths (Carstens soil association) soils over relatively high permeability chalk and bounded by brown rendzinas (luvisol) of the Andover 1 soil association (BGS 2018a; NSRI 2018; Avery 1990).

Twenty-six (65%) of long barrows on the Chalk overlie formations superior to the Seaford Formation. Eighteen (46%) long barrows are located on Newhaven Chalk. All of those mounds are located where soils primarily consist of brown rendzinas of the Andover 1 soil association (NSRI 2018; Avery 1990). Six (15%) long barrows overlie the Tarrant Member while none are situated on the Spetisbury Member of the Culver Chalk. All long barrows sited on the Tarrant Member are located where soils primarily consist of brown rendzinas of the Andover 1 soil association (NSRI 2018; Avery 1990). Two (5%) long barrows are located on Portsdown Chalk. Remains of the Dampney long mound (SU 409281 114938) are located on well-drained Frilsham fine loamy soil over Portsdown Chalk, the parent material of the soil consisting of Paleocene sand and loam (NSRI 2021a). BGS (2018) maps Quaternary sediments as Head at and in the vicinity of Dampney long barrow. The anomalous possible ‘short’ long barrow or mortuary structure at Knowle Hill Farm was constructed in an area of shallow, calcareous, well-drained Upton 1 silty soils underlain by Portsdown Chalk (NSRI 2018h, BGS 2018).

Other than Dampney, no long barrow on downs of the Chase is situated in an area underlain by Head, organic sediments, remanié clays such as Clay-with-flints, Quaternary river terrace sediments or alluvium. None of the long barrows is located over karst features mapped by Hammer *et al*. (2020) (Figure E.2.12).

Two (5%) of long barrows in the study area are located in the South Hampshire Lowlands. Verwood 1 (SU 409784 110404) is situated on a dissected terrace plateau of Eocene Branksome sands in the eastern portion of the SHL at Boveridge Heath, about 7 km southeast of the main barrow group (BGS 2018). Soil at and in the vicinity of that long barrow consists of Sollum 2 deep and often stoneless, very acid, humose sandy soils with a bleached subsurface horizon and affected by groundwater (NSRI 2021a). Holdenhurst long barrow was situated on a Quaternary gravel terrace near the River Stour about 5 km upstream from the river’s confluence with the Avon in Hampshire Basin and 3.4 km north of the current coastline (Field 2008; BGS 2018). Soil at and in the vicinity of that long barrow consists of well-drained Hucklesbrook coarse loam and some sands, commonly over gravel (NSRI 2021b).

4.0.3 Viewshed and Orientation

Thirty-eight (90%) of all long barrows in the study area are situated such that they afford a view of the uppermost elevations of the Chalk Escarpment in the region of Win Green and Winklebury Hill (Table 4.1). Locations of thirty-seven (88%) long barrows provide line of sight to upper elevations of the Chalk Escarpment between Donhead St. Mary 4 long barrow on Ashmore Down, and Trow Down. The four long mounds – Broadchalke 2, Martin 1, Furze Down 1 and Dampney – not within sight of that area on the Chase are generally west of the north end of the Dorset Cursus. Verwood 1 and Holdenhurst are located in the SHL at substantial distances from the escarpment but could have provided views of the cuesta under favorable weather and vegetation conditions.

Thirty-eight (97%) of the long barrows were sited such that the earthen mound is on or proximal to the crestline of the respective ridge, interfluve or hilltop that it is constructed, with its long axis oriented subparallel with the contours of the local topography. Of the 40 long barrows at the Chase and Hambledon Hill, twenty-four (62%) are situated on a ridgeline or crest of a hill, with the long axis oriented subparallel with the bearing of the respective ridgeline or crest. Fourteen (36%) of the barrows are located subparallel to the strike of the sideslope of the hillside that it each sits, but below the elevation of the associated escarpment or crestline of the hill. Most long barrows not on a ridgeline are at an elevation within a few meters of the nearby hillcrest. One barrow (Wimborne St. Giles 1) was constructed on a broad, low gradient slope underlain by Newhaven Chalk with the long axis oriented subparallel with the local contour. The potential ‘short’ long mound (Knowle Hill) was located on a broad, low gradient slope overlying Portsdown Chalk and oriented subparallel with the dip of the slope.

Seventeen long barrows are within 2 km of the Dorset Cursus (Figure 4.6). At least some portion or terminus location of the Dorset Cursus is within the viewshed of 34 (83%) of the long barrows. Each of seven mounds (Ansty, Sutton Down, Tarrant Rawston 1, Giants Grave Braemore, Dampney, Verwood 1 and Holdenhurst) without line-of-sight to the cursus is located in a peripheral location of the study area.

Table 4.6 provides a breakdown by quadrant of long barrow long axis orientations for the 42 long barrows located in the study area. The data is based on review of 40 qualified long mound axis orientations listed in Ashbee (1970), Kinnes (1992) and other sources including RCHME (1975a, 1975b), 30 measurements of barrow orientations obtained in the field during this study, 2 estimated orientations measured from scaled site plans prepared during previous archaeological investigations, and 2 estimated orientations based on archaeological reports and observation of historic aerial photographs provided on Google Earth. Orientations of two long barrows (Gussage Down 6 and Wimborne St. Giles (ST 0146 1476)) locate on the Chase were not quantified during this study because the respective mound is no longer extant as a result of agricultural plowing or natural degradation, and they are not readily apparent in images of historic aerial photographs provided by Google Earth. RCHME (1975a; 1975b) states that the barrow at Gussage Down 6 had a NNW-SSE orientation and Wimborne St. Giles had a SW-NE orientation.

Table 4.6
Long Barrows with Qualified Long Axis Orientations noted by others (e.g. Ashbee 1970; RCHME 1975a, 1975b; Kinnes 1992) and this study

Qualified Long Axis Orientation by Quadrant	Number of Long Barrows
NE	6
SE	30
SW	5
NW	1

Of the thirty long mounds for which the orientation (bearing toward the higher end) was measured during field observations (Table 4.1), twenty (67%) are oriented toward the southeast quadrant, five (17%) toward the northeast, four (13%) toward the southwest, and one (3%) oriented toward the northwest. Those long mounds include twenty-seven barrows on the Chase southeast of the Fovant Escarpment, two barrows located on Hambledon Hill (Hambledon Hill North and Hambledon Hill South) just southwest of the Chase and near the Stour River, and one long barrow (Verwood 1) situated in the SHL. The mean of the thirty field-measured up-barrow orientations is 152 degrees (152±10 deg. at 68%).

The mean of the forty up-barrow orientations obtained from field measurement, use of Google Earth, and site plans, is 145 degrees (145±48 deg. at 68%) (Table 4.7). None

Table 4.7

Determination of Long Barrow Orientation Mean, Variance and Standard Deviation for 40 Long Barrows

Long Barrow	Easting	Northing	Elevation(m)	Azimuth (deg)	Dev	Dev^2
Ansty	942	242	244	63	82	6724
Sutton Down	984	264	211	210	65	4225
Hambledon Hill North	845	127	190	162	17	289
Hambledon Hill South	849	121	165	158	13	169
Tarrant Rawston	915	066	104	144	-1	1
Donhead St Mary 4	916	196	251	67	-78	6084
Pimperne 1	917	105	114	157	12	144
Tarrant Hinton 2	922	093	120	122	-23	529
Tarrant Launceton 1	929	088	108	146	1	1
Chettle 2	937	135	115	160	15	225
Chettle 1	950	128	85	84	-61	3721
Tarrant Hinton 1	964	131	87	122	-23	529
Gussage St Michael 1	971	123	100	132	-13	169
Gussage St Michael 2	970	124	101	141	-4	16
Gussage Down 5	992	131	110	107	-38	1444
Gussage Down 3	993	138	113	150	5	25
Gussage Down 4	994	136	103	154	9	144
Handley 1	1012	172	109	150	5	64
Pentridge 4	1025	169	112	228	-83	8836
Knowle Hill Farm	031	104	57	148	3	9
Broadchalke 2	1034	211	150	256	111	12321
Martin Woodyates 1	1035	204	131	164	19	361
Pentridge 1	1041	187	111	170	25	625
Pentridge 2a	1041	191	111	153	8	64

Table 4.7, continued
Determination of Long Barrow Orientation Mean, Variance and Standard Deviation for 40 Long Barrows

Long Barrow	Easting	Northing	Elevation(m)	Azimuth (deg)	Dev	Dev^2
Pentridge 2b	1040	191	111	153	8	64
Pentridge 3	1039	195	120	150	5	25
Martin 1	1064	206	90	288	143	20449
Furze 1	1079	219	106	086	-59	3481
Martin 2	1088	198	94	133	-12	144
Martin 3	1090	197	93	175	30	900
Dampney	0091	151	59	060	-85	7225
Coombe Bissett 2	1095	223	119	085	-60	3600
Rockbourne Down 4	1102	222	104	159	14	196
Rockbourne 1	1104	203	83	153	8	64
Round Clump 2	1112	227	109	131	-14	196
Whitsbury Down 1	1122	220	95	150	5	25
Giants Grave Braemore	1138	200	90	037	-108	11664
Downton 2	1161	230	85	180	35	1225
Verwood	0097	105	95	148	3	9
Holdenhurst	1159	946	12	155	10	100
			Sum:	5789		93985

Determination of Long Barrow Orientation Mean, Variance and Standard Deviation

Mean (all measured long barrows) = 145/40 = 144.725, say 145 degrees

Sample Variance 93985/40 = 2349.625 Variance 93985/39 = 2409.872

Sample Std. Dev. (2349.625)1/2 = 48.47 Sample Std. Dev. (2409.872)1/2 = 49.09

Sample Standard Deviation of the Mean = 49.09/√40 = 7.76, say 8.0 **145±8** (137 to 153)

Summary: All measured long barrows - Long Barrow Azimuth 145±48 68%

145±96 95%

of the forty long barrows with quantified orientations is aligned within less than 4 degrees of any of the four cardinal directions.

Barrow orientations for the twenty-eight long mounds exhibiting an up-barrow alignment in the southeast quadrant were quantified during field measurement, using the Google Earth Ruler tool, or scaled estimates from archaeological plans. The mean of those up-barrow orientations is 148 degrees (148±15 deg. at 68%) Table 4.8). Those long mounds include twenty-four barrows on the Chase southeast of the crest of the Chalke Escarpment, the two barrows located on Hambledon Hill, and Verwood 1 and Holdenhurst long mounds situated in the SHL.

The mean of the field measured up-barrow orientations for the twenty long mounds oriented toward the southeast is 153 degrees (153±11 deg. at 68%). Those long mounds include seventeen barrows on the Chase southeast of the crest of the Chalke Escarpment, the two barrows located on Hambledon Hill, and Verwood 1 long barrow situated in the SHL.

Orientations of the two long barrows at Hambledon Hill causewayed enclosure, the two long barrows located in the SHL (Verwood 1 and Holdenhurst), and the anomalous 'short' long barrow or mortuary structure at Knowle Hill Farm are notable. Verwood 1 is located at a ground surface elevation of 94 m near the south end of a dissected terrace of Reading Beds in the southeast portion of the study area. The measured up-barrow longitudinal axis of Verwood 1 is 148 degrees, with a clear up-barrow view toward the English Channel located 19 km to the southeast. An orientation of 155 degrees for the Holdenhurst long barrow was estimated from the scaled plan drawing of the mound provided by Piggott (1937b). The two side ditches associated with the Knowle Hill Farm feature have a NW-SE orientation; a long axis orientation of 148 degrees for the former mound was estimated from a scale plan of the site (Delbarre *et al*. 2019). Hambledon Hill North has an up-barrow bearing of 161 degrees. Hambledon Hill South has a bearing of 160 degrees, although the mound is a reconstruction after intrusive archaeological investigation had removed the barrow (Mercer 2008). Viewsheds of both long mounds at Hambledon Hill include clear up-barrow view toward the English Channel located 32 km to the southeast. All five orientations are within the statistical range of orientations (153±11 deg. at 68%) from the field measured set of SE oriented long barrows on the Chase and the

Table 4.8

Determination of Southeast Oriented Long Barrow Orientation Mean, Variance and Standard Deviation

Long Barrow	Easting	Northing	Elevation(m)	Azimuth (deg)	Dev	Dev^2
Hambledon Hill North	845	127	190	162	13	169
Hambledon Hill South	849	121	165	158	9	81
Tarrant Rawston	915	66	104	144	-5	25
Pimperne 1	917	105	114	157	8	64
Tarrant Hinton 2	922	93	120	122	-27	729
Tarrant Launceton 1	929	88	108	146	-3	9
Chettle 2	937	135	115	160	11	121
Tarrant Hinton 1	964	131	87	122	-27	729
Gussage St Michael 1	971	123	100	132	-17	289
Gussage St Michael 2	970	124	101	141	-8	64
Gussage Down 5	992	131	110	107	-42	1764
Gussage Down 3	993	138	113	150	1	1
Gussage Down 4	994	136	103	154	5	25
Handley 1	1012	172	109	150	1	1
Knowle Hill Farm	031	104	57	148	-1	1
Martin Woodyates 1	1035	204	131	164	15	225
Pentridge 1	1041	187	111	170	21	441
Pentridge 2a	1041	191	111	153	4	16
Pentridge 2b	1040	191	111	153	4	16
Pentridge 3	1039	195	120	150	1	1
Martin 2	1088	198	94	133	-16	256
Martin 3	1090	197	93	175	26	676
Rockbourne Down 4	1102	222	104	159	17	289
Rockbourne 1	1104	203	83	153	4	16
Round Clump 2	1112	227	109	131	-18	324
Whitsbury Down 1	1122	220	95	150	1	1

Table 4.8, continued

Determination of Southeast Oriented Long Barrow Orientation
Mean, Variance and Standard Deviation

Long Barrow	Easting	Northing	Elevation(m)	Azimuth (deg)	Dev	Dev^2
Verwood	097	105	95	148	-1	1
Holdenhurst	1159	946	12	155	6	36
				4325		7106

Mean (SE oriented long barrows) = 4325/29 = 149.1379, say 149 degrees

Sample Variance 7106/29 = 245.0345 Variance 7106/28 = 253.7857

Sample Std. Dev. (245.0345)1/2 = 15.65358 Sample Std. Dev. (253.7857)1/2 = 15.93065

Sample Standard Deviation of the Mean = 15.93065/√29 = 2.958, say 3 **149±3** (146-152)

Summary: Long Barrow Azimuth 149±16 = 133 to 165 68%
149±32 = 117 to 181 95%

set of all twenty-eight long barrows exhibiting orientations toward the southeast (148±15 deg. at 68%).

Based on field measurements, eight long barrows (27%) exhibit a broad range of up-barrow orientations toward either the northeast or southwest quadrants (61±20/241±20 degrees at 68%). Six (75%) of those long barrows are located at peripheral locations of the Chase, while one barrow (Pentridge 4) is within the confines of the Dorset Cursus and another (Chettle 1) appears oriented generally toward the top of Gussage Hill where the cursus crosses the hillcrest nearby two other barrows (Gussage 3 and Gussage 4). Two (Chettle 1 and Combe Bissett 2) of those ten long barrows have up-barrow azimuths within a narrow range of 84- to 85 degrees, while a third mound (Furze Down 1) exhibits an orientation of 86 degrees based on use of the Google Earth Ruler tool. Donhead St. Mary 4 is situated on Ashmore Down near the crestline of the Chalke Escarpment, at the highest elevation (251 m) of all of the long barrows. It's up-barrow long axis azimuth of 67 degrees is subparallel with the ridgeline of the cuesta and appears oriented toward the crest of the escarpment at Winklebury Hill. One (2%) long barrow (Martin 1) is oriented up-barrow toward the northwest.

The distribution of all measured long barrow orientations was evaluated for randomness using the von Mises distribution as a circular analog of the univariate distribution (Appendix A). Figure 4.3 includes a rose diagram of the long barrow directions. The mean direction $\bar{\theta}$ of the 40 long barrows for which quantitative up-barrow directions were determined is 145 degrees. The calculated interval including the true population mean direction is directed toward the southeast at 145±96 degrees (95% probability). The mean resultant length ($\bar{R}$) is 0.722 and the critical value of $\bar{R}_{40,\ 5\%}$ is 0.273. Since the computed value of $\bar{R}$ is well exceeds the critical value, the set of long barrows has a preferred trend.

Figure 4.4 includes a histogram and rose diagram of the twenty-eight long barrows oriented toward the southeast. The mean direction $\bar{\theta}$ of the twenty-eight long mounds exhibiting a quantified up-barrow alignment in the southeast quadrant is 148 degrees. The calculated interval including the true population mean direction (95% probability) is 148±15 degrees. The mean resultant length ($\bar{R}$) is 0.967 and the critical value of $\bar{R}_{28,\ 5\%}$ is 0.332. Therefore, the set of southeast-directed long barrows has a preferred trend.

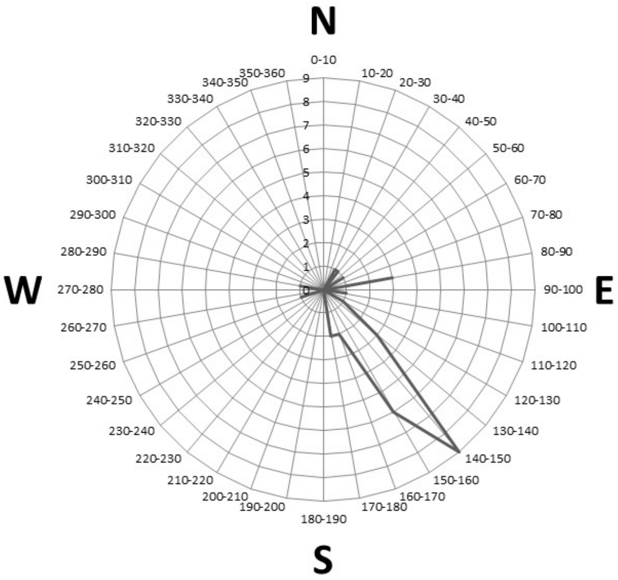


Figure 4.3: Rose diagram of azimuths of the 40 long barrows measured at the Chase and SHL during this study.

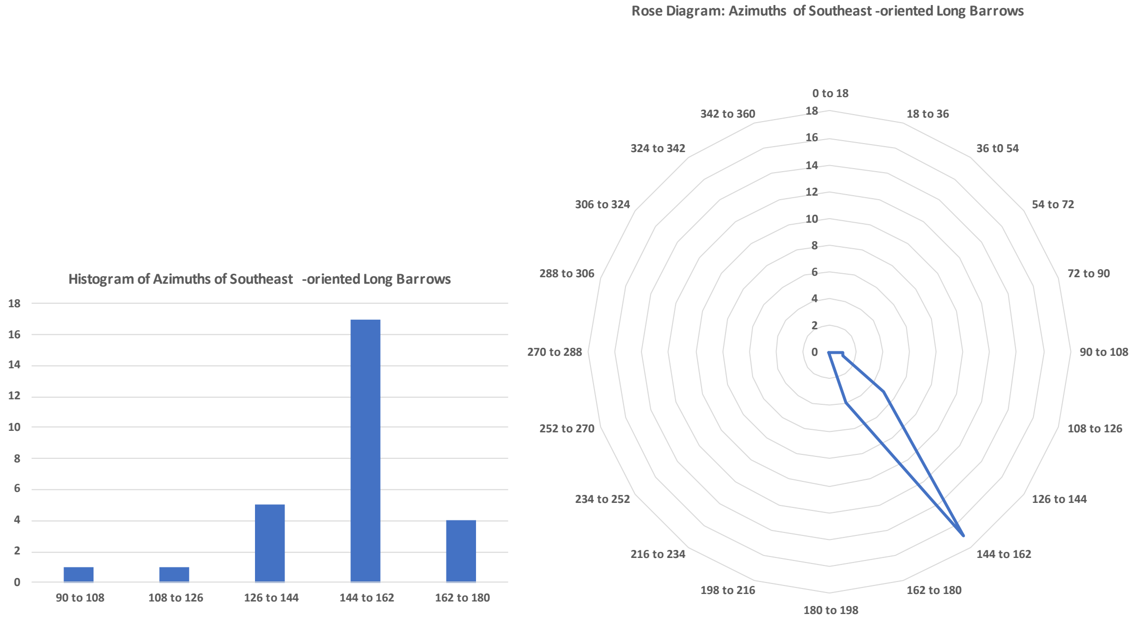


Figure 4.4: Azimuths of the 28 southeast-oriented long barrows in the study area. a) histogram; b) rose diagram

Of the twenty-eight long barrows for which the up-barrow compass bearing toward the southeast was evaluated, the orientation of twenty-one (75%) barrows exceeds 143 degrees.

4.0.4 Up-barrow Horizon Altitude

The horizon in the up-barrow direction at each long mound location ranges from 0 to +5 degrees elevation. Thirty-five (83%) of the 42 long barrows are oriented with the up-barrow end directed toward a horizon altitude of less than +1 degree. Locations of twenty-eight (67%) of the mounds exhibit a horizon altitude of less than +0 degree with a southeasterly up-barrow view of the English Channel (Table 4.1). The crest of the Chalke Escarpment prevents observation of the Channel from the two mounds (Ansty and Sutton Down) on the Fovant Escarpment. Most of the remaining barrow locations without a view of the Channel are located in the northeast portion of the Chase, northeast of the Dorset Cursus, where Pentridge Hill or other topographic features limiting the extent of the viewshed toward the southeast.

4.0.5 Intervisibility

The two long barrows situated in the SHL are not visible from any long barrow site on the Chase. Verwood 1 is located on a southeast-sloping plateau that faces away from the core area of barrows 6 km to the northwest. Holdenhurst long barrow is situated on a low terrace of the Stour River about 23 km southeast of the core area of long mounds, preventing the mound from being observed from long barrows situated on the Chase. Nonetheless, the Verwood 1 and Holdenhurst sites have direct line of sight to each other across the SHL.

Two long barrows, Ansty (elev. 244 m) and Sutton Down (elev. 211 m), are located along the north limit of Cranborne Chase, near the crest of the Fovant Escarpment and offer views north toward the River Nadder. High ground between the two barrows prevents their intervisibility. Views from the Fovant Escarpment toward the south and into the Chase generally are prevented by the height of the Chalke Escarpment. Thus, the Ansty and Sutton Down barrows cannot be seen from the other long barrows on the Chase and were not included in the monument intervisibility analysis. In addition, Dampney long barrow is located at least 5 km from any other know long mound location, and behind low hills of rolling downland preventing it from being visible with other long barrows on the Chase.

Figure 4.5 illustrates the frequency of long barrow intervisibility and the ten sets of random point locations. Long barrow intervisibility ranges from 1 to 22 sites (mean 6.7)

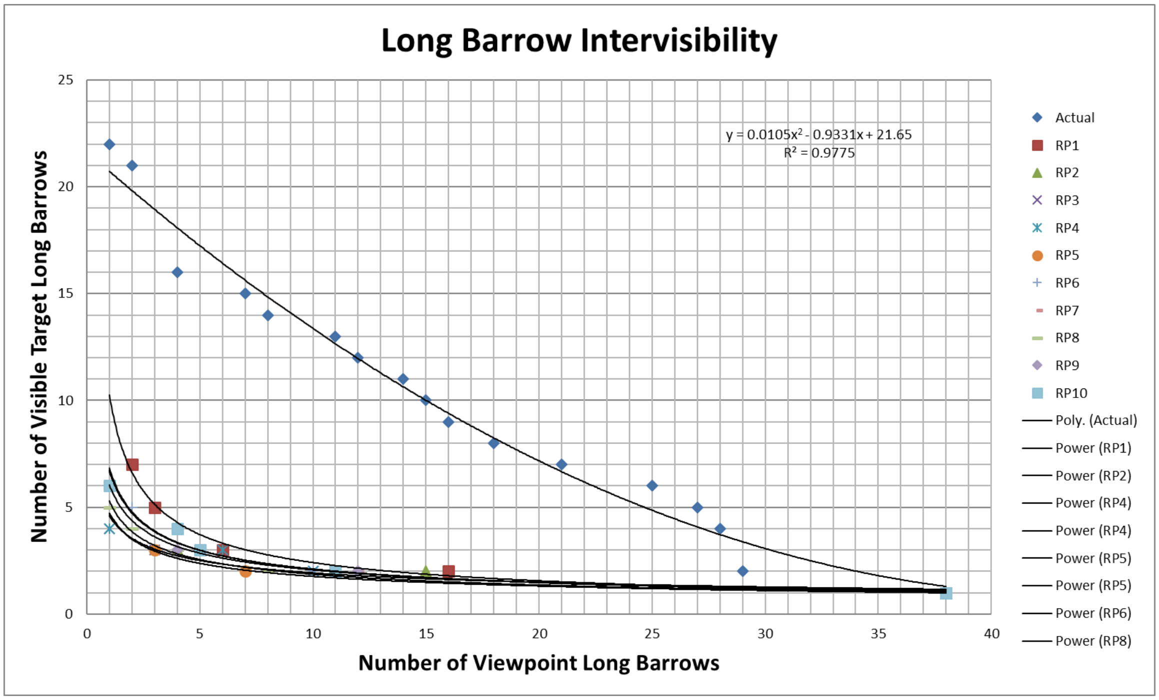


Figure 4.5: Chart showing number of intervisible long barrows for each of 38 actual long barrow locations on the downs of the Chase, and ten sets of 38 random locations also located across the downs. (Chart prepared by P. Melius, unpublished)

visible from actual barrow locations. Intervisibility for each of the ten sets of 38 random points ranges from 1 to 7 sites. The average mean number of point locations visible within the ten sets of random points is 1.55. The mean of the maximum number of intervisible random points is 4.9 ($2\sigma = 2.8$), while the maximum number of long barrows that may be seen from the actual site locations is 22. Siting of actual long barrow locations compared to the ten sets of random points demonstrates that the long barrows were placed allowing for intervisibility of the structures. However, it is not clear if intervisibility was an intentional facet of monument placement on the landscape, or simply an artefact of constructing most of the long barrows on or proximal to hillcrests.

4.1 Orientations of Valleys and Ridges

Each of the valleys and interfluves between the River Stour and the north end of the Pentridge Cursus at Martin Down is readily apparent from vantage points along upper reaches of the Chalke Escarpment between Donhead St. Mary 4 long barrow on Ashmore

Table 4.9: Cranborne Chase – Azimuths of Valleys and Ridges

Item	Description	Length (km)	Azimuth (deg.)
Valleys			
The Tarrant	Gore Farm to Tarrant Stubhampton	5.5	149
	Stubhampton to Tarrant Launceston	3.875	148
	Tarrant Launceston to river bend at Ash Plantation	2.875	153
	total length	**12.25**	**149.6** (avg.)
Crichel	Chettle to Holly Grove Farm	4.5	139
	Holly Grove Farm to Mabel Cottages	1.5	123
	total length	**6.0**	**135.0** (avg.)
Gussage	Win Green to Gussage St. Andrew	7.94	145
	Winklebury Hill to Gussage St. Andrew	6.4	163
	Gussage St. Andrew to Gussage All Saints	5.0	144
	total length (ridge to GSA)	**12.17**	**150.8** (avg.)
River Allen	Trow Down to Wyke Farm	9.875	153
	Sixpenny Handley to Wyke Farm	3.25	157
	Wyke Farm to Wimborn St. Giles	2.25	134
	total length (ridge to WSG)	**12.17**	**148.9** (avg.)
River Crane	Bottlebrush Down to Cranborne	3.75	135
	total length	**3.75**	**135**
Ridges			
Ridge Between The Tarrant and Crichel	Caesars Camp to Launceston Down	**5.875**	**157**
Ridge Between Crichel and Gussage	Donhead St. Mary 4 long barrow to South end of Dorset Cursus	**8.8 km**	**143.5**
Ridge Between Gussage and R. Allen	Higher Bridmore Farm and Gussage Hill	**7.8 km**	**155**
Ridge Between R. Allen and R. Crane	Wor Barrow to Creech Hill	**5.375 km**	**142**
Valleys and Ridges			
Valleys	avg. length	**9.268**	**145.0** (avg.)
Ridges	ave. length	**6.963**	**149.3** (avg.)
Valleys and Ridges	avg. length	**8.30**	**146.6** (avg.)

Table 4.9: Cranborne Chase – Azimuths of Valleys and Ridges, continued

Summary of Analysis

	Statistic	Azimuth
Valleys:	Range	135.0 – 150.8
	Average (per km.)	145.0
Ridges:	Range	142.0 – 157.0
	Average (per km.)	149.3
Valleys & Ridges:	**Range**	**135.0 – 157.0**
	Average	**146.6**

Valleys and Ridges

Item	Average Azimuth	Deviation	$(\text{Deviation})^2$
The Tarrant	149.6	3.3	10.89
The Tarrant-Crichel	157.0	10.7	114.49
Crichel	135.0	-11.3	127.69
Crichel-Gussage	143.5	0.2	0.04
Gussage	150.8	4.5	20.25
Gussage-River Allen	155.0	8.7	75.69
River Allen	148.9	2.6	6.76
River Allen-River Crane	142.0	-4.3	18.49
River Crane	135.0	-11.3	127.69
Mean	1316.8 / 9 = **146.3**		**Σ 501.99**

Sample Variance 501.99/9 = **55.78** **Variance** 501.99/8 = **62.75**

Sample Std Dev. $(55.78)^{1/2}$ = **7.47** **Std. Dev.** $(62.75)^{1/2}$ = **7.92**

Valley and Ridge Azimuth **146.3±7.9 = 138.4 – 154.2 68%**

146.3±15.8 = 130.5 – 162.1 95%

Down, and South Down. The preferred trend of the direction of long barrows in the study area was evaluated with respect to the orientation of valleys and ridges encountered across the chalk uplands between the Chalke Escarpment to the northwest and the South Hampshire Lowlands to the southeast (Table 4.9). The general bearing of the respective valleys ranges from 135 degrees to 151 degrees, with a mean orientation of 145 degrees. The bearing of the ridgelines ranges from 142 degrees to 157 degrees, with a mean orientation of 149 degrees. The mean orientation $\bar{\theta}$ of the nine measured valleys and ridges as a set of linear geomorphic features of the landscape having a circular, univariate distribution similar to the analysis of long barrow orientations is 146 degrees ($2\sigma=16$, 95%). Distribution of the valley and ridge directions was evaluated for randomness assuming a von Mises distribution The calculated interval including the true population mean direction (95% probability) is directed toward the southeast at 146±16 degrees. The mean resultant length (R) is 0.99 and the critical value of $R_{36,\ 5\%}$ is 0.602. Since the computed value of R exceeds the critical value, the set of valleys and interfluves has a preferred trend.

The two sets of long barrow and valley and ridge directional vectors were tested for equality (Davis, 2002: 326-327). The F-test statistic ($F_{1,35}$) is 0.12 and the critical $F_{(\alpha=0.05)}$ is 4.13. Since the critical value is far greater than the test value, the long barrow orientations and valleys and ridges are drawn from a common population of directions toward the southeast. In other words, from a statistical basis, the set of long barrow directions reflects the orientation population of valleys and interfluves. Azimuths of each measured long barrow, valley and ridge southeast of the Chalke Escarpment are indicated on Figure 4.6. Table 4.10 lists summary orientations of long barrows, valleys and ridges on the Chase.

Table 4.10

Summary of Long Barrow, Valley and Ridge Orientations

All 40 Long Barrows	145±48 deg. at 68% (97 to 193 degrees)
28 Long Barrows oriented SE	148±15 deg. at 68% (133 to 163 degrees)
Valleys and Ridges	146±8 deg. at 68% (138 to 154 degrees)

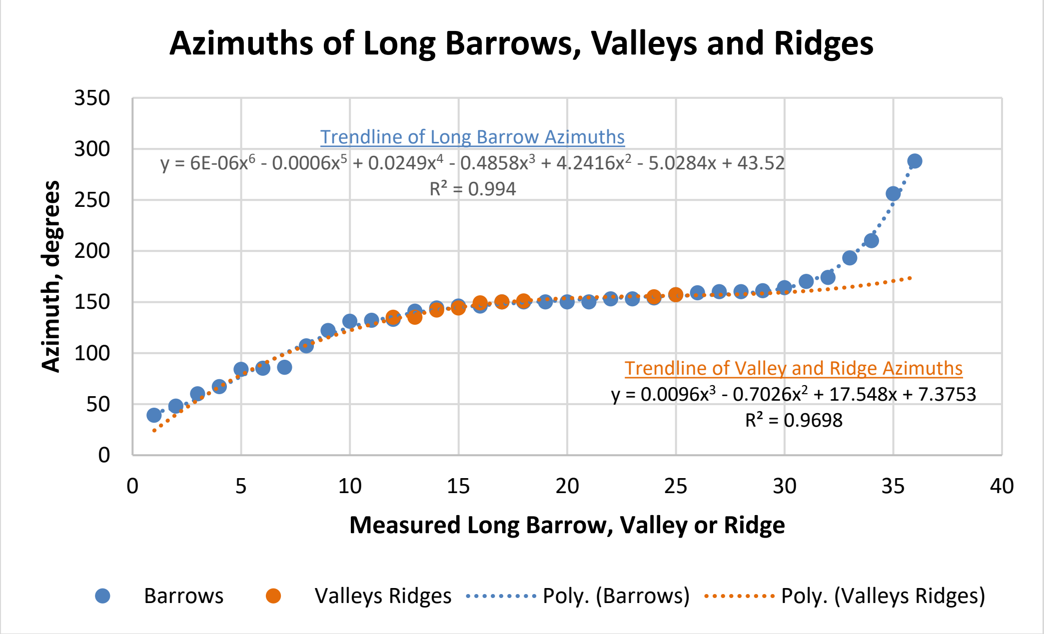


Figure 4.6: Azimuths of measured long barrows, valleys and ridges on the Chase. Note that the set of valley and ridge orientations closely follows the trendline of the long barrow orientations between azimuths of 135 and 160 degrees.

4.2 Dorset Cursus

4.2.1 Location, Elevation and Alignment

The cursus' alignment is located about 8- to 9 km southeast of the Chalke Escarpment. The cursus follows a 10 km curvilinear, north-northeasterly alignment from the south terminus of Gussage Cursus on Thickthorn Down about 2 km northwest of the village of Gussage St. Michael, to the north terminus of Pentridge Cursus on Martin Down about 1.5 km northeast of the village of Pentridge. Table 2.1 provides a summary of the location and topographic variability of the cursus. Figure 1.3 illustrates the ground plan and longitudinal ground surface profile of the Dorset Cursus. Figure 4.7 includes two ground surface profiles along the centerline of the cursus (one illustration with 25x vertical exaggeration, and one with no vertical exaggeration), and lists aspect ratios of the monument based on the topography of the cursus along the centerline of its 10 km alignment.

With a maximum change in elevation of 49 m over the course of its length of almost 10 km length, the alignment-enclosed aspect ratio (height to width) of the cursus is 0.0049, with a longitudinal orientation within 0º 16' 54" of being level. The change in elevation from the north end to the south end of the cursus is 7 m (aspect ratio = 7/9970 = 0.0007) resulting in a longitudinal orientation from the north end of the cursus to the south terminus of 0^{o} 2’ 24”. Given those aspect ratios and orientations over the length of the cursus, the earthen monument when viewed from the crest of the Chalke Escarpment generally appears subparallel with the overlying ‘flat’ horizon of the English Channel between the Isle of Wight and the Isle of Purbeck (Figure 4.7).

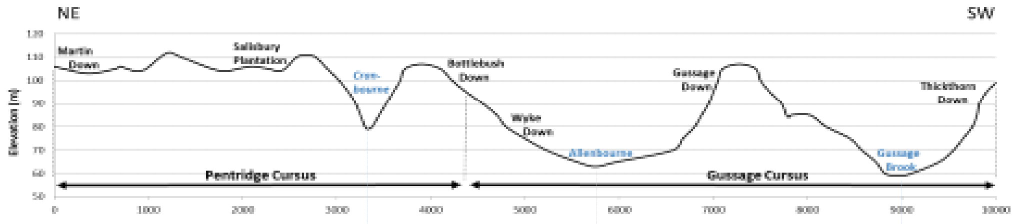
The alignment of the Gussage Cursus and south portion of the Pentridge Cursus is sub-perpendicular to interfluve ridges and broad stream valleys on the chalk downs (Figure 1.3 and Figure 4.2). The aspect of most slopes along the alignment approximate the local longitudinal direction of the cursus, particularly along the Gussage Cursus. The cursus’ alignment is nearly at right angles to crestlines of interfluves on Thickthorn Down, Gussage Down and Bottlebrush Down, and proximal to the respective interfluve’s maximum elevation along the ridgeline at those locations. The north portion of the Pentridge Cursus is aligned subparallel to the orientation of the ridge upon which it was constructed (Figure 1.3, Figure 4.7, Appendix G Profile G.12).

4.2.2 Geology, Pedology, Topography

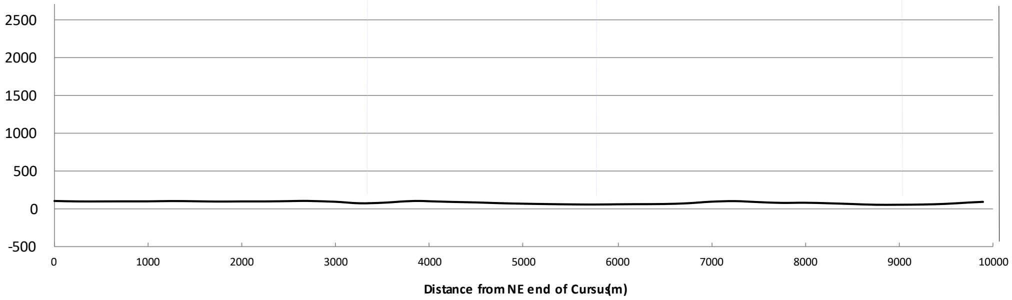
About 8 km (80 per cent) of the Dorset Cursus was constructed where the Chalk is encountered immediately beneath a thin, commonly rendzinic soil profile (French *et al*. 2007; NSRI 2017; NSRI 2018). River and stream valleys crossed by the cursus are underlain by chalk of the Newhaven Formation, while incomplete sections of the Tarrant Member of the Culver Formation are located in upper portions of interfluvial ridges situated between the valleys (Figure 4.8). The Gussage Cursus is founded on chalk of the Newhaven Formation for most of its length, the exception being the Tarrant Member of the Culver Formation that overlies the Newhaven along the upper slopes of Gussage Down.

Similarly, other than Tarrant chalk encountered for about 300 m in the upper portion of the ridge at Bottlebrush Down, the Pentridge Cursus was constructed on Newhaven chalk between the south terminus of the cursus and the vicinity of Pentridge 4 long barrow located in Salisbury Plantation. The cursus continues across the Tarrant Member before encountering Newhaven chalk along the last 650 m of the monument’s approach to its north terminus on Martin Down. As such, the alignment of the Dorset Cursus is situated above the base of the secondary escarpment encountered above the

Dorset Cursus Centerline Profile



vertical exaggeration - 25:1



vertical exaggeration - 1:1

Dorset Cursus aspect ratio Δh/Δw: 49:9970 ~ 1:203

Alignment-enclosed aspect ratio Δh/Δw (height/width) = 49/9970 = 0.0049

arcsin 0.0049 = 0.2815 degrees = 0^{o} 16’ 53.74”

Δh north to south = 106 m – 99 m = 7 m, Δh/Δw = 7/9970 = 0.0007

arcsin 0.0007 = 0.0402 degrees = 0^{o} 02’ 24.82”

Figure 4.7: Ground surface profiles along the centerline of the Dorset Cursus, one illustration with 25x vertical exaggeration, and one with no vertical exaggeration. View is toward the southeast.

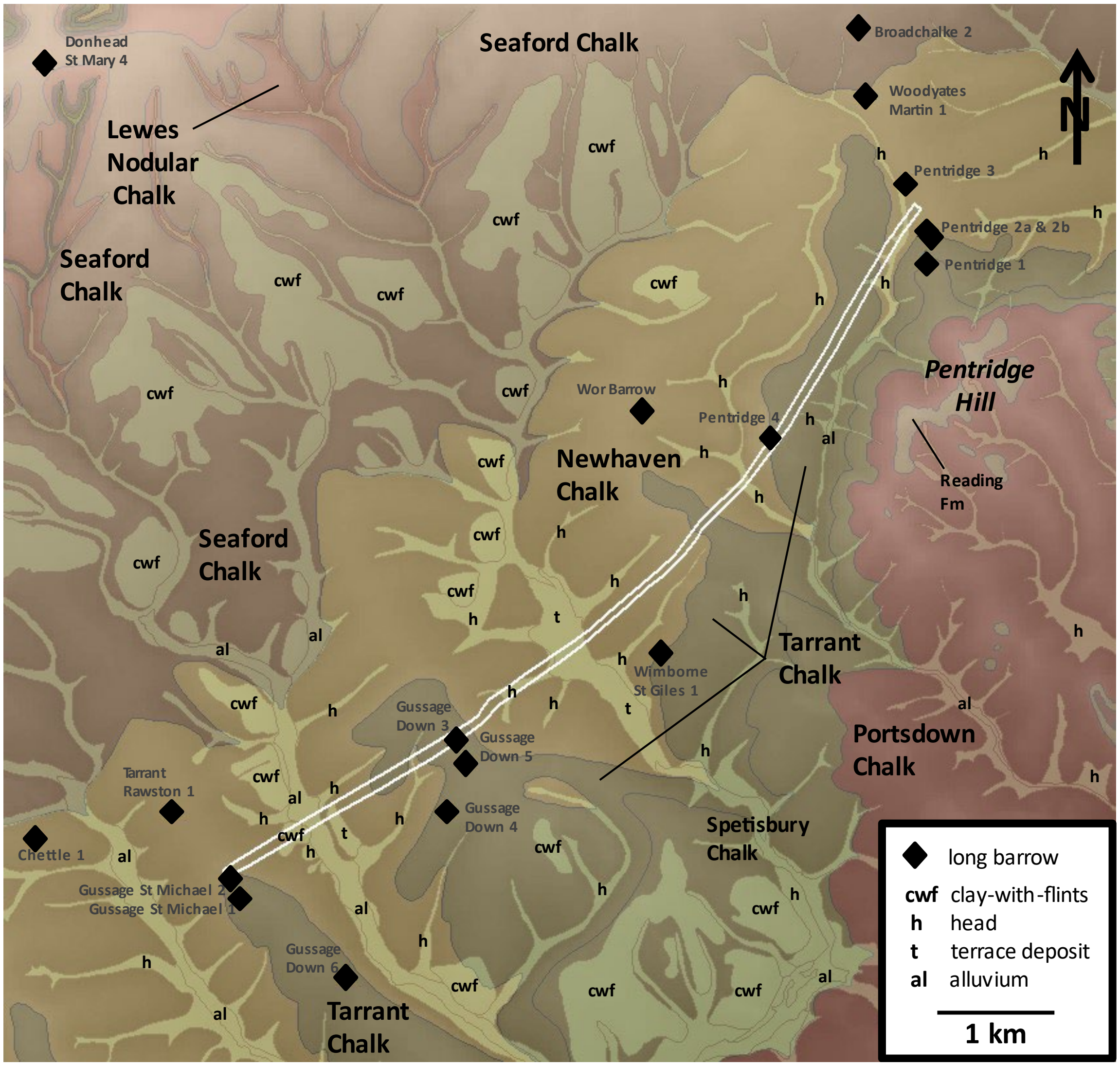


Figure 4.8: Geologic map showing locations of long barrows in the vicinity of the Dorset Cursus overlying formations of the Chalk. The earthen monuments occupy an area underlain by Seaford and Newhaven formations and Tarrant Member of the Culver Formation. Base geologic map courtesy BGS (2018).

contact between the Seaford and Newhaven chalks and capped by Culver Chalk. The cursus crosses interfluves capped by the Chalk of the Tarrant Member of the Culver Formation, and rises above surface elevations west of the alignment where the dip slope is underlain by Seaford and Newhaven chalks.

Soils encountered along most of the length of the Dorset Cursus consist of brown and grey rendzinas of the Andover 1, Combe 1 and Upton 1 soil associations (NSRI 2018). The Andover 1 soil association is encountered along the majority of the cursus, commonly on hillslopes and crests. The Combe 1 soil association is found along the lower portion of the slope on Thickthorn Down, across the valley bottom of the Allenbourne, and lower portion of the Gussage Down slope to the southwest. The Upton 1 soil association is encountered along the lower portion of the valley sideslope of Gussage Brook north of the stream, as well as along the northern 1 km of the Pentridge Cursus between Pentridge and the terminus on Martin Down. Lastly, the Frome soil association, consisting of shallow calcareous and non-calcareous loamy alluvial soils over flint gravel affected by groundwater, is encountered where the Gussage Cursus crosses the Gussage Brook floodplain.

Dorset Cursus is situated southeast of extensive areas of Clay-with-flints that overlie Seaford Chalk along upper elevations of the dip slope southeast of the Chalke Escarpment (Barrett *et al*. 1991a; Green and Allen, 1997; French *et al*., 2007; NSRI 2018) (Figure 4.9). Only about 2 km (20%) of the Dorset Cursus was constructed across stream valley bottoms and interfluve slopes where sediments are encountered between the chalk bedrock and overlying soil cover. Slopes where the cursus is underlain by Head include portions of hillsides on Gussage Down and the low-gradient southeast-facing slope on which the majority of the Pentridge Cursus is situated north of Pentridge 4 long barrow. Clay-with-flints along the cursus monument's alignment is limited to a length of about 0.2 km developed on Newhaven Chalk west of Gussage Brook. The cursus then crosses about 0.3 km of alluvium and river terrace deposits in the vicinity of the brook before rising upslope toward Gussage Down. The Gussage Cursus then crosses about 0.5 km of clayey and silty Head before crossing about 0.4 km of river terrace and flood plain deposits of the Allenbourne. Farther north, the Pentridge Cursus crosses about 0.25 km of Head associated with a bourne of the River Crane south of Salisbury Plantation, and another 0.15 km of Head north of Pentridge before terminating on Martin Down. In summary, about 8.2 km (82%) of the cursus's length was constructed where chalk would have been encountered below thin rendzina soils, while only about 1.8 km (18%) of the alignment was underlain by Clay-with-flints, Head, terrace sands or alluvial sediments where chalk would generally have been encountered at greater depth.

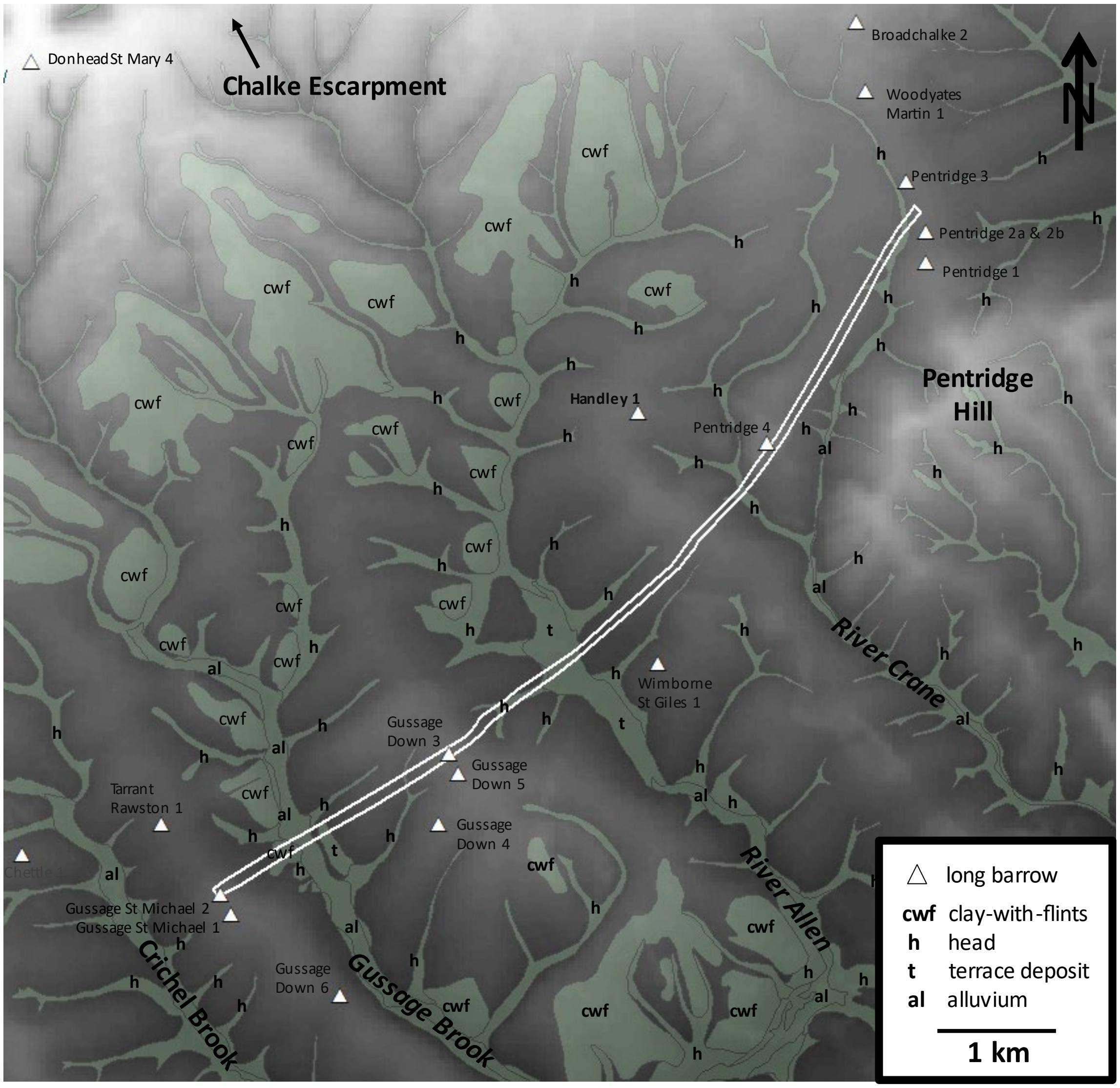


Figure 4.9: Geologic map showing locations of long barrows and the Dorset Cursus constructed over Quaternary sediments. The sediments generally include Head, terrace deposits and/or alluvium. Other than a small area near the south end of the cursus on Gussage Down, the cursus monument is not sited where Clay-with-flints is located. Base geologic map courtesy BGS (2018).

4.2.3 Alignment Geometry

The Dorset Cursus was constructed across the dip slope on the Chase, crossing interfluves and river and stream valleys eight- to nine kilometers from the crestline of the Chalke Escarpment (Figure 4.2, Figure 4.9). Figure 4.10 includes eight ground surface profiles along NW-SE trending lines between Winklebury Hill at the crest of the Chalke Escarpment and the central portion the Chase. The location of the Dorset Cursus is indicated on each profile. As indicated in each profile, the cursus was situated such that the

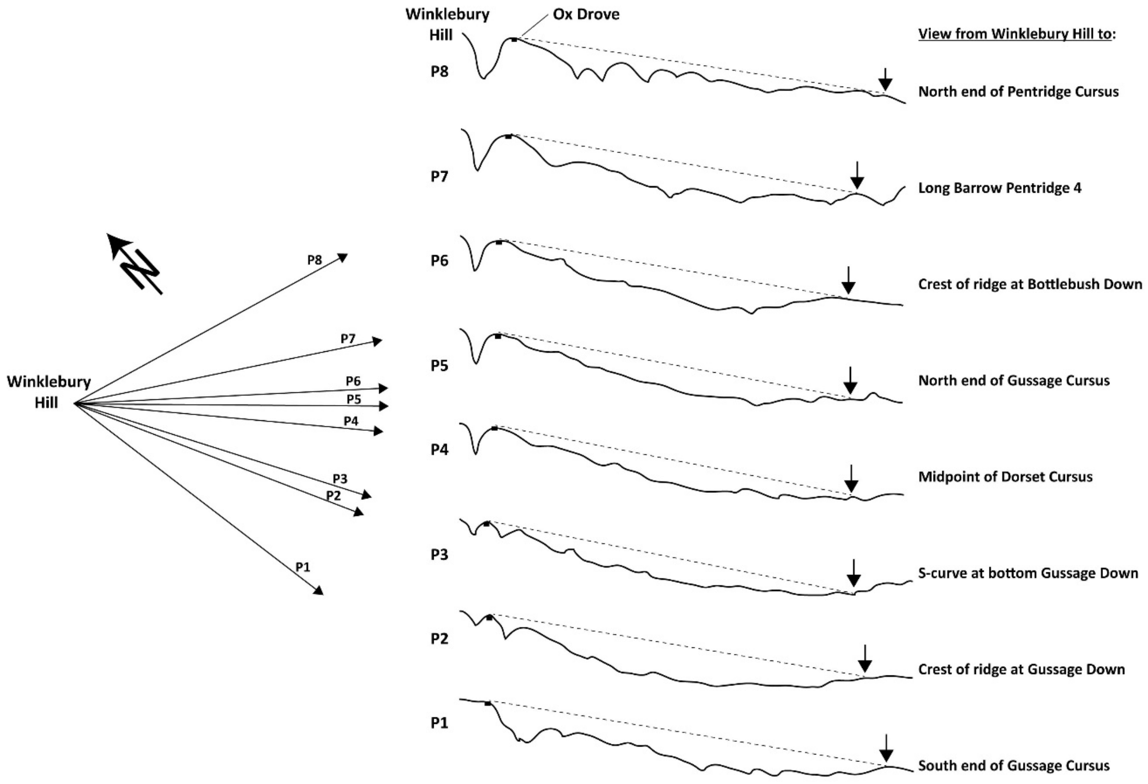


Figure 4.10: Eight ground surface profiles between the Ox Drove at Winklebury Hill and the Dorset Cursus. The profiles were obtained from the DEM using ArcMap. Orientations of the profiles are illustrated on the left. Arrows above each profile on the right indicate the location of the Dorset Cursus. As indicated, the cursus is visible from the Ox Drove along each of the sightlines.

monument is within the viewshed from upper elevations of the escarpment. Of the total length of the Dorset Cursus, 9500 m (95 per cent) is visible from upper elevations of the cuesta between Ashmore Down and South Down. Appendix G includes twelve additional ground surface profiles between Winklebury Hill and locations southeast of the Dorset Cursus. The profiles illustrate cross sections beginning at the south end of Gussage Cursus (Profile G.2) and ending at the north end of Pentridge Cursus (Profile G.13).The cursus is visible from Winklebury Hill along eleven of the twelve profiles.

Some sections of the Dorset Cursus alignment such as those between Thickthorn Down and Gussage Down, and between Salisbury Plantation and Martin Down, are nearly straight. Slight S-shaped or reverse curves along the alignment are located on the northeast-facing slope of Gussage Down and the southwest-facing slope of Bottlebrush Down

(Figure 4.11). A transverse-oriented ground surface gradient is located on the lower slope of Gussage Down, immediately east of the cursus.

Aside of the above-reference breaks in alignment, including the two slight S-curves, the cursus appears to form a broad arc across the landscape. The curvilinear alignment of the Dorset Cursus is apparent in plan view (Figure 1.3 and Figure 4.9). Latitudes and longitudes of the thirty-three point locations recorded along the alignment of the Dorset Cursus were plotted and a best fit line (a second-order parabolic polynomial $y = 4.346x^2 - 17.926x + 69.397$) was drawn through the resulting alignment, the regression analysis providing a near-perfect approximation ($R^2 = 0.9962$) of the real data points (Figure 4.12).

The alignment of the monument also may be modeled as a circular curve. Approximately 92 per cent (about 9150 m) of the curve forms an arc length of 42 degrees contained between the north and south lateral ditches and banks (Figure 4.14). The chord of the arc has a length of 9800 m bearing 226 degrees between the north terminus of the Pentridge Cursus and the south end of Gussage Cursus. The perpendicular bisector to that chord has a bearing of 136 degrees. The circular arc has a radius of between 13,840 m to 13,950 m centered at the village of Donhead St. Andrew, Wiltshire. (Figure 4.13). The apex of Winklebury Hill (ST 951 212, elev. 260 m.) and Wimborne St. Giles long barrow (SU 015 147, elev. 81 m.) are located along the bearing of the perpendicular bisector. Measured from the top of Winklebury Hill, the north end and south end of Pentridge Cursus are aligned on a bearings of 101 degrees and 129 degrees, respectively, and the south end of Gussage Cursus is observed at a bearing of 168 degrees.

Nearly all (~ 4790 m) of the length of Gussage Cursus follows a circular curve fitted within the 90- to 100 m width between the two lateral ditches. The only portion of the Gussage Cursus not contained within that curve is located along and north of the S-curve on the east side of Gussage Hill. The chord of the arc of Gussage Cursus has a length of 5645 m bearing 235 degrees between the north to south termini. The perpendicular bisector to that chord has a bearing of 145 degrees. The Ox Drove alongside the crest of the Chalke Escarpment intersects the perpendicular bisector of the Gussage Cursus at an elevation of 248 m on the west side of Winklebury Hill (ST 946 206). From that vantage

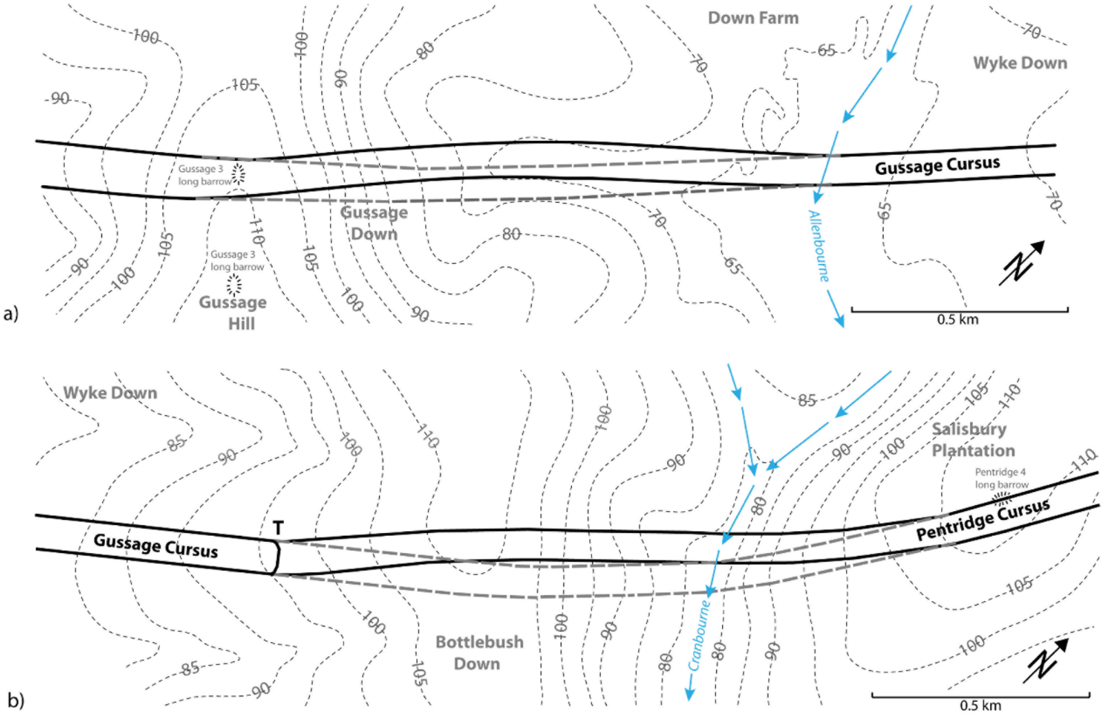


Figure 4.11: S-curves along the Dorset Cursus alignment. a) reverse curve east of Gussage Hill; b) reverse curve crossing Bottlebrush Down and valley of the Cranbourne

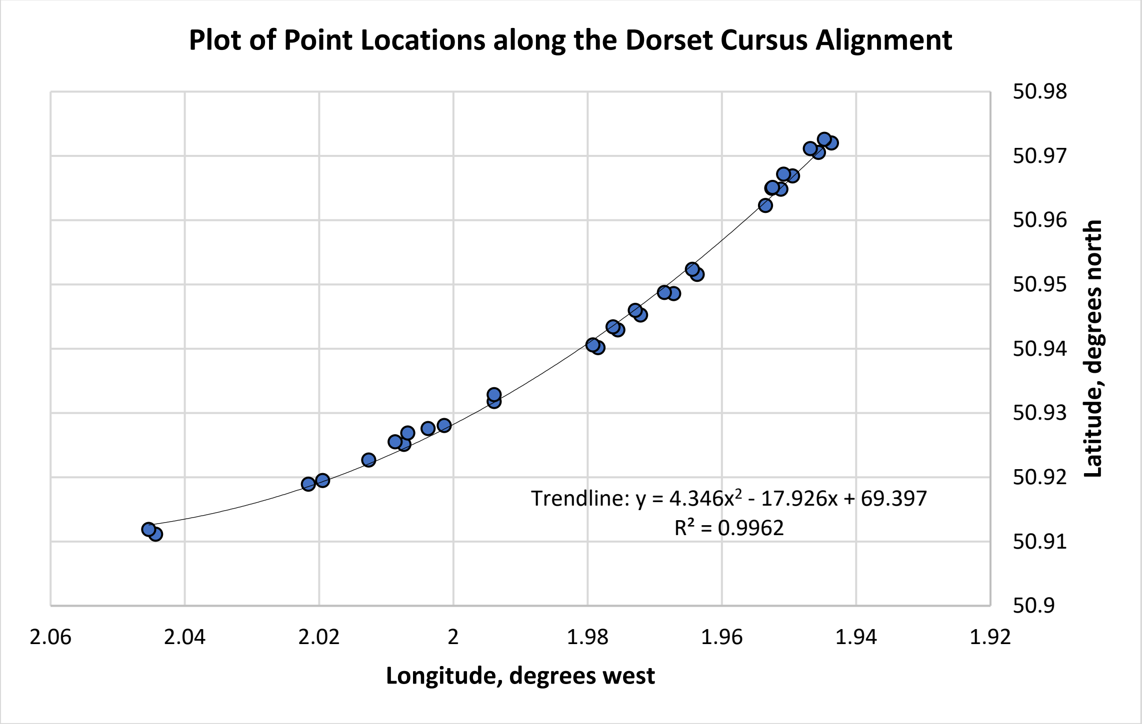


Figure 4.12: Chart showing plot of 33 point locations along the alignment of the Dorset Cursus

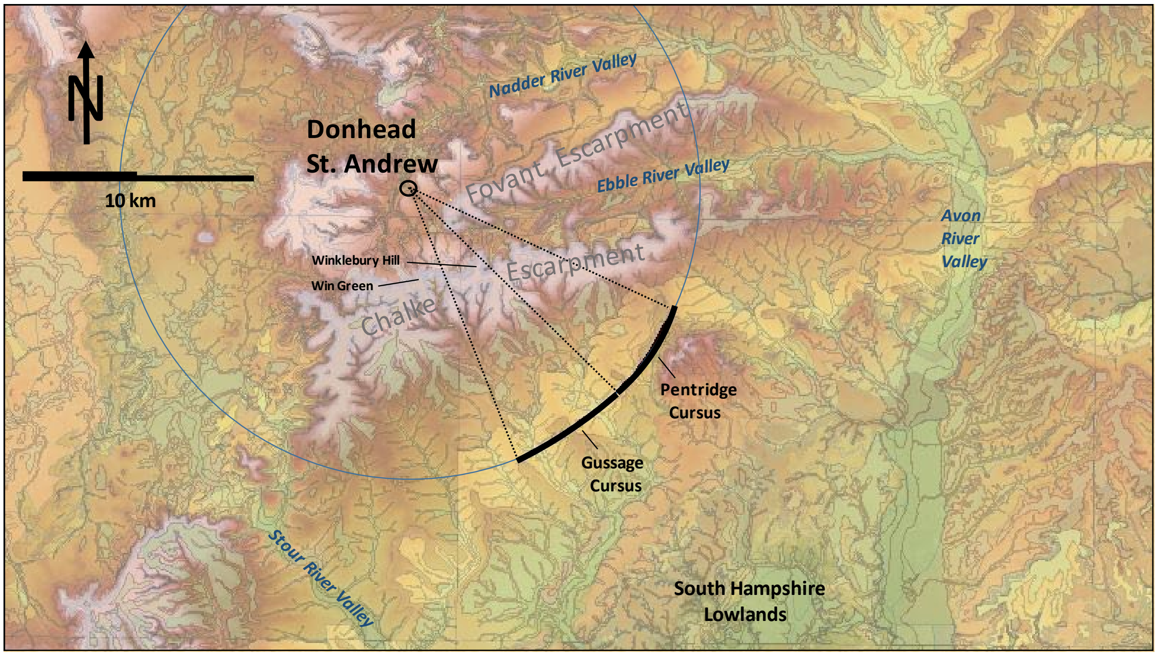


Figure 4.13: The circular arc contained between longitudinal ditches of the Dorset Cursus has a radius of between 13,840 m and 13,950 m, centered at the village of Donhead St. Andrew, Wiltshire. The perpendicular bisector of the cursus passes through Winklebury Hill.

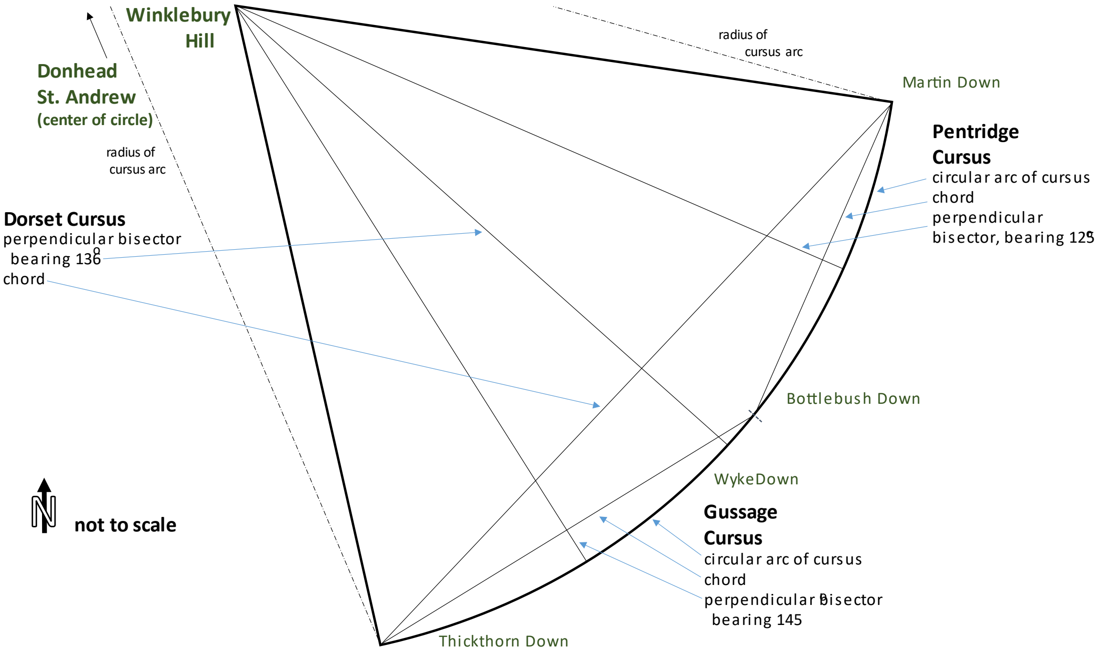


Figure 4.14: Geometric model of the Dorset Cursus alignment. The alignment may be modeled as a circular curve along which 92 per cent (about 9150 m) of the cursus forms an arc length of 42 degrees contained between the north and south lateral ditches and banks of the monument.

point the north and south ends of Gussage Cursus are apparent at bearings of 126 and 164 degrees, respectively. Long barrows Gussage Cow Down 3 and Gussage Cow Down 4, each located along the ridgeline between Gussage Brook and the Allenbourne, are within about 0.5 degree of the bearing of the perpendicular bisector as viewed from the intersection of the bisector and the Ox Drove. Observed from the top of Winklebury Hill, Gussage Cursus provides an arc length of about 39 degrees between bearings of 129 and 168 degrees.

Ninety-nine percent (4360 m) of Pentridge Cursus is aligned along a circular curve similar to the one defining the majority of Gussage Cursus. The only portion of Pentridge Cursus not located along that curve is the northern-most 40 m approaching the north terminus on Martin Down. Pentridge Cursus provides an arc length of about 28 degrees between bearings of 132 and 104 degrees. The chord of the arc of Pentridge Cursus has a length of 4310 m bearing 215 degrees from north to south termini. The perpendicular bisector to that chord has a bearing of 125 degrees. The Ox Drove intersects the perpendicular bisector at an elevation of 229 m at Trow Down (ST 972 204), 2 km east of Winklebury Hill. From that vantage point the south end of Pentridge Cursus is apparent at a bearing 142 degrees. The north end of Pentridge Cursus is not apparent from that location. However, long barrow Pentridge 1, located about 0.5 km south and 9 m above the north end of the cursus, and oriented along a ridge overlooking the cursus, is apparent at a bearing of 110 degrees.

4.3 Summary of Long Barrow, Cursus and Physiographic Orientations

Table 4.11 provides a summary of orientations related to long barrow longitudinal axes, bearings of chords and perpendicular bisectors associated with the Dorset, Gussage and Pentridge cursuses, and valleys and ridges of the Chase located south of Pentridge Hill. It is notable that the bearing of the perpendicular bisector of the circular curve modeled for the Gussage Cursus (145 degrees) is equivalent to the average downstream orientation of the stream valleys it crosses and less than one standard deviation of the mean orientation of southeast-oriented long barrows and azimuths of valleys and ridges, the directional vectors drawn from the earthen monuments and natural physiographic features having a common population of directions toward the southeast.

Table 4.11
Summary of Long Barrow, Cursus and Physiographic Orientations

Item	Orientation (degree)
Long Barrows	
Up-barrow SE bearing (n=28)	148±15 (68%), 148±30 (95%)
Dorset Cursus	
Chord bearing	226
Perpendicular bisector bearing	136
Gussage Cursus	
Chord bearing	235
Perpendicular bisector bearing	145
Pentridge Cursus	
Chord bearing	215
Perpendicular bisector bearing	125
Valleys and Ridges	
Stream Valleys - average downstream bearing	145.0
Ridges - average down gradient bearing	149.3
Valleys and Ridges, mean azimuth	146.6
Valleys and Ridges azimuth	146±8 (68%), 146±16 (95%)

4.4 Winklebury Hill

The viewshed from the apex of Winklebury Hill (50º 59’ 15.17” N 2º 04’ 18” W; ST 951 209; elev. 260 m) above the Ox Drove, trending southwest-northeast below and subparallel with the crest of the Chalke Escarpment between Win Green and Trow Down, includes a southeasterly view of the Chase south of Pentridge Hill and the SHL beyond (Figure 4.15, Figure 4.16, Appendix G Profiles G.2 through G.13). The English Channel is apparent between the Needles at the west end of the Isle of Wight and the east end of the Purbeck Monocline near Studland at the east end of the Isle of Purbeck. Table 4.12 lists some of the geographic and cultural features of the study area and surrounding environment that are visible from Winklebury Hill. The list assumes a viewshed unhindered by vegetation. The viewshed includes Gussage Cursus, Pentridge Cursus, and all long barrows located southeast of the Chalke Escarpment and south of the north terminus of the cursus. Those long mounds include the two long barrows located on Hambledon Hill, 13.5 km southwest of Winklebury Hill, and Tarrant Rawston 1 long barrow on Luton Down, 14.5 km south-southwest of Winklebury Hill. Also, potential sightlines exist between the apex of Winklebury Hill and locations of the two long barrows in the SHL (Verwood 1 and Holdenhurst), distances of about 18 km and 31 km, respectively. In addition, a sightline exists between Winklebury Hill and the anomalous ‘short’ long barrow at Knowle Hill Farm (SU 403062 110415) located about 13.3 km to the southeast. Pentridge 1 long barrow is visible from vantage points along the crest of the Chalke Escarpment between Ashmore Down and Winklebury Hill, including Win Green.

Figure 4.15 illustrates the viewshed from four locations along the crest of the Chalke Escarpment – Win Green, Winklebury Hill, Trow Down and South Down. Most of the length of the cursus is visible from vantage points located between Win Green and Trow Down. Farther east along the top of the escarpment, including at South Down, portions of Gussage Cursus become unobservable, such as the west-facing slope between North Farm along Gussage Brook and the crest of Gussage Down. The crest of the escarpment farther east decreases in elevation, and the ridge at Stonedown Wood prevents viewing Pentridge Cursus and all long barrows east of Gussage Hill.

A geologic cross-section between Winklebury Hill and the Dorset Cursus on the crest of Gussage Down is shown in Figure 4.17. Locations of surface contacts between formations shown in the profiles are based on BGS (2018a). Thicknesses of chalk formations illustrated in the profile are based on stratigraphy of the White Chalk Subgroup in Dorset and Hampshire described by Hopson (2005). The profile indicates a chalk dip slope of about four degrees to the south-east based on mapped contacts between formations (BGS 2018).

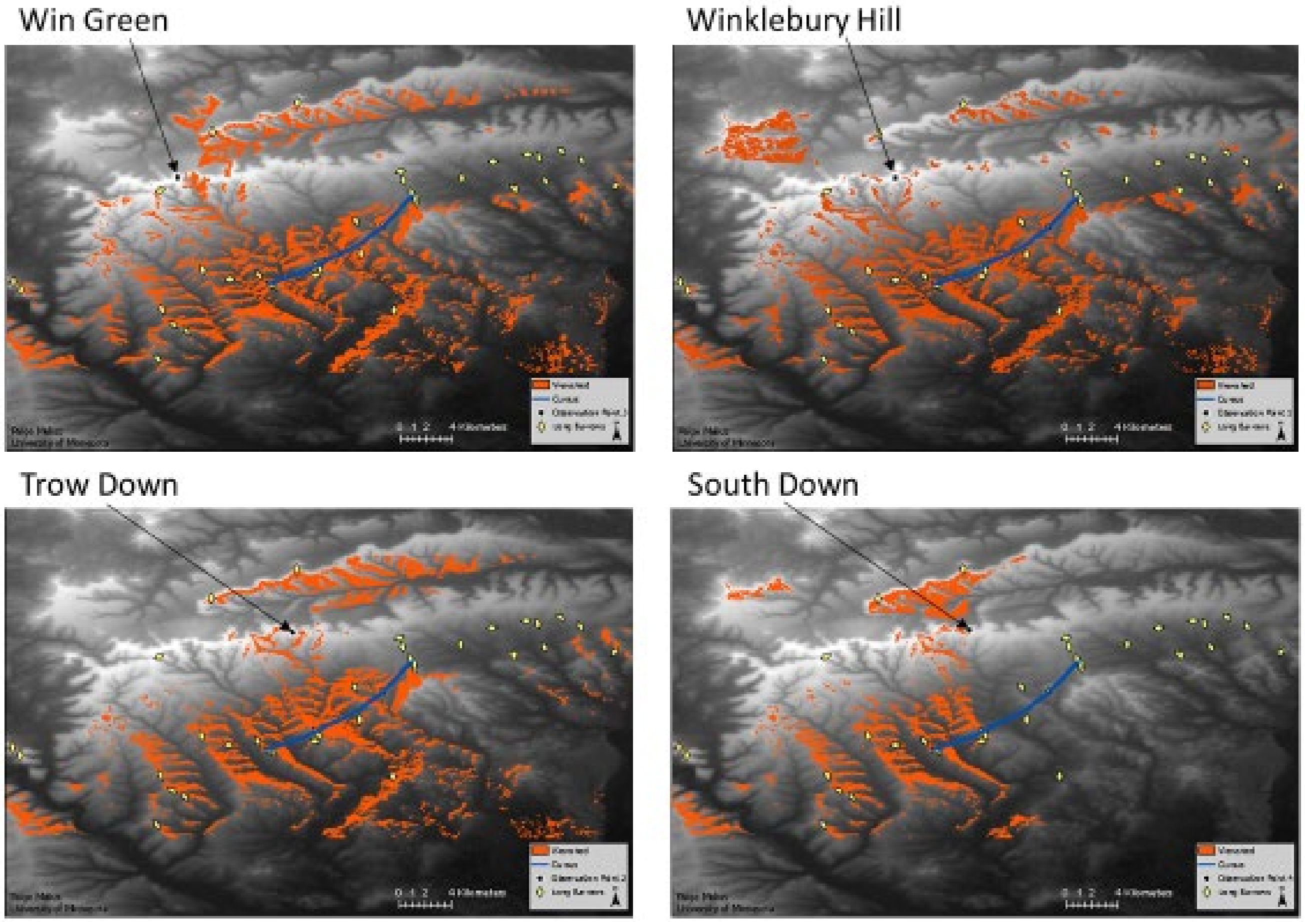


Figure 4.15: Viewshed across Cranborne Chase from four locations along the crest of the Chalke Escarpment. Almost the entire alignment of the Dorset Cursus is apparent from locations between Win Green and Trow Down, including Winklebury Hill. (Based baps prepared by P. Melius)

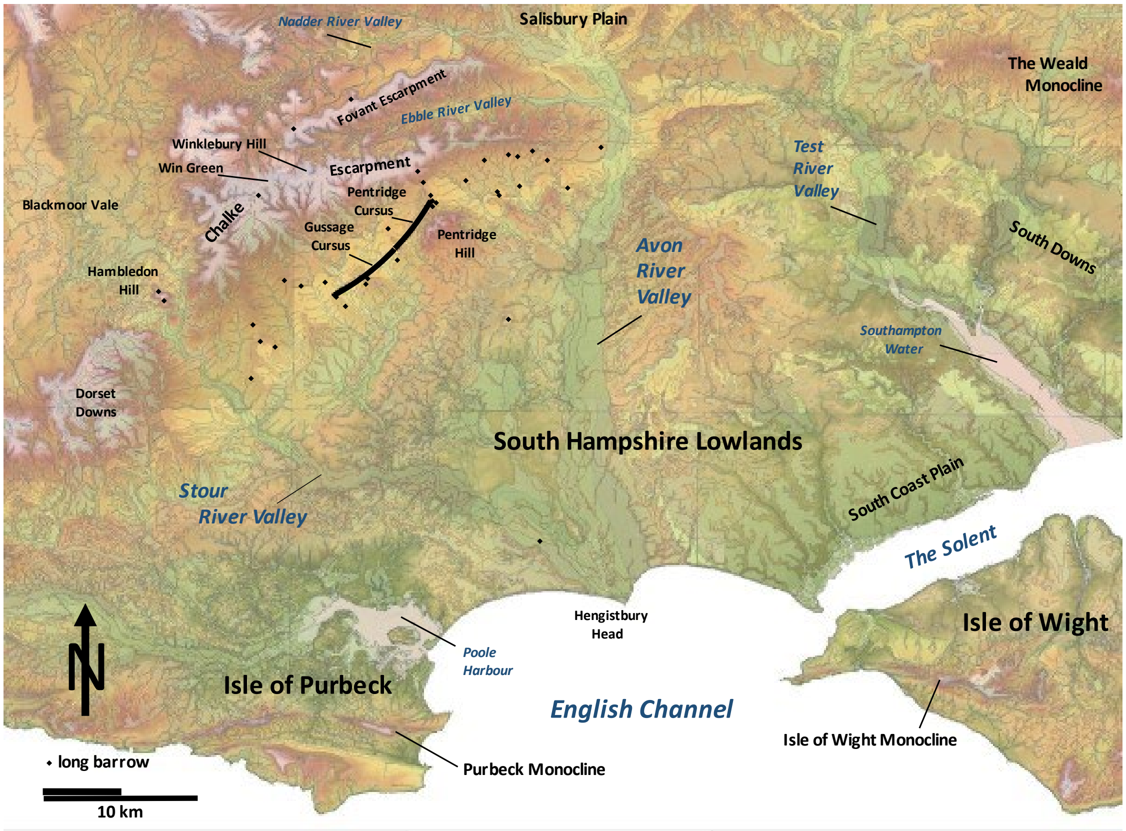


Figure 4.16: Map of the study area and adjoining landscapes of south-central Britain. The viewshed toward the southeast from the Chalke Escarpment between Win Green and Winklebury Hill includes Cranborne Chase, the SHL, and the English Channel between the Isle of Purbeck and the Isle of Wight.

Table 4.12
Natural and Cultural Features of the Landscape
Observable from the Apex of Winklebury Hill

Location	Azimuth (degrees)	Distance (km)
North end Pentridge Cursus	101	9
Pentridge 1 Long Barrow	103	9
Pentridge 4 Long Barrow	118	9
S. end Pentridge Cursus/N. end Gussage Cursus	129	9
Saddle of Isle of Wight Monocline at Freshwater Bay	132	53
Wimborne St Giles Long Barrow	134	9
West end of Isle of Wight Monocline	136	50
English Channel	136 - 166	45
Hengistbury Head	143	37
Holdenhurst Long Barrow	148	31
Gussage 3 & 4 Long Barrows	149	9
East End of Purbeck Monocline at Studland	166	41
South end Gussage Cursus	168	9
Chettle 1 Long Barrow	180	8

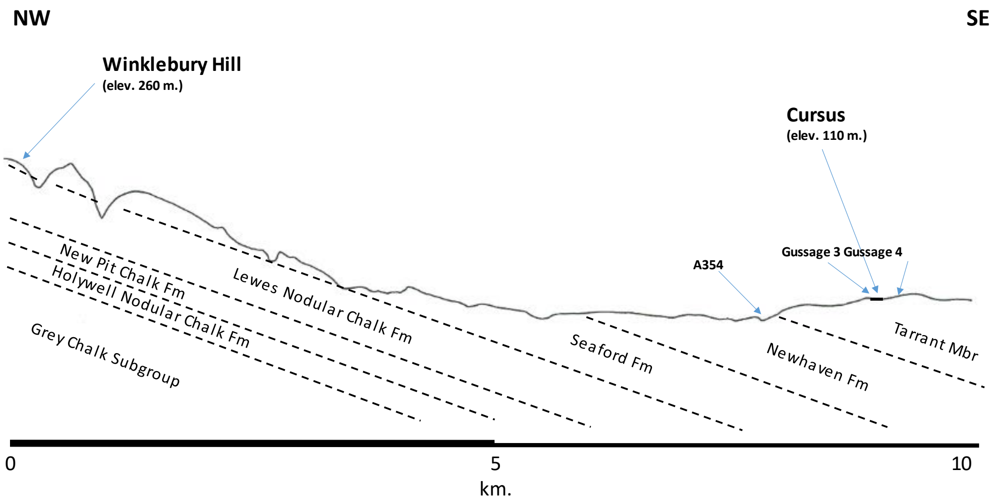


Figure 4.17: Geologic cross-section between Winklebury Hill and the Dorset Cursus on the crest of Gussage Down. The viewshed from the apex of Winklebury Hill includes the cursus alignment and nearby long barrows. Locations of surface contacts between formations based on BGS (2018).

The crest of the Chalke Escarpment between Win Green and Winklebury Hill attains elevations exceeding the surrounding landscape between the Mendip Hills 40 km to the northwest and Pewsey Basin to the north in central Wiltshire, and the English Channel and the ridgeline of the Purbeck-Isle of Wight Monocline to the south and southeast. Appendix G includes a ground surface profile along the length of the Dorset Cursus and twelve additional ground surface profiles between the Droveway on Winklebury Hill and locations up to 24 km to the southeast. The location of the Dorset Cursus is indicated on each profile. Similar to profiles included in Figure 4.17, the cursus is located within the viewshed of Winklebury Hill. The profiles demonstrate that adjustment of the alignment of the cursus from its as-built location to the northwest or southeast might have prevented observation of the monument along those orientations because of topographical constraints. Figure 4.18 includes a mapview of sightlines from Winklebury Hill toward the termini and centerpoint of Gussage Cursus. Figure 4.19 provides an aerial oblique view from above the Chalk Escarpment toward the southeast.

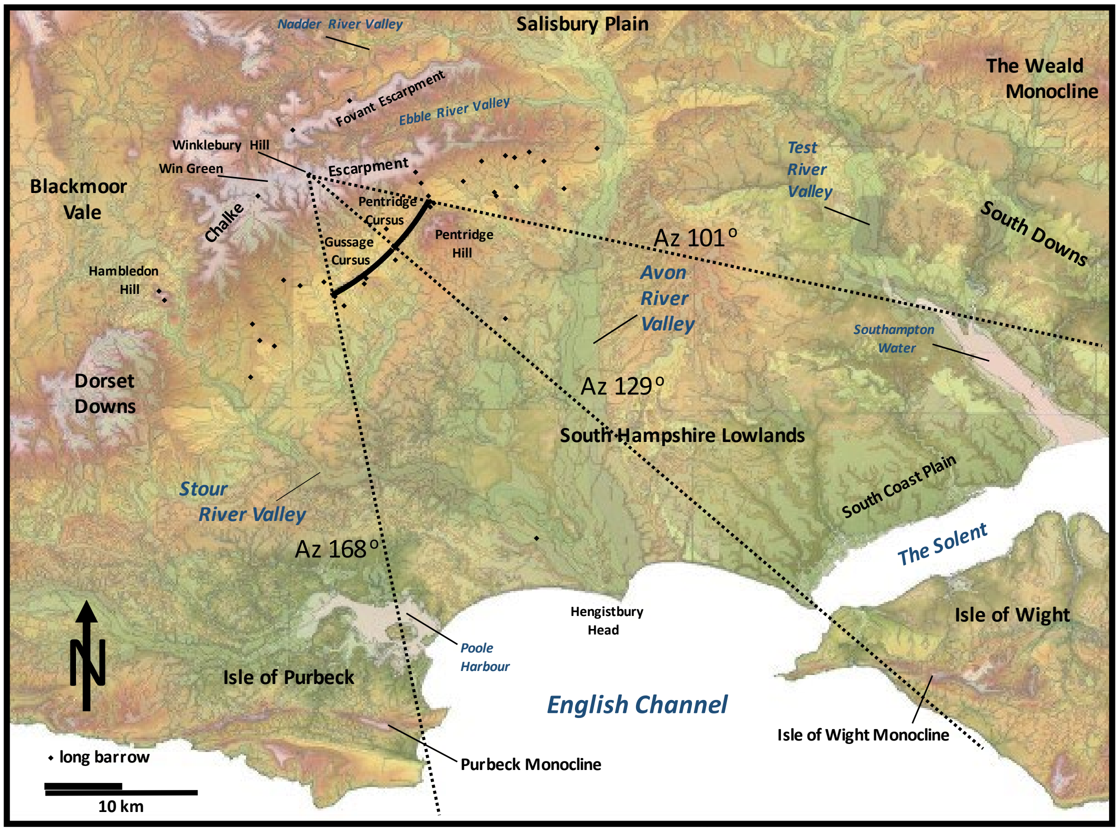


Figure 4.18: Map of the study area and adjoining landscapes, showing sightlines from Winklebury Hill through the termini of Gussage Cursus, and beyond.

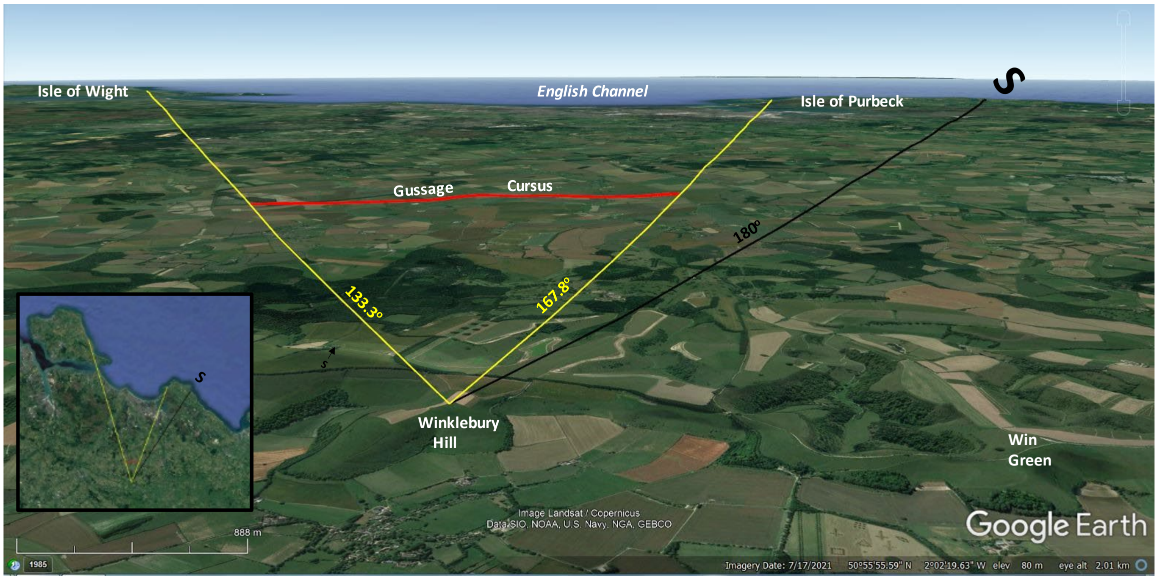


Figure 4.19: Oblique view toward the southeast from above Winklebury Hill, showing sightlines through the north and south termini of Gussage Cursus and the distant horizon including the English Channel between the Isle of Wight and the Isle of Purbeck. Azimuths of the cursus' termini and the sightline South of the observation point are indicated. Inset is a map view of study area and surrounding landscape. Base photo courtesy of Google Earth.

4.5 Archaeoastronomical Analysis

4.5.1 General Findings and Information

Based on results of the analysis of long barrow orientations, interfluve and valley orientations, and the alignment geometry of the Dorset Cursus described above (Section 4.1.3 Alignment Geometry), the key location for studying astronomical events potentially related to the cursus was determined to be the apex of Winklebury Hill (ST 951 212, elev. 260 m.). In general, that location was chosen based on 1) Winklebury Hill's position at the intersection of the crest of the Chalke Escarpment and the perpendicular bisector of the Gussage Cursus, and 2) its elevation of 260 m., second only to the apex of Win Green (277 m) located 2.5 km to the west along the ridgeline of the cuesta. The viewshed at Winklebury Hill includes a virtually level horizon (altitude <+0.5 degree) in all directions. The highest point along the southeastern horizon is St Boniface Down rising to 241 meters on the Isle of Wight. To the south, Swyre Head at 208 m is the highest point of the Purbeck Hills and the Isle of Purbeck, Dorset. The analysis evaluated alignments extending from Winklebury Hill through the termini of Gussage and Pentridge Cursuses to the horizon, and relationships between those orientations and stellar events at and above the horizon. The analysis considered alignments with the 39 brightest stars (magnitude less than +2.50 determined by the maximum visual magnitudes as viewed from Earth) observed in the southeast quadrant of the sky (azimuths of 90 to 180 degrees with 0º horizon; declinations of 0 to -39 degrees).

Based on results of that analysis, sets of stars were evaluated with respect to spatial and temporal alignment with Dorset Cursus, local and regional geographic points of interest (such as prominent hilltops and hydrologic features) and significant locations of potential cultural interest in the skyscape such as the horizon and south meridian. A virtual skyscape above the Chase was analyzed using Starry Night Enthusiast to evaluate the spatial and temporal conditions. The analysis included documenting the calculated azimuth and altitude of stars during the years 4000 BC, 3800 BD, 3500 BC, 3350 BD, 3200 BC and 3000 BC. Those years correspond generally to the beginning of the British Neolithic, the estimated beginning of British long barrow construction, the middle of the 4th millennium, the mean date of construction of the Dorset Cursus, the estimated end date of long barrow construction, and the end of the British Middle-Neolithic, respectively.

The crestline of the Chalke Escarpment between Win Green and Winklebury Hill provides an unobstructed view of the skyscape with a 0 degree horizon altitude in all directions. Declinations of stars rising in the southeast quadrant of the horizon azimuths of 90 to 180 degrees with 0° horizon viewed from Winklebury Hill c. 3800-3200 BC ranged from 0 to -39 degrees. The calculated obliquity of the ecliptic ranged from 24° 05’ 41” in 3800 BC to 24° 02’ 07” in 3200 BC. During that period sunrise viewed from Winklebury Hill occurred at a minimum azimuth (summer solstice) of 49° 34’ 08” and maximum azimuth (winter solstice) of 130° 25’ 52”. Sunrise during vernal and autumnal equinoxes, of course, occurred due East (azimuth 90°) at a declination of 0°.

4.5.2 Skyscape Analysis

Appendix A describes methods for determing earthen monument orientation and alignment with astronomical events. Appendix B includes background astronomical information related to lunar orbital inclination, stellar visibility near the horizon, lists of the brightest stars seen from the study area c. 4th millennium BC, and discussion of relationships between azimuth, stellar declination and right ascension as they pertain to archaeostronomical analyses. Appendix C reviews accuracy of star position data derived from commercial astronomical programs, including Starry Night Enthusiast, version 4.5 used in this study.

Nearly all 10 km of the length of Dorset Cursus follows a circular curve fitted within the 90- to 100 m width between the two lateral ditches. A circle is the curve along which all points in a plane are equidistant from a given point (the focus). Given the circular curvature of the Dorset Cursus along almost its entire alignment and the perpendicular bisector of the curve passing through Winklebury Hill, we assume that the crest of the Chalke Escarpment at that location was the point of observation of the cursus. In otherwords, Winklebury Hill is the focus of the cursus’ circular geometry within the context of Cranborne Chase. We assume the apex of Winklebury Hill was used as the point for observation of the landscape and skyscape during construction and use of the monument during the latter half of the 4th millennium. That location serves as the focus for the archaeoastronomical analysis. The analysis assumes the length, location, orientation and geometrical configuration of the cursus was designed to signify a relationship not only with the landscape upon which it was constructed, but toward celestial events above.

The curvilinear geometry of the cursus results in an alignment along which the distance between the cursus and the apex of Winklebury Hill varies by only 6.6 to 7 percent, between 8500 and 9100 m, along the 10 km length of the earthen monument, the center of curvature passing through crestline of the Chalke Escarpment at the hill. In addition, while the cursus rises and falls along the natural topography of the Chase, from the perspective of observation at Winklebury Hill the cursus generally appears sub-parallel with the southeast horizon above it (Figure 4.7, Figure 4.19), from the north end of Pentridge Cursus (azimuth 103° = declination -7°), to the north end of Gussage Cursus (azimuth 131° = declination -27°) and the south end of Gussage Cursus (azimuth 168° = declination -38°) (Figure 4.18, Figure 4.19). The range of azimuths of Dorset Cursus from the point of observation is 67 degrees (103° to 168°), equivalent to 73% of the southeast skyline.

Viewed from the apex of Winklebury Hill, Gussage Cursus (azimuthal range 129° to 168°) underlies 41% of the southeast horizon. Astronomical declinations of the horizon above the north and south ends of Gussage Cursus c. 3350 BC are -23° and -38°, respectively. Review of stars listed in Table B.2 shows two stars rose within one degree of -23° declination: Sirius (dec. -23.75; mag. -1.47) and Menkar (dec. -23.6; mag. 2.515). Sirius is the brightest of all stars. Given the difference in apparent magnitude of the two stars, Sirius appears about 40 times brighter than Menkar, and is therefore a better candidate for an alignment with the north end of Gussage Cursus. Review of stars listed in Table B.2 shows no stars rising within one degree of -38° declination, equivalent to the azimuth direction toward the south end of Gussage Cursus.

Table B.2 lists two stars within one degree of -7° declination, the equivalent azimuth direction (101 degrees) of the north end of Pentridge Cursus: Aldebaran (dec. -7.00; mag. 0.85) and Menkent (dec. -7.27; mag. 2.058). Aldebaran is the seventh brightest star that could have been observed at the study area during the Neolithic. Given the difference in apparent magnitude of the two stars, Aldebaran appears about 3 times brighter than Menkent, making it a better candidate for an observed alignment with the north end of Pentridge Cursus. At the horizon (alt. 0.00°) Aldebaran was located at azimuth 101.1692°, and at an altitude of 1.00° at azimuth 102.4167°.

Right ascensions of Aldebaran and Sirius are 23.90433 hr and 2.85638 hr, respectively. That is a difference of 2.95205 hr. In about 3350 BC Aldebaran crossed the horizon at azimuth 101.17º, above the location of the north end of Pentridge Cursus, and continued rising farther south. About four and a half hours later, Sirius was at the horizon at azimuth 129.79º, above the location of the north end of Gussage Cursus. Considering atmospheric extinction and the potential for humid conditions, the apparent or visual magnitude of Sirius (-1.47) might not have been bright enough to allow naked eye observation of the star at 0° altitude (Bender 2011). However, under suitable atmospheric conditions, Sirius can be observed above an altitude of about 1 degree (Ceragioli 1993). In 3350 BC Sirius could have been seen along an azimuth of 131º 25' at an altitude of 1 degree above the horizon. At that moment, Aldebaran was at an altitude of 31º 16' at an azimuth of 167º 31'. In other words, upon first observation of Sirius on the horizon above the north end of Gussage Cursus, Aldebaran appeared vertically above the south end of Gussage Cursus. At the moment Sirius was at the horizon (alt. 0.00º, az. 129.8º), the Pleiades were located at the south meridian (az. 180 degrees) with Alcyone at 179.8º azimuth, altitude 36.7º. Eight minutes later Sirius would have been apparent at 131.4º, altitude 1.0º, with Alcyone at azimuth 182.4º, alt. 36.6º.

The Pleiades would have been observed over the course of about 8 hours as they progressed skyward and southward toward the south meridian. A skywatcher could have anticipated the arrival of Sirius at the horizon by knowing the star became apparent upon the Pleiades reaching the south meridian. The question arises: Was this condition whereby the Pleiades could be observed crossing the vertical plane of the south meridian at the same moment Sirius crossed the horizontal plane of the horizon always the case at Cranborne Chase? If not, then when did it occur, and over what length of time could it have been observed?

A virtual skyscape above the Chase was analyzed using Starry Night Enthusiast to evaluate spatial and temporal conditions related to the rise of Sirius at the moment the Pleiades crossed the plane of the south meridian. The analysis included documenting the calculated azimuth and altitude of Alcyone, Aldebaran, Alnilam and Sirius at two times: when Alcyone was due South (azimuth 180.00º) of the apex at Winklebury Hill, and when Sirius was at the east horizon (altitude 0.00º). The azimuth and altitude of the four stars was recorded for those two events during the years 4000 BC, 3800 BD, 3500 BC, 3350 BD, 3200 BC and 3000 BC. Appendix D includes tables listing positions of those stars during that period. Those years correspond generally to the beginning of the British Neolithic, the estimated beginning of British long barrow construction, the middle of the 4th millennium, the mean date of construction of the Dorset Cursus, the estimated end date of long barrow construction, and the end of the British Middle-Neolithic, respectively. Note that the apex elevation at Winklebury Hill exceeds all observable ground surface elevations between azimuths of 124° and 185°, including the range of azimuths associated with the rising of Sirius and viewing the horizon above the Gussage Cursus.

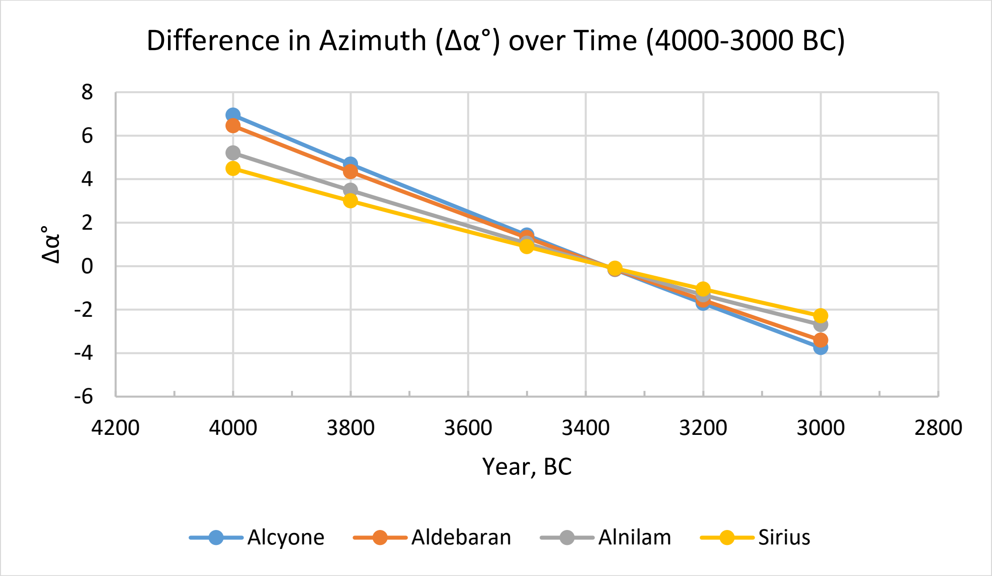
- Table D.1 lists star positions (azimuth and altitude as viewed from the study area) at two moments in time: when Alcyone approached culmination (az. 180°) and when Sirius approached the eastern horizon (alt 0°).
- Table D.2 lists the difference in azimuth and altitude of those stars between the time Alcyone was at culmination and Sirius was at the eastern horizon.
- Table D.3 lists star azimuths, altitudes and declinations during the period 3800 BC to 3100 BC for Sirius, the Belt Stars, Aldebaran and Alcyone for the following events:
    - Alcyone at the south meridian (azimuth 180° 00');
    - Sirius at altitude 0° 00' at the eastern horizon; and
    - Sirius at altitude 1° 00' at the eastern horizon.
- Table D.4 lists star coordinates (right ascension, declination and azimuth at 0 degree altitude rising) of Alcyone, Aldebaran, the Belt Stars and Sirius as viewed from Winklebury Hill in 3350 BC.

Data in Table D.1 through Table D.4 was used to determine changes in star azimuths and altitudes between 4000 BC and 3000 BC as they relate to the period between culmination of the Pleiades and first appearance of Sirius at the eastern horizon. Figure 4.20 illustrates differences in star azimuths between the moment Alcyone culminated (azimuth $\alpha = 180^\circ\ 00'\ 00''$) and the moment Sirius was at the east horizon (altitude $h = 0^\circ\ 00'\ 00''$) as viewed from Winklebury Hill between 4000 and 3000 BC. Figure 4.21 shows results of a similar evaluation for stellar altitudes during that time frame. For each star, no change in azimuth ($\Delta\alpha^\circ = 0$) during the time period between the two events occurred in 3365 BC (Figure 4.20). Similarly, no change in altitude ($\Delta h^\circ = 0$) of each star occurred during the time period

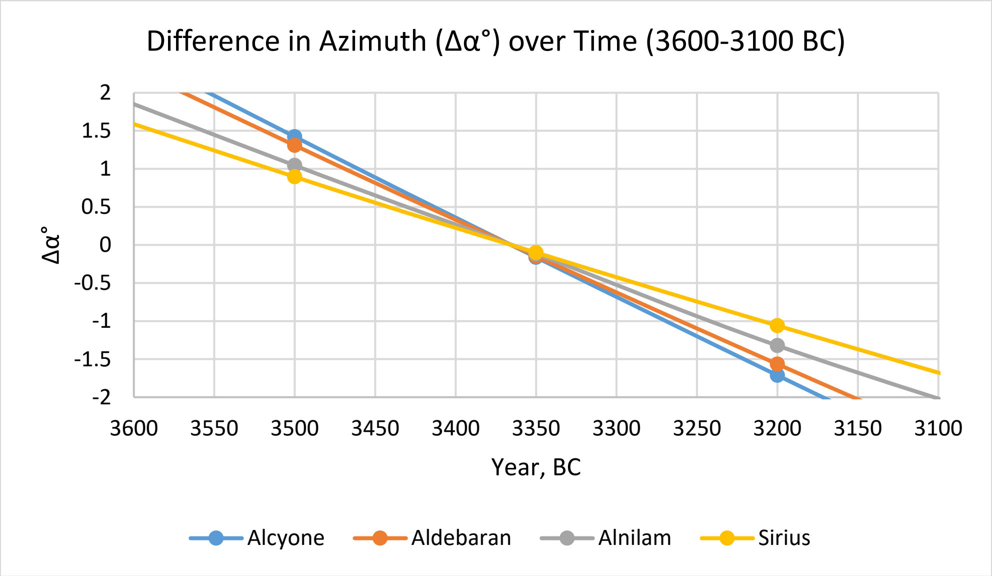
Figure 4.20

Changes in Star Azimuths 4000 to 3000 BC

The following charts illustrate differences in star azimuths between the moment Alcyone culminated (azimuth α = 180º 00’ 00”) and the moment Sirius was at the east horizon (altitude h = 0º 00’ 00”) as viewed from Winklebury Hill. Azimuths for Alcyone, Aldebaran, Alnilam and Sirius were determined using Starry Night Enthusiast, version 4.5. Star azimuths were recorded for the years 4000, 3800, 3500, 3350, 3200 and 3000 BC. For each star, no change in azimuth (Δα° = 0) during the time period between the two events occurred in 3365 BC (Figure 3.20c). In other words, Sirius was at the horizon at the moment Alcyone culminated in 3365 BC.



a)



b)

Figure 4.20 (continued)

Changes in Star Azimuths 4000 to 3000 BC

c)

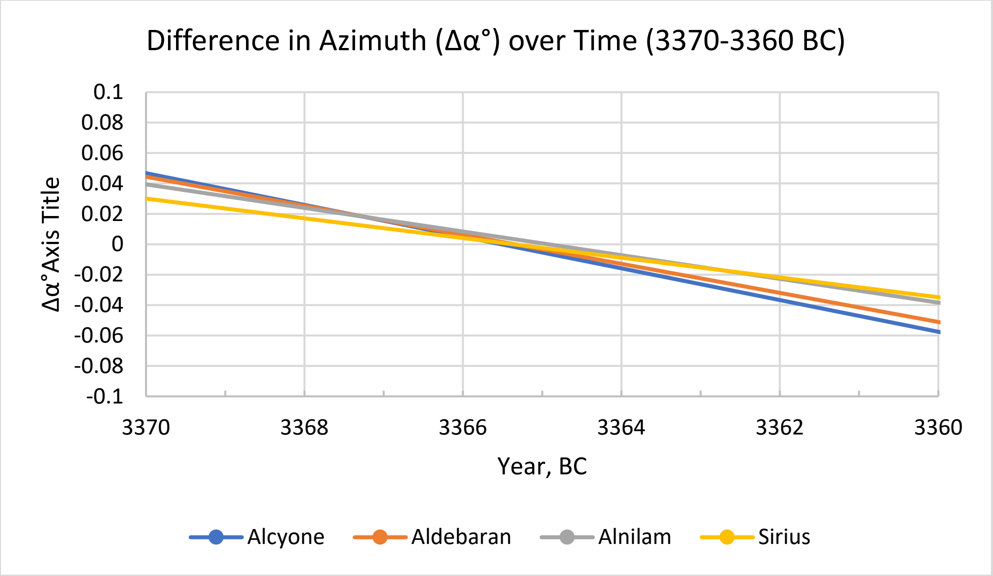


Figure 4.21

Changes in Star Altitudes 4000 to 3000 BC

The following charts illustrate differences in star altitudes between the moment Alcyone culminated (azimuth α = 180º 00’ 00”) and the moment Sirius was at the east horizon (altitude h = 0º 00’ 00”) as viewed from Winklebury Hill. Altitudes for Alcyone, Aldebaran, Alnilam and Sirius were determined using Starry Night Enthusiast, version 4.5. Star altitudes were recorded for the years 4000, 3800, 3500, 3350, 3200 and 3000 BC. For each star, no change in altitude (Δh° = 0) during the time period between the two events occurred in 3365 BC (Figure 3.20c). In other words, Sirius was at the horizon at the moment Alcyone culminated in 3365 BC. Between 3460 BC and 3013 BC Sirius could have been observed when it was at 0º to 1º altitude while Alcyone was within 1 degree of the south meridian (Figure 3.21c). Subsequent to that period of time, Sirius would have appeared before the Pleiades was within a degree of the south meridian.

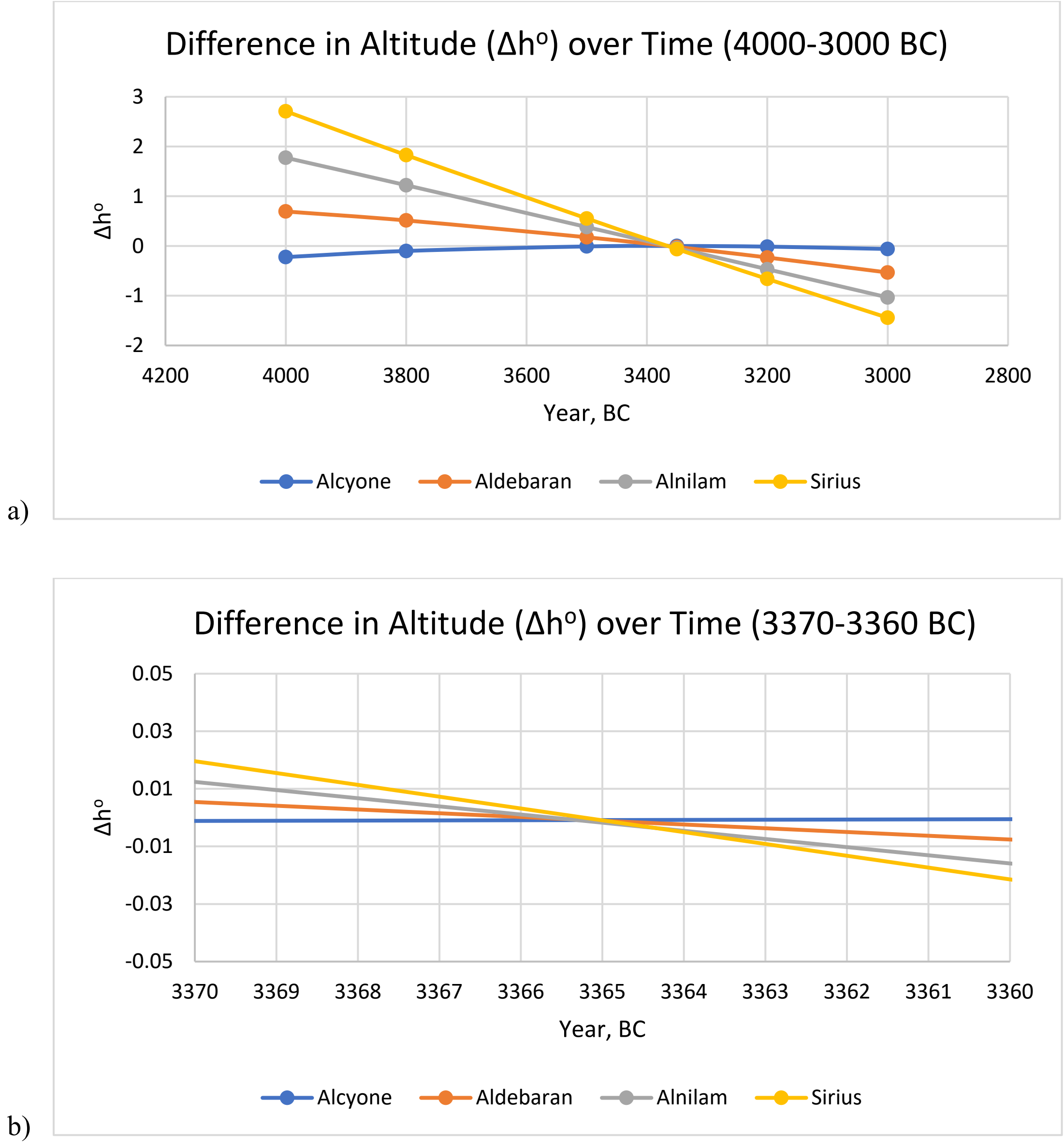
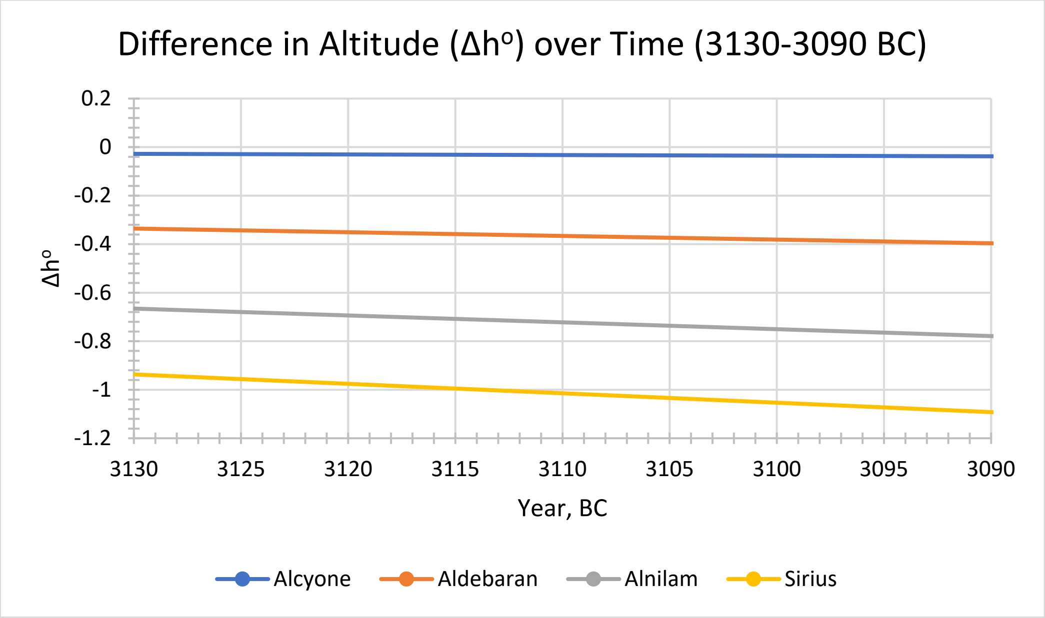


Figure 4.21 (continued)

Changes in Star Altitudes 4000 to 3000 BC



c)

between the two events in 3365 BC (Figure 4.21a and Figure 4.21b). In other words, Sirius was at the horizon at the moment Alcyone culminated in 3365 BC. Between 3460 BC and 3013 BC Sirius could have been observed when it was at 0° to 1° altitude while Alcyone was within 1 degree of the south meridian (Figure 4.21c). Prior to 3460 BC, Sirius did not appear before Alcyone was more than 1° beyond culmination. Subsequent to 3013 BC, Sirius appeared before Alcyone was within a degree of the south meridian.

Referencing the list of stars in Table B.2, we find that all stars related to the series of astronomical events described above are located in the first bin, with right ascension ranging between 23 and 3 hours. The question arises as to potential relationships between sets of stars in the other five bins and the length and location of the Dorset Cursus. Review of the skyscape c. 3350 BC using Starry Night Enthusiast with regard to sets of stars in each of those bins yields the following results.

Stars within Right Ascension 3 hour to 7 hour

Each of the five stars in that bin were located at declinations less than or equal to -31.35 degrees. The azimuth at rising (0.00° altitude) of each of those stars exceeded 146.0 degrees, and the maximum altitude of those stars at the azimuth of the south end of the Gussage Cursus (168°) did not exceed 6.5°. In addition, none of the stars has a visual first magnitude (<1.5). Therefore, stars in this bin did not exhibit characteristics conducive to associations with the location and length of the Dorset Cursus.

Stars within Right Ascension 7 hour to 11 hour

Of the 12 stars in that bin, 7 are located at declinations less than or equal to -30 degrees. While Menkent has a declination (-7.27 degrees) comparable to that of Aldebaran (-7.00), as we have seen, it is significantly less bright than Aldebaran. Of the four other stars with declinations greater than -30 degrees, none has an apparent magnitude less than 2.0. The azimuth of Menkent at the horizon (0.0° alt.) was 101.7°, and 102.87° at an altitude of 1°. Those alignments with respect to Winklebury Hill approximate the azimuth of the north end of Pentridge Cursus. However, there was no other star in the bin above the horizon. When Menkent is aligned with the link between the Pentridge and Gussage cursuses (129° az.) there were no other stars in the bin with a position that could reference other features of Dorset Cursus: Zeta Centauri (136.8° az.), Epsilon Centauri (141.7° az.), Gamma Centauri (149.1° az.), Delta Centauri (154.9° az.). A similar situation occurred when

Menkent was over the south end of the Gussage Cursus (168°), as no other star in the bin aligned with certain features of the cursus. In summary, while the number of stars (12) in the bin is the same as the number of stars in the first bin, they were not in a configuration reflecting a relationship with the location and length of the Dorset Cursus.

Stars within Right Ascension 11 hour to 15 hour

That bin contains 7 stars ranging in declination between -1.9 and -22.-3 degrees. The star rising first in the group is Antares (mag. 1.09) at an azimuth of 93.0 degrees. None of the other stars was above the horizon when Antares was above the north end of Pentridge Cursus (101° az.). When Antares was over the link between the Pentridge and Gussage cursuses (129° az.) the other five stars in the bin that were above the horizon were situated in a narrow band of azimuths ranging from 126.3° to 130.7°, and did not provide spatial correspondence with the cursus. A similar situation occurred with Antares located over the south end of the Gussage Cursus (168° az.), with azimuths of the other stars ranging from 149.3° to 165.9°. In summary, the stars in that bin did not provide spatial relationships associated with the location and length of the Dorset Cursus.

Stars within Right Ascension 15 hour to 19 hour

There are two stars in that bin. Both stars have a visual second magnitude and had a declination of less than 3 degrees from each other. Enif and Markab rose at 91.7° az. and 96.4° az., respectively. The declination of each star (-1.07 and -4.05) was rather close to the celestial equator, resulting in the respective star rising high as it traversed the southeastern sky. As the two stars rose and moved west across the southeastern sky, they provided no indication of a spatial or temporal relationship as they appeared to move over the length and termini of the Dorset Cursus.

Stars within Right Ascension 19 hour to 23 hour

There are two stars in that bin. Hamal has visual first magnitude, while Menkar has visual second magnitude. Their declinations ranged from -4.83 to -23.6. Hamal rose at an azimuth of 97.7° while Menkar was below the horizon and did not reach the horizon until 129.5° azimuth. That azimuth approximated the azimuth of the link between the Pentridge and Gussage cursuses. At that moment, Hamal was situated at an azimuth of 132.5°. When Hamal was above the south end of the Gussage Cursus, Menkar was at 157.1° azimuth. In summary, the two stars yielded no indication of significant spatial relationships that would define the location and length of the Dorset Cursus. It is notable, however, that while Hamal was over the south end of the Gussage Cursus, Alcyone and Aldebaran were already south of the link between the Pentridge and Gussage cursuses, and Mintaka (the southern-most of the three Belt stars of Orion) began to rise above the horizon at 121.1° azimuth.

4.4.3 Sirius and Winter Solstice Sun and Moon

Figure 4.22a shows azimuths of Alcyone and Sirius at the moment Sirius was at the eastern horizon (0° alt.) from 4000 to 1000 BC. Primarily as a result of Earth's axial precession during that time fame, the azimuth of the rising of Sirius ranged from about 136° to 118°, with corresponding azimuths of Alcyone above the horizon at that moment ranging between 186° and 158°.

Figure 4.22b shows the same azimuthal trendlines for those two bodies in addition to the azimuth of the Sun at rising during winter solstice. Figure 4.22c and Figure 4.22d illustrate Sirius's rising azimuth and setting azimuth, and the azimuths of the Sun's azimuth at winter solstice sunrise and sunset during the same period. As shown in the charts azimuths of the rising point and setting point of Sirius approximated azimuths of sunrise and sunset at winter solstice c. 3450 BC. The apparent size or angular diameter of the Sun viewed from Earth is about half a degree (0.5°). The azimuthal rate of northward advance of the rising and setting of Sirius along the horizon over the course of the 4th millennium was about 12 degrees, or about one half degree per 40 years. Therefore, as the azimuth of the rising and setting of Sirius progressed northward during the latter half of the 4th millennium, Sirius would have appeared to rise within the 0.5° range in azimuth along the horizon where the Sun rose and set at winter solstice for about 40 years. The conjunction of rising and setting azimuths of Sirius and the Sun occurred c. 3450, about a century before Sirius reached the eastern horizon at the same moment Alcyone culminated in 3365 BC (Figure 3.20c).

Also, the mean orbital inclination of the Moon to the ecliptic is 5° 08' 42" (Appendix B). The Moon's declination (obliquity + lunar inclination) is the angle between the celestial equator and lunar orbital plane. Over a synodic month (about 29.53 days) the Moon's orbital position shifts with respect to the ecliptic. A result of the Moon's orbital inclination with respect to the ecliptic is that lunar standstills occur gradually between

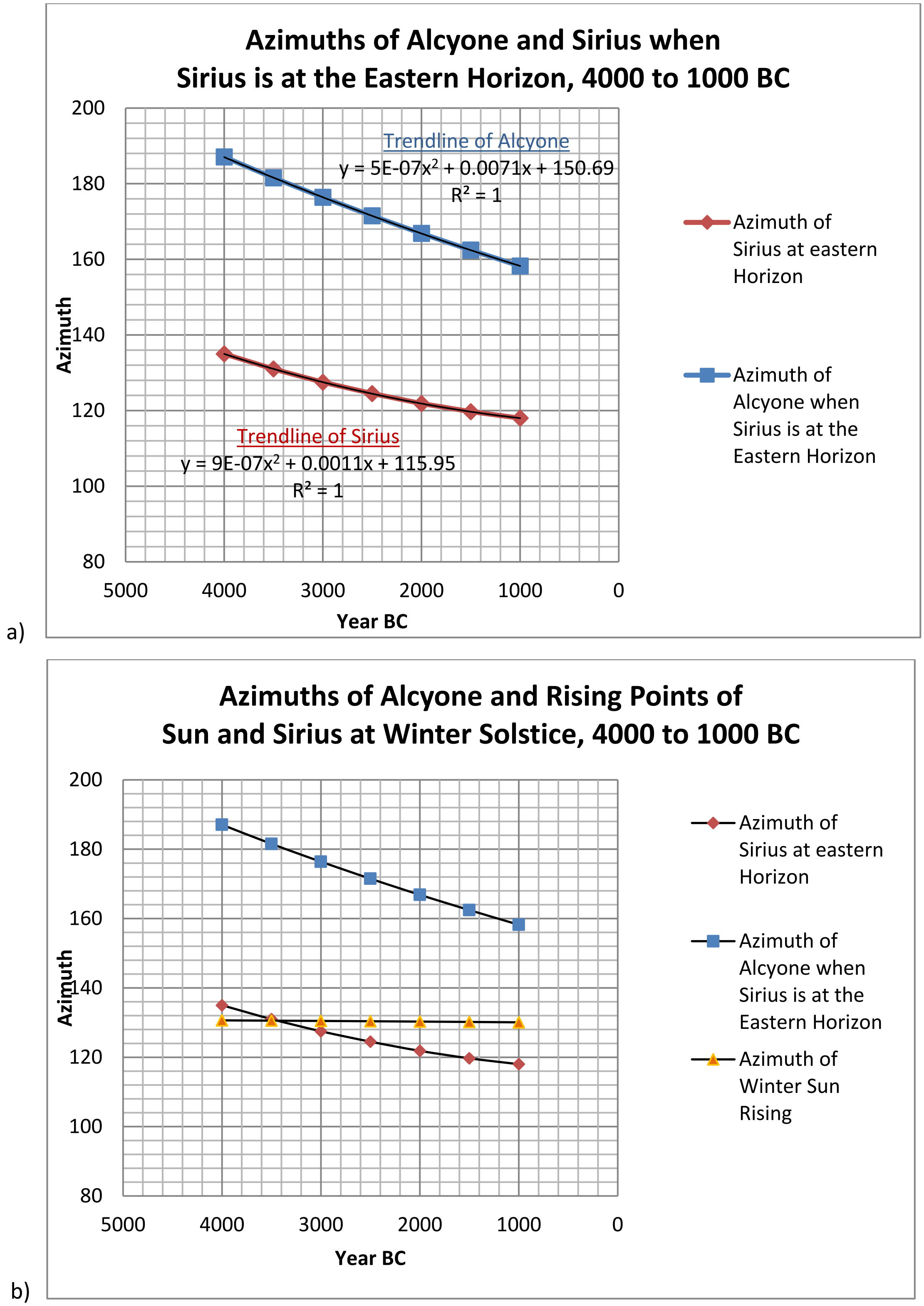


Figure 4.22: a) azimuths of Alcyone and Sirius at the moment Sirius was at the eastern horizon (0° alt.) from 4000 to 1000 BC. b) azimuthal trendlines for Alcyone and Sirius in addition to the azimuth of the Sun at rising during winter solstice

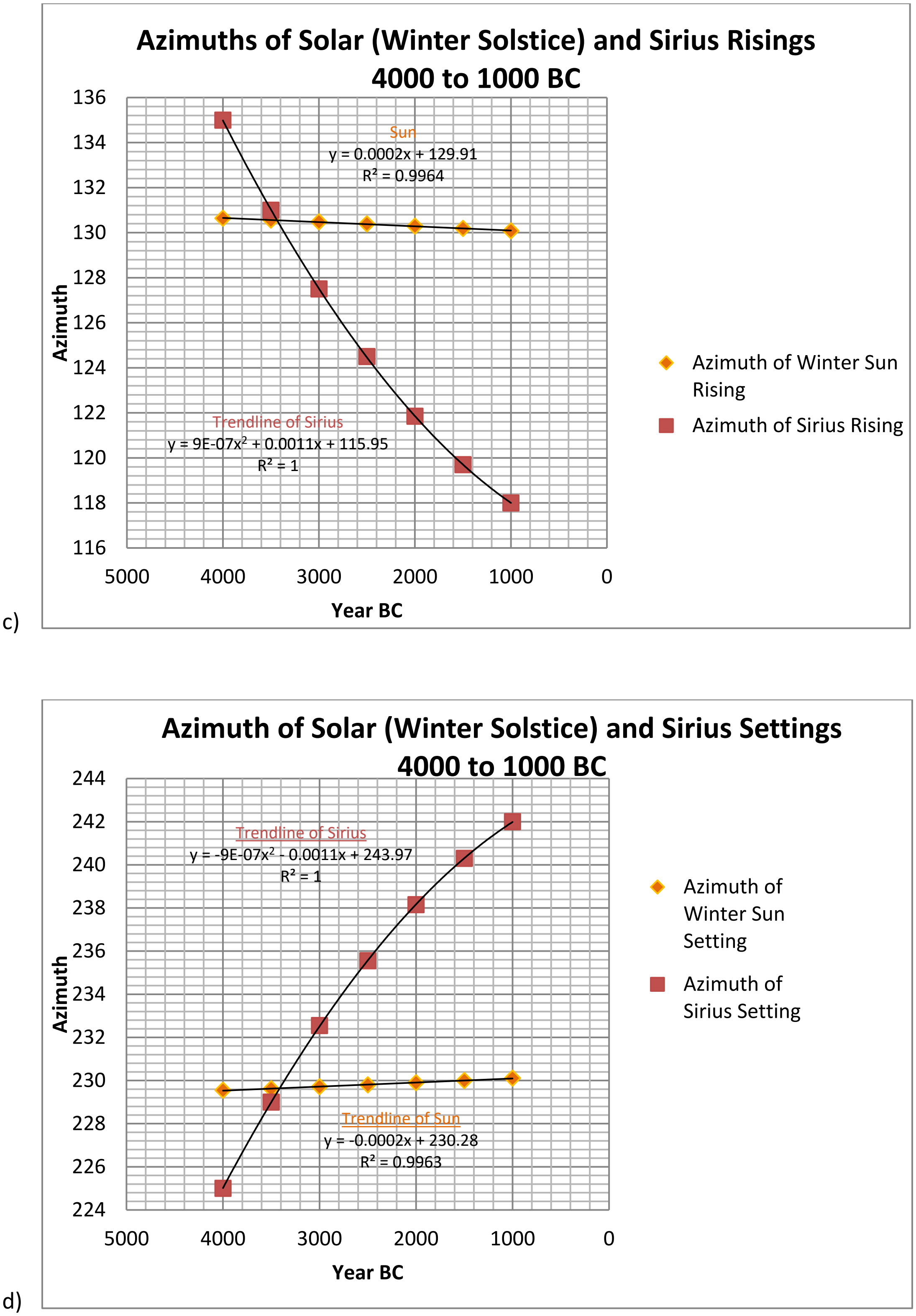


Figure 4.22: Sirius's rising azimuth and setting azimuth, and the azimuths of the Sun at c) winter solstice sunrise and d) winter solstice sunset during 4000 BC to 1000 BC

northern and southern limits of the lunar declination during half of a two week (13.66 days) sidereal month. As a result, azimuths of lunar risings and settings will frequently approximate solar risings and settings. Therefore, viewed from Winklebury Hill, at winter solstice of certain years during the 34th and 35th centuries BC, Sirius, the Sun and Moon would have risen at approximately the same location on the southeastern horizon, in alignment with the north terminus of Gussage Cursus.

Chapter 5. Discussion

5.0 Introduction

The purpose of this study is to resolve temporal and spatial relationships between one of the highest concentrations of Early- to Middle-Neolithic earthen monuments in Britain – those situated across Cranborne Chase and the adjoining SHL – and features of the surrounding natural environment. Geological, hydrogeological, paleoenvironmental and astronomical features of the contemporary landscape and skyscape are identified and evaluated with respect to elements of the monumental architecture. As stated in Section 1.2, the aim of this study is to address the following questions.

- What are the spatial relationships between the monumental architecture, geology (bedrock structure and stratigraphy, geomorphology, pedology, karst elements, periglacial features and topography), and paleoenvironment (climate and vegetation) of the study area?

- Identify and quantify orientations (azimuths) of elements of the cultural landscape and skyscape, and evaluate them for statistically significant, common orientations.

- What natural features of the Chase and SHL differentiate the study area from elements encountered at other British landscapes, and how did those differences develop?

- What influence did astronomical events (e.g., solar, lunar, stellar) have on the siting and architecture of those monuments?

- Does the spatial pattern and orientation of monuments reflect a process of purposeful long-term development of the landscape? If so, are the patterns of monument siting and architectural elements related to ritual functions of the landscape?

5.1 Discussion of Major Findings

Natural physiographic characteristics of the study area in tandem with possibly continuing anthropomorphic modification of local vegetation patterns on the downs since the Mesolithic provided a distinctive setting where the Early- to Middle-Neolithic cultural landscape of earthen long barrows, the Dorset Cursus, Hambledon Hill enclosure and other significant cultural elements were developed (Appendix E). Natural elements of the landscape are products of the unique structural and stratigraphic history of the northwest portion of Hampshire Basin in contrast with the surrounding terrain. Geomorphology, topography and hydrogeology of southern Britain are influenced significantly by underlying geological structures of Wessex Basin. NW-SE- oriented topographical features such as interfluve ridges and surface hydrology of the study area are likely related to NW-SE- trending fold and fault structures extending across the northwest portion of Hampshire Basin in tandem with surface processes exacerbated during periglacial conditions.

Results of this study demonstrate that Early- to Middle-Neolithic monumental earthen architecture on Cranborne Chase emphasizes use of geomorphological features of the natural landscape exhibiting a NW-SE- oriented surface expression and highlight southeasterly views from the majority of long barrows and along the crest of the Chalke Escarpment. The areal extent of the set of long mounds and the Dorset Cursus is defined by geological and hydrogeological features of the chalk plateau of the Chase and low-lying dissected plain of the SHL. The drainage basin of the study area is delineated by the Fovant and Chalke Escarpments along the northwest side of the Chase, the axis of the basin east of Wareham including Poole Harbour and the Solent, and the south limb of Hampshire Basin continuing southward to the Purbeck-Isle of Wight Monocline. The highest elevations of the Chase are situated along the primary escarpment and the lowest elevations are located to the southeast, culminating at the confluence of the two rivers 2 km north of Hengistbury Head and the English Channel. Thus, the southeasterly viewshed from upper elevations of the escarpment extends across the Chase and SHL to the natural horizon including the English Channel situated between ridgelines of the Isle of Wight and Purbeck monoclines, allowing a specific set of stellar events in the skyscape to be observed during the 4th millennium.

The structural, stratigraphic and hydrogeologic nature of the Chase is significantly different than regions to the west, north and east. Compartmentalization of Wessex Basin defines morphotectonic regions, each with a specific structural expression of uplift, warping, sedimentation, and erosion (Small 1980, 56-57; Jones 1999b). Variations in topographic features of Chalk formations encountered in each sub-basin across southern England are associated with changes in lithofacies and lithostratigraphy, structural attitude of bedrock, local erosional and weathering history, and deposition of superficial sediments (Aldiss *et al*. 2012). Sub-basins of Wessex Basin beyond the study area exhibit significantly different structural, stratigraphic and hydrogeologic frameworks across other regions of southern Britain and form the foundations of topographies and hydrogeologic conditions unlike those readily observed across the Chase and SHL.

Development and orientation of interfluves and stream valleys in the study area are related to structural and stratigraphic conditions of the northwest portion of the Hampshire Basin. The most influential extensional structural elements bounding the north and south extent of the study area are the west-east- trending Wardour-Portsdown and Abbotsbury-Ridgeway-Purbeck-Wight fault zones forming two distinct structural and topographic expressions of Paleogene inversion (Farrant *et al*. 2012). A Late Cretaceous line of periclines extending across the Wessex Shelf of east-central Dorset resulted in structural control and stratigraphic complexity in the Chalk during condensation between Cranborne Chase and the Purbeck-Isle of Wight anticlines (Mortimore, 1983; Bristow *et al*. 1998). Those complexities are related to the underlying basement structures, expressed by folding along the north rim of the Hampshire Basin and outcrops of near-vertical chalk along the Purbeck-Isle of Wight monocline (Hopson 2010, Figure 5; Allen and Crane 2019) (Figure E.2.4, Figure E.2.5). NW-SE- oriented topographical features in the study area, extending southeastward from the Chalke Escarpment to the Solent and bound by the Avon River valley to the east and the Stour River valley to the southwest, are situated between those structures. Geomorphological features of the Chase include the lattice-like drainage pattern related to local NW-SE and NE-SW joint sets and regional NW-SE fold and fault structures of the Chalk (Jung *et al*. 2015). The resulting southeasterly drainage pattern that predominates across the study area is unique in southern England.

The highest elevations of the Chase were not favored for siting long barrows and the cursus. Rather, most long mounds and the cursus are situated on or nearby crests of inferior chalk-cored ridges and hilltops southeast of the Chalke Escarpment. However, currently there is no evidence of intention by the builders to ensure monument intervisibility. Intervisibility of long barrow (and cursus) viewsheds including upper elevations of the Chase may be unintended or fortuitous results of siting the monuments on or proximal to ridgelines of interfluves and hill tops of the downs. It is possible that siting long barrows proximal to ridgelines ensured visibility of certain features of the natural environment such as surrounding hills, valleys, surface waters, distant horizon, and the sky itself. Topographic prominence would be preferable in this regard. Results of this study demonstrate that similar to the far-reaching southeasterly viewshed from the crest of the escarpment, almost all barrows are situated such that up-barrow horizons are less than +1 degree altitude, with many of the mounds situated to provide a southeasterly view toward the English Channel between the Isle of Wight and the Isle of Purbeck. The predominant southeasterly orientation contrasts with the far more prevalent easterly orientation exhibited by long barrows located across other British landscapes noted by others (e.g. Ashbee 1970; Kinnes 1992).

The favored siting of long barrows on the Chase appears to have been related not only to certain topographic and viewshed considerations, but economical access to the Chalk for construction of the mounds. Forty of the 42 long mounds and the entire length of the Dorset Cursus are situated on the chalk downs, strongly indicating that the chalk substrate was a preferred building material for earthen mounds, banks, and ditches associated with the monumental structures. Long barrows on the downs are situated where predominant soils consist of shallow (< 30 cm), well-drained rendzinas. Previous studies (Tilley, 1994; Barrett *et al*. 1991a; Bradley, 1986; French, 2007: 186; Mercer and Healy, 2008) have shown that the downs included well-established, pre-existing grassland underlain by rendzina soils, with some areas of parkland-type vegetation in upper elevations of the Chase during the 4th millennium BC, at the time of monument construction. Review of map data provided by the National Soil Resources Institute indicates only one long barrow (Dampney) on the Chase underlain by Head, organic sediments, remanié clays such as Clay-with-flints, Quaternary river terrace sediments or alluvium. None of the long barrows are located over mapped karst features. Similarly, more than 8o per cent of longitudinal ditches excavated to construct the Dorset Cursus are located where thin, brown and grey rendzinas dominate soil profiles across the downs, while only 18 percent of the cursus was constructed where sediments including Clay-with-flints, Head, terrace sands or alluvial sediments are encountered between the chalk bedrock and overlying soil cover. In general, the location and orientation of the cursus have the effect of maximizing the extent of thin rendzina soils overlying chalk along the monument's alignment, while minimizing the amount of thicker sequences of sediments along its length that would have made excavation to underlying chalk strata more labor intensive and time-consuming.

Thin, well-drained soil conditions, removal of Pleistocene soils by solifluction during Late Devensian periglacial conditions, and climatic amelioration during the Holocene resulted in upper elevations of the study area generally free of trees, similar to other chalkland environments of Southern England (Piggott and Walters 1954; French *et al*. 2007; French *et al*. 2012), with a significant amount of openness possibly developed and managed during the Mesolithic (French *et al*. 2012, Table 8). In contrast, pollen data from a relict channel near the Knowlton henge complex southeast of the Dorset Cursus demonstrates that grassland in the upper downs transitioned to a variable mosaic of vegetation and then to predominantly deciduous woodland across the South Hampshire Lowlands where Paleogene sedimentary cover is located (Seagriff 1960; French *et al*. (2007). Topographic, pedologic and shallow chalk bedrock conditions at most long barrow locations within the main corridor of monuments provide evidence of generally open grass downland prevailing at the time of long barrow and cursus constructions, c. 3800 to 3200 BC (Canti *et al*., 2013; Roberts *et al*., 2018). The open conditions across the downs potentially led to focusing development of Neolithic monuments including long barrows and the Dorset Cursus in lightly-shaded grassland supported by thin rendzina soils situated between higher elevations of the chalk dip slope and combes to the northwest, and more intensely wooded broken topography to the southeast (French, 2009).

Results of this study indicate that the contrast in prevalent southeasterly long barrow orientations at the study area compared to easterly orientations of long mounds that predominate across other British landscapes may be related to similarly contrasting orientations of topography, stream flow directions, and possible correspondences between alignment of natural elements of the landscape and observation of astronomical events. Those correspondences between barrow orientations and surrounding environment are striking for two reasons. First, results of this study demonstrate that directional vectors drawn from long barrows, the cursus, and natural physiographic features of the Chase have a common population of orientations toward the southeast (Table 4.11). The mean direction of the twenty-eight long mounds with a quantified up-barrow alignment oriented toward the southeast quadrant is 148±5 degrees (95% probability), while none of the forty long mound barrows with quantified orientations is aligned within less than 4 degrees of any of the four cardinal directions. This indicates long barrows at the study area were not aligned with solar equinoxes nor the North-South meridian. Rather, statistical analysis including circular directional data analysis, testing for randomness of that data, and testing the equality of sets of directional vectors related to the long mounds, hills and valleys of the Chase demonstrate that the measured set of long barrow directions reflects the orientation population of valleys and interfluves extending NW-SE across the Chase. Viewed as linear features of the landscape, the mean direction of the nine valleys and interfluves between the River Stour and the north end of the Pentridge Cursus at Martin Down have a mean orientation of 146 ±5 degrees. Second, while almost all cursuses in Britain exhibit a straight longitudinal axis, the alignment of the Dorset Cursus forms a broad arc across the landscape, generally following a circular curve confined between the north and south-side lateral ditch works along almost the entire 10 km length of the monument. The circular curvature of the Gussage Cursus passes through Winklebury Hill, with the perpendicular bisector to the chord of the Gussage Cursus curve bearing 145 degrees. The curve is interpreted to be an intentional aspect of its alignment emphasizing attention toward the Chalk Escarpment and Winklebury Hill, in particular. Ninety-nine percent of the Pentridge Cursus alignment is contained within the same circular curve that defines the majority of the Gussage Cursus. This is not to imply that the alignment of the Dorset Cursus accurately reflects a circular curve. The apparent tangent sections and two slight reverse curves demonstrate the difficulty in constructing an accurately aligned 10 km long earthen structure across the downs, particularly in light of local topographical conditions in tandem with considerable geometrical considerations including a radius of curvature on the order of 14 km.

The two slight S-shaped curvatures of the cursus' alignment on the northeast-facing slope of Gussage Down and the southwest-facing slope of Bottlebrush Down remain problematic. The transverse-oriented ground surface gradient located on the lower slope of Gussage Down, immediately east of the cursus, appears to have been avoided between the crest of Gussage Hill and Down Farm by constructing the cursus along a shallow, dry swale located at the lower portion of the slope. As the alignment progresses south-west (uphill) it curves around a steeper section of slope that may be related to the contact between the Newhaven and Tarrant chalks (Refer to Figures 4.8, Figure 4.11a). In that way, the alignment circumvents the steeper, cross-gradient slope to the east. The result is the slight S-curve in that area.

A purpose for the slight S-curve located along the alignment of the Pentridge Cursus as the monument arches over the crest of Bottlebrush Down is not readily apparent. Nonetheless, both reverse curves result in a change in the longitudinal direction toward the north. While both curves cause the overall circular curvature of the cursus to extend beyond the limits of the two lateral ditches in the vicinity of the S-curves, it is possible that the reverse curves represent attempts to keep the alignment along the general form of the circular curvature, tying together the two sections on either side of the respective curve. The slight right-hand bend along the northern-most half kilometer of Pentridge is another enigma. However, the right-hand curve (viewed from the south) improves observation of the terminus of the cursus from the Chalke Escarpment between Ashmore Down and Winklebury Hill.

The location and orientation of the Dorset Cursus along the undulating topography of interfluves and valleys in the central portion of the Chase is significant for understanding the purpose behind the size, form and functioning of the monument. The monument's alignment occupies a prominent location within the viewshed of many locations across the Chase. The geometrical configuration of Gussage Cursus with the perpendicular bisector extending from the center of the cursus through Winklebury Hill, corresponding with orientations of local topography and the drainage network of the Chase, suggests the earthen monument was designed to be viewed from the crest or upper elevations of the

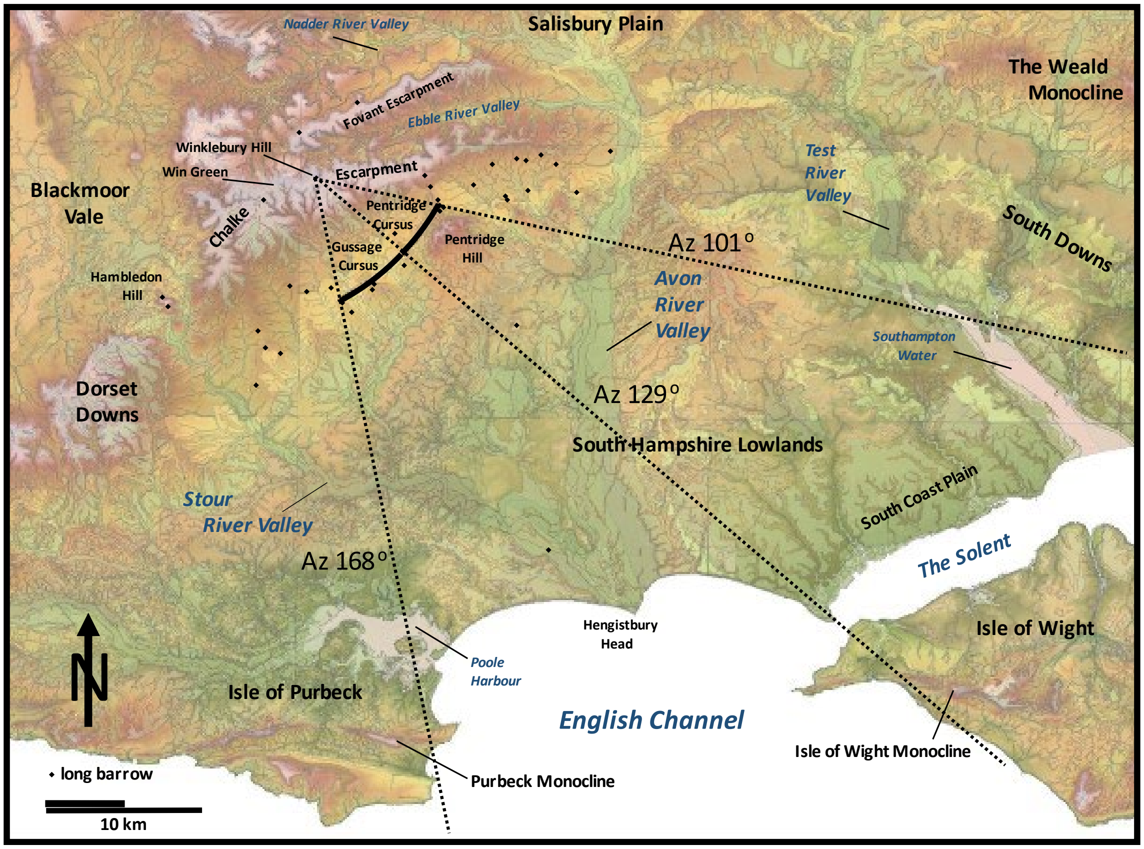


Figure 5.1: The curve of the Dorset Cursus focuses attention towad the Chalke Escarpment. The perpendicular bisector extending from the center of the Gussage Cursus passes through Winklebury Hill. From the apex of that location the viewshed extends southeast across the Chase and SHL, with sightlines aling the termini of Gussage Cursus defining the limits of viewing the English Channel between the Isle of Wight and the Isle of Purbeck.

Chalke Escarpment, centered at Winklebury Hill (Figure 5.1). Observed from that location, the cursus is situated about 9 km to the southeast and forms an alignment that is subparallel with the horizon above it, and perpendicular to interfluves and streams it crosses. The perpendicular bisector of the chord of the arc of Gussage Cursus passes through the crest of the Chalke Escarpment at Winklebury Hill. Results of the viewshed analysis indicate that the view from Winklebury Hill across the central portion of Gussage Cursus is aligned with valleys and interfluve ridges of the Chase, and natural geographic features of the study area and beyond. The view, then, simulates the mean southeastward up-barrow orientation of the set of long barrows on the Chase and SHL (Figure 5.2).

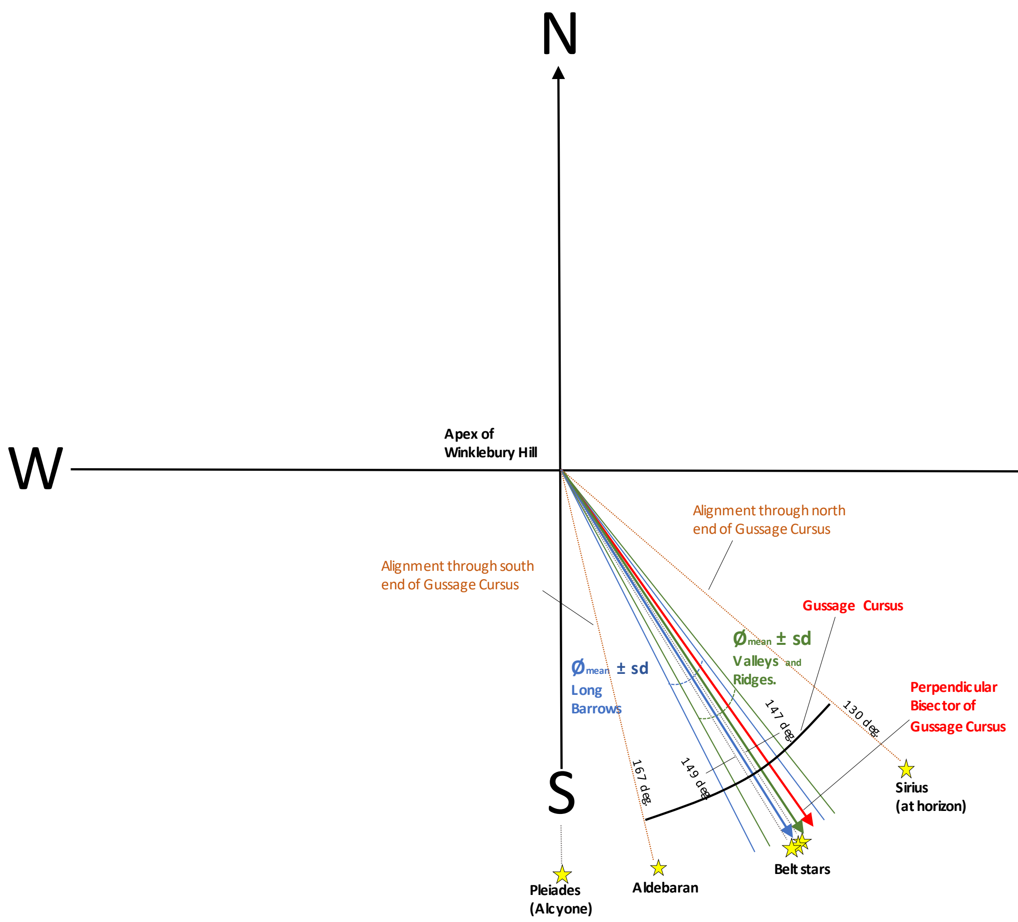


Figure 5.2: Sightlines oriented from Winklebury Hill toward the stars at the moment the Pleiades culminate and Sirius appears at the eastern horizon during construction and use of the Gussage Cursus. The perpendicular bisector of Gussage Cursus approximates the mean orientation of long barrows, valleys and ridges of the Chase. Those orientations directed attention toward the location of the Belt stars of Orion over the English Channel.

In summary, the purpose for siting, sizing and orientation the alignment of the Dorset Cursus is evident by the following:

- the cursus – particularly Gussage Cursus – is located and sized so that it can be observed from Winklebury Hill;

- the orientation and curving alignment of the cursus reflects the near-level circular horizon viewed from Winklebury Hill;

- the length of Gussage Cursus was determined based on the observed alignment of the north terminus of the cursus with the rising of Sirius at the time of culmination of the Pleiades, while the south terminus was aligned with observation of Aldebaran at the moment of Sirius' rising;

- the orientation for observation of the Belt stars of Orion at the rising of Sirius is along the perpendicular bisector of Gussage Cursus that parallels the orientation of the long barrows, interfluves and river valleys of the Chase; and,

- the location and orientation of Pentridge Cursus, constructed soon after completion of Gussage Cursus, represents a northeast extension of the width and generally curvilinear orientation and function of Gussage Cursus across the dip slope of the chalk. In so doing, the northern portion of the Chase, including locations of long barrows situated in that area, might have been symbolically related to the purpose and use of Gussage Cursus and landscape in general.

Relationships between the Dorset Cursus and topographic and geomorphic elements of the Chase have been proposed to effect certain physical and visual experiences between persons inside and along the confines of the cursus and long barrows proximal to the monument, or serving to divide the natural landscape while also inherently part of the cultural landscape (Barrett *et al*. 1991a: 46-7; Bradley, 1993; Tilley 1994; Brophy 2016). Barrett *et al*. (1991a:56,58), Bradley (1992:50-2), and Tilley (1994:197,199) argue that spatial relationships between cursuses, burial monuments including long barrows, and topography must be understood in terms of human movement within cursuses themselves. Similarly, Harding (1999: 30) concludes that the association between cursuses and long mounds and cursuses such as the Dorset Cursus "is only significant when viewed or encountered by those moving along the interior of the monument." Results of this study do not discount the possibility of such uses of the monument. However, Brophy's (2016:171) conclusion that, "On balance, the evidence to date suggest that cursus builders and users were more concerned with looking towards cursus monuments, than away from them" is well-supported by the evidence presented herein. The cursus crosses and engages with waters that flow toward the coast and discharge to the Channel. It appears to have served as a signpost directing attention toward the southeast and the boundary between the Earth and sky, therefore referencing symbolism associated with waters of the Chase discharging to the Channel. When Sirius appeared at the horizon in alignment with the north terminus of Gussage Cursus, Aldebaran appeared above the south terminus of Gussage Cursus, and the Pleiades were at culmination. At that moment, the Belt stars of Orion situated above the English Channel aligned with the interfluves, rivers and long barrow orientations across the Cranborne Chase and the SHL. The cursus can be envisioned to represent a liminal space separating the observer from the observed, a conceptual if not physical barrier between the chalk landscape of the Chase and SHL from the 'watery abyss' of the Channel and skyscape above.

Sightlines from the apex of Winklebury Hill toward Sirius and Aldebaran were aligned with the termini of the cursus when Sirius first appeared on the eastern horizon. That geometry helps explain the purpose of the location, size and orientation the Gussage Cursus alignment with respect to Winklebury Hill. The data suggests that between about 3500 and 3230 BC Sirius could have been seen at azimuth 130° (alt. 0° to 1°) when the Pleiades were apparent within 1 degree of the south meridian, with Alcyone crossing the south meridian at the same time Sirius was at 0.0° altitude in 3365 BC. A ±2 degree difference in the referenced azimuths or altitudes occurred between about 3800 and 2900 BC. The period of construction of long barrows in southern Britain, likely between 3750 and 3300 BC (Whittle *et al*., 2007; Allen et al., 2016), approximates that timeframe during which Sirius and the Alcyone were within ±2 degrees of the horizon and south meridian, respectively. Significantly, the view from Winklebury Hill along the perpendicular bisector of the Gussage Cursus was centered toward the Belt of Orion situated over the English Channel at the moment Sirius was at the horizon and the Pleiades appeared at the meridian. At that moment in 3350 BC Alnilam was at 148° azimuth, within the range of directional vectors associated with mean orientations of long axes of long barrows, the cursus, and natural physiographic features of the Chase and along southeast horizon.

Occurrence of those astronomical events approximate the range of dates for construction of long barrows, Dorset Cursus and Hambledon Hill causewayed enclosure. Radiocarbon analyses related to three long barrows in the study area (Hambledon Hill

Table 5.1: Dorset Cursus Dates

Date	Source
3500-3200 cal BC	French *et al*. (2007:186)
3342-3042 cal BC	Entwistle and Bowden (1991:22-23)
3650-3000 cal BC	Omish and Tuck (2002)
3360-3030 cal BC	Barclay and Bayliss (1999)

South, Wor Barrow and Thickthorn) indicate dates of construction between 3689 and 3165 BC (Mercer *et al*., 2008; Allen *et al*. 2016), with similar long mound structures built in southern Britain c. 3750 and 3300 BC (Whittle *et al*., 2007; Allen *et al*., 2016). Based on radiocarbon dates of ditch fills and associated mathematical modeling performed during previous investigations of the Dorset Cursus, timeframes for construction and use of the Dorset Cursus date to the latter half of the 4th millennium (Table 5.1). Similarly, initial dates for Hambledon Hill causewayed enclosure range from 3385 to 3220 cal BC (French *et al*., 2007, p. 186; Whittle *et al*. 2011:150). Long barrow construction ended by the 33rd century.

In sum, dates associated with the earthen structures approximate the period between 3500 and 3230 BC when Sirius could have been seen within a degree of the eastern horizon while the Pleiades were within 1 degree of the south meridian. Alcyone crossed the south meridian at the same time Sirius was at 0.0° altitude in 3365 BC. Based on the correspondence between the date of that astronomical event and timeframes for initial construction of those monuments, it is possible that construction of the earthen monuments was related to observation of that celestial event during the period between 3500 and 3230 BC. Note that the slope of the line for each star in Figure 3.20 and Figure 3.21 is unique because each star is situated at a unique declination. A higher declination (i.e. closer to the celestial equator) results in a steeper slope with regard to the difference in azimuth over the specified time frame. In contrast, the closer a star is to the south meridian, the flatter the curve with respect to the difference in altitude over the course of time. Between 3460 BC and 3013 BC Sirius could have been observed when it was at 0° to 1° altitude while Alcyone was within 1 degree of the south meridian (Figure 3.21c). Subsequent to that period of time, Sirius would have appeared before the Pleiades was within a degree of the south meridian. Alcyone achieved a net zero slope at 3365 BC, with its curve extending below the zero difference line before and after that time, as the star approached and then proceeded beyond the south meridian as Sirius rose to and then above an altitude of 0.0 degrees.

In general, each long barrow oriented toward the southeast was sited with a limited up-barrow viewshed including the English Channel because of the surrounding local topography. However, the cursus was situated to allow observation of virtually the entire monument from the crest of the Chalke Escarpment, where the viewshed allowed observation of the entire skyscape above a zero degree horizon in all directions. This finding indicates that the cursus might have been designed to allow macro-scale observation of the alignment of cultural and natural elements with the skyscape by persons traversing the highest elevations of the landscape. The optimal location for observing and recognizing the geographical and astronomical relationships associated with the long barrows and the Dorset Cursus in particular, was at upper elevations of the Chalke Escarpment at and in the vicinity of Winklebury Hill. That location might have served as an observational 'platform'. Significantly, Maguire (2015) proposes that areas of higher topography could serve as 'viewing platforms' providing views *toward* cursus monuments. Results of this study support that idea. The current study demonstrates that:

- the Dorset Cursus was constructed proximal to higher topography (the crest of the Chalke Escarpment including Winklebury Hill) that could have served as a viewing platform providing views toward the cursus, and landscape and skyscape beyond;

- placement and orientation of the cursus was related to geological, geomorphological, hydrological, and paleoenvironmental conditions, including orientation perpendicular to interfluve, river and stream crossings; and

- viewing of the cursus – including the cursus' termini – was maximized by siting the cursus within the viewshed of Winklebury Hill.

5.2 Cultural Context of Results

Previous suggestions that cursus monuments might have been related to pilgrimages or sacred journeys to monument complexes in the British Isles during the 4th millennium correspond well with results of this study. Networks of transportation and communication are closely related to elements of the British Neolithic landscape, particularly topography and surface hydrology. Natural topography appears to have been valued during siting of Mesolithic hunter-gatherer cemeteries (Ahola 2019) and physical modification of the environment through construction and use of platforms (Blinkhorn and Little 2018). Brophy (2016) notes that British rivers are boundaries and corridors that both inhibited and facilitated transportation and communication since at least the Mesolithic, and the relationship between rivers and ritual landscapes is significant in the interpretation of Neolithic cultural landscapes. Loveday (2015: 469, 474) proposes that cursus complexes across southern England expressed new ideations with linkages to a pilgrimage phenomenon and long-distance replication rather than regional invention, exemplified by the Thornborough complex of monuments in the Vale of Mowbray of North Yorkshire. Chris Scarre (2001:18) proposes the practice of a sacred journey rather than pilgrimage associated with various prehistoric sites in France, Britain and Ireland. Moore (2016) suggests sacred journeys associated with c. 4th millennium BC Irish passage tombs at Carrowkeel-Keshcorran, the tumuli serving as portals to and from the Otherworld.

The relationship between long barrows, Dorset Cursus and topography of the study area corresponds with the findings of Maguire (2015) in which it is suggested that cursus monuments linked earlier structures with certain topographical settings. Contrary to Atkinson's (1955) suggestion that activities associated with the Dorset Cursus were related to a processional or linear pattern or similar ideas related to ritual activities conducted *inside* the cursus (Brophy 1999; Loveday 2006: 124-6), the processional route or point of observation of the cursus might have been *well-beyond* the cursus, 9 km distant from the monument, along the crest or shoulder of the Chalke Escarpment (i.e. the drove way or similar). The droveway leading to and from Winklebury Hill and the nearby causewayed enclosure at Hambledon Hill represents a potential route for pilgrimages or sacred journeys where sojourners could perceive the landscape-skyscape alignments. Those alignments might have linked the living and the dead, and a unification between Earth and cosmos culminated by construction of the earthen monuments directing the observer's attention toward the Channel and celestial events above.

The proximity of the Ox Drove to Hambledon Hill causewayed enclosure, situated above the Stour River valley at the south end of the Chalke Escarpment, potentially provided both physical and conceptual connections between the living, the dead, and the surrounding environment. Gebauer (2015) suggests causewayed enclosures represented liminal zones at focal points accessible by road or watercourse and marked by natural features and manmade barriers allowing contact with the spirit world. Such spatial associations between tumuli and communication and transportation routes are also indicated by long barrows (Gebauer 2015). Results of this study indicate that the long barrows and cursus monuments at the study area, in tandem with the causewayed enclosure, might symbolize long-held cosmological beliefs related to perceived unification of the living, the dead, Earth and cosmos, with the boundary between land and sea potentially conceived as symbolic of a liminal zone between earthly life and the world of the dead. Therefore, the relationship between the siting and orientation of earthen monuments and the natural environment of the study area may be associated with a cosmology referencing liminal transitions between the landscape, seascape and skyscape. This conclusion conforms with those of Scarre (2002d: 100), Gebauer (2015), and Harris (2015) regarding other Neolithic earthen and megalithic monuments in Britain and the Atlantic façade. Scarre (2002d:86) suggests the sea provided an important visual feature when viewed from Neolithic tombs. Whittle (2002: 195) suggests monuments constructed near the sea might have been situated at a particular spatial and temporal threshold, served as portals providing access or restricting entry to a special place. The southeasterly orientation of most long barrows in the study area, including mounds at Pistle Down and Holdenhurst oriented toward the nearby English Channel, supports the idea of the waters serving as a threshold between Earth and Sky.

Hollestelle (2016) states, "Ordering is indicated by what we perceive of the world . . . Time order specifically relates to sky movements." Symbolic meaning in architecture can be expressed through elements of geometrical proportion and perspective, spatial sequences, vistas and juxtapositions, environmental appropriations and displacements (Barrie 2010). Barrie (2010) states,

> The setting of sacred architecture is critical to its power and meaning . . . Sacred architecture employs a variety of means to establish a place that is both separated and connected to its contexts. A symbolic language, delimitation of space, articulate approach, entry and path sequence, geometry and proportion, and diverse representational media are employed- often in concert - in the creation of the sacred place.

Seen as a sacred element designed and constructed across the downs of the Chase, the Dorset Cursus appears to have brought those elements together. However, the spatial and temporal relationships the monument highlighted between Earth and sky would end. Maintenance of Dorset Cursus appears to have fallen out of favor at the same time the observed synchronization between the cursus' geometry and stars ended. Infilling of the cursus' ditches and paleoenvironmental evidence of increasingly shaded conditions likely related to woodland development in the vicinity of the cursus during the late 4th millennium are indicated between Gussage Down and Bottlebrush Down (French *et al*. (2007). The cursus was failing to maintain its value as a unifying construct between Earth and cosmos. Ritual observation of the alignments from Winklebury Hill was no longer tenable. Schiffer (172) states,

> In order to continue activity performance, and hence maintain the values of subsystem variables, it is necessary to replace elements which become exhausted or otherwise unserviceable. The failure of an element to articulate properly with other elements is a significant bit of information to the system, which initiates the performance of other activities resulting eventually in element replacement, or activity structure change . . . . Perhaps the most important aspect of the notion of systemic context is that there is a specifiable spatial location, or locations, for each process through which an element passes.

By the beginning of the late Neolithic at end of the 4th millennium, henges – including Phase I construction of the circular bank and ditch at Stonehenge (Parker Pearson *et al*. 2007) about 15 km north of Cranborne Chase, and the set of three henges mirroring the Belt stars of Orion near Thornborough in Yorkshire (Harding *et al*. 2006:40, 47; Harding 2015) – began to dominate earthen monument construction in Britain while cursus construction fell out of favor.

Archaeological evidence demonstrates that the design of structures such as tumuli, identification of natural topographic, geologic and hydrogeologic features (such as hills, mountains, caves, rivers, coastlines, etc.) as sacred places, and conceptions of relationships between those cultural and natural features, typically conform to certain ideas related to order and orientation within time and space (Vastokas 1969; Wheatley 1971; Carrasco 1981; Meyer 1978; Kalland 1996; O'Brien 2002; Singh and Malville 2009; Rappenglück 2013). Ruggles (1999: 83-87, Figure 8.1) concludes there is only one reason why Neolithic communities in the British Isles would have enshrined astronomical observations in earth and stone monuments: purposeful architectural alignments functioned symbolically to express relationships between the physicality of death and burial on the one hand, and the ideation of funerary ritual and celestial cosmology on the other. The linkage between culture and the natural environment of the study area would have enabled the conception of passages between the existential and spiritual worlds. In this way, sacred sites and architectural structures such as the earthen monuments of the Chase were manifest features of cosmovisions (Rappenglück 2013).

Symbolic expression built into the cultural landscape might have been central to perpetuating communication related to cosmogony and the cosmography of the otherworld, and aiding social unification, as proposed by Knapp and Ashmore (1999) with respect to symbolic expression in general. As Magli (2009) notes, celestial cycles were a key interest of builders of Neolithic stone and earthen monuments, with those materials expressing, through architectural signs and symbols, the importance of astronomy in the function of the structures. Founded on perceived geomorphological, hydrogeological and astronomical correspondences of the natural environment, earthen monument design and construction at the Chase emplaced cultural elements upon the landscape to create meaningful signs and form continuous interactive linkages. The lifespan of linkages between landscape and skyscape were limited because of precession, while linkages between the natural landscape and earthen monuments remain. The result parallels Moore's (2016) definition of space in terms of use of physical or conceptual boundaries to produce order from chaos with locations of transition given importance. In keeping with Barrie's (2010) observation of sacred architecture's role in a quest for permanence in an impermanent world, earthworks at the Chase exemplify metaphorical bridging of physical and psychic divides between people and the larger environmental context.

Comparative ethnology offers a means of evaluating the plausibility of astronomical claims related to prehistoric cultural residues (Hayden and Villeneuve 2011). In the study area those residues include the long barrows and Dorset Cursus amongst possibly many others. Aveni (2019) provides accounts of numerous stories and myths from around the world that relate historic cosmologies with pareidolia, including universal observation and meaningful interpretation of random patterns of celestial bodies and periodic astronomical phenomena. Spatial and temporal relationships between Neolithic megalithic and earthen monumental structures and certain elements of the surrounding landscape, seascape, and skyscape may be key to recognizing and understanding the symbolism expressed by the architecture, and whether it is related to a hunter-gatherer cultural substrate, brought forth by aspects of Neolithic culture reminiscent of astronomical knowledge in the Near East and Egypt, or a derivative of the two. Relationships between Sirius and the Belt stars of Orion, earthen and megalithic monuments, and cosmology in ancient and indigenous cultures around the world are well-known (e.g. Campbell 1991:47; Shaltout *et al*. 2005; Harding *et al*. 2006:40,47; Hayden and Villeneuve 2011; Harding 2015; Michel *et al*. 2016, D'Huy and Berezkin 2017; Aveni 2019). Long barrows and the Dorset Cursus represent further evidence of this strong association. Numerous archaeological studies of the Neolithic lifeway address relationships between cosmology and earthen and megalithic monuments such as long barrows, cursuses and causewayed enclosures with reference to social memory, transformation, monument place and orientation and importance of landscape features and astronomical events (Burl 1981; Thomas 1999; Field 2006; Lewis-Williams and Pearce 2005; Darvill 2011; Pelisiak 2014; Ahlers 2018; others). Lewis-Williams and Pearce (2005:232) suggests alignments related the dead to the Otherworld and events in the skyscape.

Sacred Neolithic cultural landscapes were perceived at areas set apart from the mundane world, including distinct groups of monumental earthen structures such as those in the study area and other environments of southern England (Robb 1998). Harris (2015) suggests the landscapes served as mnemonics for relationships between the living and the dead, a transition from this World to the Otherworld in the cosmos. Ahlers (2018:16) proposes a mnemonic role for Early Neolithic mortuary structures and associated architecture, including British long mounds, in which cosmological ideologies and concepts supported cultural traditions. Sanjuán and Wheatley (2010) propose a similar mnemonic symbolism extending beyond archaeological artifacts and funerary architecture in the Neolithic of southern Iberia, where natural shapes and forms in stones and geological formations assisted to maintain cultural memory. Design and use of landscape and cultural features within it would frequently accord with specific "cosmological concepts and astronomically-oriented organization", including cultural order and orientation indicated by certain alignments focused "on one-dimensional sequences and directionality" (Ruggles 1999; Rappenglück 2013). Examples include hills, caves and cultural features that are directionally-arranged, often with a vertical dimension, within a cosmology in which both cultural features and the natural environment (including land, sea and skyscape) are conceived to be alive (Lewis-Williams and Pearce 2005; M.A. Rappenglück 2013). In this way, the Otherworld of the dead is conceived as a part of the world of the living (Hentze 1961: 14-22; Rappenglück 2013). Earthen long barrows as tumuli served that function. Similarly, the Dorset Cursus served the living as a signpost directing attention from upper elevations of the Chalke Escarpment toward the English Channel and the cosmos at a specific moment in time when elements of Earth aligned with the stars. As Larsson (2014) states, people care primarily about the living, not the dead. Results of this study indicate long barrows might have been designed as a means for the living to direct the dead toward the Otherworld, while the cursus aided the living to direct their attention toward the same region in the cosmos. Rappenglück (2013) concludes that prehistoric cultures perceived and described the world in terms of "a spatiotemporal domain of interacting powers" most often conceived by the shape of individual or patterns of things, a prominent role being celestial bodies and events. That spatiotemporal domain, including relationships between life and death, Earth and cosmos, were recognized and then expressed symbolically upon the landscape of Cranborne Chase.

Brophy's (2016:171) proposal that cursus monuments might have been intended to link with natural elements of the surrounding environment appears well-founded as the evidence supports intended linkages between the Dorset Cursus and environment both above and below the horizon. Contrary to Loveday's (2006:36) conclusion that cursus alignments are not oriented with any particularly significant features of the landscape – noting that they seem to "flow nowhere" – the location, size, and alignment of the Dorset Cursus appear designed to communicate a very precise moment in time and space related to specific elements of the landscape, skyscape, and long barrows of the Chase. Those spatial and temporal features, including the southeasterly alignment of the earthen monuments and natural elements of the landscape toward the Belt stars, support Devereux's (2003: 69-72) suggestion that cursuses delineated ritual spaces as corridors for spirits coursing toward the Otherworld. However, the course appears not to be along the length of the cursus monument's alignment, but across it.

Correspondence between the rise of Sirius at the moment the Pleiades crossed the plane of the south meridian, centered at 3365 BC as it relates to the geometry of the Dorset Cursus when viewed from Winklebury Hill, supports previously reported dates of construction of Gussage Cursus based on radiocarbon analysis (French *et al*., 2007, p. 186). The stellar event could have been perceived to occur between about 3500 and 3000 BC, and we propose that is the reason for the size, location and date of construction of the Gussage Cursus. The astronomical event of specific interest – observation of the Belt stars over the English Channel – could have been anticipated as the Pleiades rose over the course of about 8 hours before culmination and the appearance of Sirius at the horizon. This proposed relationship between the cursus and stars is in keeping with Hensey's (2008) proposal that a longer viewing-time range providing astral alignment was sufficient – indeed anticipated – for the intended purpose and was valued and afforded greater opportunity for observation of phenomena of interest.

A number of cultural and environmental factors likely influenced development of temporal and spatial relationships identified between the cultural landscape of the study area and the surrounding environment. Evidence from material culture indicates multiple points of origin of the Neolithic lifeway in Britain (Tresset 2015:121). Brace *et al*. (2019) finds a shared ancestry between Neolithic individuals in Britain and populations in Iberia who migrated along the Atlantic seaboard, mixed with hunter-gatherers of Western, Southern and Central Europe, and then traveled across the English Channel. Brace *et al*. (2018) suggests related ancestries between British and Iberian populations during the Neolithic derived from a common association with Anatolian farmers who had travelled along the Mediterranean route to Iberia before entering Britain from northwestern continental Europe by 3975–3722 cal BC (95% confidence interval) (Brace *et al*. 2019). Therefore, it is possible that the significance of the above-referenced alignments between earthen moments, landscape and skyscape might represent and reflect cultural influences derived from the eastern Mediterranean, potentially as far east as the Near East and Egypt. However, the Mesolithic-Neolithic transition in Britain likely involved a complex and irregular geographic and demographic distribution indicated by the range of variability in material characteristics and architectural form of megalithic monuments of not only Brittany and Iberia, but long barrows that first developed with emergence of the TRB cultural complex in north-central Europe (Whittle 207:124; Ahlers 2018:4).

Kinnes (1992) states that evolution in tumuli design and structural sequencing is indicative of "increasingly elaborate manipulation of spatial relationships" related to intensified social and ritual behaviors, with those activities by spatially and temporally unrelated groups suggesting a common belief in place. Modification and transformation of the Neolithic lifeway in terms of economic, social, political and religious needs as migration proceeded in Britain during the early 4th millennium might be related to a period of significant rapid climate change c. 6000–5000 cal yr BP associated with North Atlantic ice rafting and strengthened westerlies over the North Atlantic (Mayewski *et al.* 2004; Midgley 2011). After several centuries of demographic and social changes and economic growth during the Early Neolithic in Britain, significant declines in population and cereal use occurred between about 3700 and 3400 cal BC (Collard *et al*. 2010; Whittle *et al*. 2011:724–6; Stevens and Fuller 2012; Whitehouse *et al*. 2013), followed by increasing reliance on livestock at Hambledon Hill and other causewayed enclosure locations (Rowley-Conwy and Legge 2015; Whittle *et al*. 1999). Significantly, the time frame for the mid- 4th millennium decline in cereal production and population also corresponds to an increase in construction of earthen monuments c. 3700 and 3200 BC (Whittle *et al.* 2011:724–6; Thomas 2015: 1075; Loveday 2016). Development of cursus monuments in southern Britain began during a period of deteriorating climate and provisional abandonment of agricultural practices in the mid- to later 4th millennium, those events potentially associated with increasing transhuman pasturing as a response to the deteriorating agricultural conditions and replacement or over-printing former elements of the environment. (Loveday 2016; Fari 2016). Recognizing and understanding the relationship between environmental context and construction of earthen monuments becomes a matter of identifying the parameters of cultural reference (Kinnes 1992). In summary, the evidence suggests a possible modulating role of regional climate on Neolithic innovation in terms of the subsistence economy and monumental architecture in Britain, and as noted by Glassie (2000), architectural change is evidence of spatial and temporal cultural changes.

Knapp and Ashmore (1999) notes that transformation of landscapes by situating a set of places with differing conceptions and relationships with the world can be related to cyclical time and effecting change in terms of social tension, contestation or transformation. Such transformations in landscape and social behaviors may be indicated by the transition from long barrows to development of far more substantial earthen structures. Brophy (2016:31) concludes that "cursus monuments would have been a major transformation of the landscape." Certainly the gargantuan size of the Dorset Cursus dwarfs the scale of the long barrows. And yet, the unique geological conditions of the study area and orientations of architectural elements of the earthen monuments – aligned in common with features of the natural landscape and astronomical events – indicate that their purpose might have served similar symbolic needs.

In the case of the set of southeast-oriented long barrows, the evidence suggests each mound – generally assumed to serve as a tumulus – was constructed to align with sighting of the Belt of Orion over the English Channel at the moment the Pleiades were apparent at the meridian. While many of the long barrows are situated to allow observation of a level up-barrow horizon in the direction of the English Channel, the horizon at 130° azimuth generally exceeds 0° altitude at each mound location, and sighting of Sirius at altitude 0° was not available from those locations. Therefore, some variability in mound orientation with respect to alignment with the Belt stars should be expected, and would depend on when an observer considered the Pleiades to have achieved culmination. This could amount to several degrees, depending on the observers ability to accurately recognize the timing of that event. Greater variability in long barrow orientation should be expected over the course of the 600 year interval during which long mounds were constructed, as the timing of the stellar events changed due to precession. This is indicated by 20 of the 29 (62%) long barrows oriented toward the southeast exhibiting up-barrow azimuths within 15 degrees of the azimuth of the Belt stars (Alnilam at 148° azimuth c. 3350 BC) at the moment the Pleiades culminated over the course of the 4th millennium.

5.3 Spatial Relationships between Monuments, Geology and Paleoenvironment

What are the spatial relationships between the monumental architecture with respect to bedrock stratigraphy, geomorphology, pedology, karst elements, periglacial features, topography, and paleoenvironmental vegetation of the study area?

This study demonstrates relationships between Neolithic experience of the natural landscape and the visual complexity built into the cultural landscape. The evidence includes linkages between long barrows, the Dorset Cursus and surrounding geological and paleoenvironmental landscape. The cultural landscape exhibits a unique correspondence of orientation related to interfluves, rivers and streams, and long barrows, with the long axes of mounds aligned with local contours. From a statistical basis, the set of long barrow directions reflects the orientation valleys and interfluves south of Pentridge Hill. Therefore, the orientation of long barrows is directly related to the geomorphology, topography and hydrology that in turn are associated with the underlying bedrock structure and stratigraphy, and surface processes that sculpted the land surface. That intimate relationship between the unique geological and paleoenvironmental conditions of the study area and the pattern of cultural elements emplaced upon the landscape is key to understanding why the orientation of long barrows on the Chase is so uncharacteristic with respect to the general trend of mound orientations in Britain. The Neolithic architecture was designed to correspond closely with the regional physiography of the natural landscape, and events observed in the skyscape.

Spatial relationships between the earthen monuments and landscape are evident by site-specific geology, topographical position, monument orientation and viewscape associated with each long barrow and the Dorset Cursus. The greatest density of long barrows is found on chalk at and below an elevation of 150 m, forming an arcuate pattern trending southwest-northeast within a few kilometers of the cursus and reflecting the lateral extent of Seaford, Newhaven and Culver Chalk formations across the central portion of the downs. The majority of long mounds were constructed parallel with but notably off-center of the crestline of hills and interfluves, with few situated on broad slopes. This indicates a possible intention for the mounds to not dominate the landscape in terms of topographical prominence. Evidence of pervasive siting of monuments nearby crests and shoulders of upland areas of the Chase indicates a strong preference for constructing long barrows and the majority of the cursus in areas where soft to medium hard, permeable, frost-shattered chalk could be obtained and easily excavated at shallow depths, rather than requiring deeper excavation to obtain suitable substrates for bank and ditch construction. Long barrows and the majority of the Dorset Cursus were constructed where easily-accessible, chalk beneath shallow, well-drained rendzina soils could be obtained on the Chase (Table 4.4). Each barrow was sited where soil cover was thin rather than along valley sides and bottoms where periglacial processes of solifluction transported sediment from upper elevations downslope and deeper soils and sediments would be encountered. Other than Dampney, no long barrow on the Chase is situated in an area underlain by Head, organic sediments, remanié clays such as Clay-with-flints, Quaternary river terrace sediments or alluvium. None of the long barrows is located over karst features mapped by Hammer *et al*. (2020) (Figure E.2.12).

Subsurface conditions along most of the length of the Dorset Cursus are similar to those encountered at long barrows on the chalk downs. About 8 km (82 per cent) of the Dorset Cursus was constructed where the Chalk was encountered immediately beneath thin, brown and grey rendzinas that dominate soil profiles across the downs. Only about 2 km of the cursus' alignment was constructed across stream valley bottoms and interfluve slopes where sediments including Clay-with-flints, Head, terrace sands or alluvial sediments are situated between the chalk bedrock and overlying soil cover. Beyond the three channel and floodplain crossings, excavations during construction of the Dorset

Cursus encountered shallow well-drained, fine silty soils over chalk. Periglacial and karst features such as naleds mapped across the Allen River floodplain may be located where the cursus crosses other valley bottoms.

Given the near-uniformity of subsurface conditions at long barrow locations, it is possible that some degree of limited subsurface investigation such as pit excavations, was performed at proposed monument locations to evaluate the type and thickness of soil and sediment, and the depth to and quality of chalk for use in construction. Similar conditions were encountered for most of the length of the cursus. Knowledge of generally favorable subsurface geological conditions on crests and shoulders of ridges and interfluves could explain the consistent and continued use of geomorphologically similar locations for construction of long mounds.

The trend in siting long barrows near hilltops and ridgelines in the central portion of the Chase also appears related to providing a monument viewshed with particular interest in orientation along a certain azimuth, the southeast direction predominating in the study area. While long barrow and cursus intervisibilty might have been a factor in mound placement, such monument intervisibility might have been an unintended or fortuitous result of siting monuments on or proximal to ridgelines of interfluves and hill tops. Results of this study indicate a landscape-scale viewshed might have been of greater importance than intervisibility between monuments, with a preference for a far-reaching viewshed toward the southeast. This infers that sites surrounded by grasslands of the downs were preferred monument locations. Extensive viewscapes along monument alignments would have required observations unfettered by vegetation. While wooded areas may have existed in shaded combes or across extensive areas of Clay-with-flints where deeper soils and remanié sediments were located on the dip slope of Seaford chalk during the early Holocene, paleoenvironmental evidence indicates that by the Early to Middle-Neolithic a dry chalk grassland to broken parkland landscape had developed across lower dip slopes of Seaford, Newhaven and Tarrant chalks that underlie much of the downs (French *et al*. 2007). Thin, well-drained soil conditions and removal of Pleistocene soils by solifluction during Late Devensian periglacial conditions, in tandem with climatic amelioration during the Holocene, resulted in upper elevations of the downs generally free of trees, similar to other chalkland environments of Southern England (Piggott and Walters 1954; French *et* *al*. 2007; French *et al*. 2012; Hudson *et al*. 2022). Lightly-shaded grassland supported by thin rendzina soils developed between higher elevations of the chalk dip slope and combes to the northwest, while more intensely wooded areas developed on broken topography to the southeast (French, 2009). Pre-existing grassland with some areas of parkland-type vegetation in upper elevations of the Chase during the 4th millennium BC is evident by pre-monument rendzina soils encountered beneath long barrows on Gussage Down and ditches of the Gussage Cursus between Thickthorn Down and Bottlebrush Down (Tilley, 1994; Barrett *et al*. 1991a; Bradley, 1986; French, 2007: 186; Mercer and Healy, 2008).

Temporal and spatial relationships are indicated between long barrows oriented toward the southeast, the geometry of the Dorset Cursus (Gussage Cursus in particular), topographic and geographic features apparent along the southeast horizon, and the southeastern skyscape. The strong relationship between southeasterly long barrow orientations and orientations of the nine valleys and interfluves on the Chase is supported by statistical analysis of the set of directional vectors, while the perpendicular bisector of the Gussage Cursus alignment is equivalent to the average NW-SE orientation of interflueves and stream valleys it crosses and less than one standard deviation of the mean orientation of southeast-oriented long barrows. The southeasterly view from Winklebury Hill parallels the orientation of interfluves and valleys and the flow directions of brooks and rivers of the Chase. Gussage Cursus is oriented sub-perpendicular to stream crossings and engages with surface waters flowing toward the coast and discharging to the Channel.

Spatial relationships related to monument orientations and viewscapes provide further evidence of the importance of topography and surface waters to development of the Early- to Middle-Neolithic cultural landscape. Near-linear distributions of mound elevations above and below the elevation of 120 m (Figure 4.1) indicates a breadth of locations suitable for long barrow construction. It is reasonable to assume that the siting of each long barrow was conducted independent of elevations of other contemporary long mounds on the Chase. Therefore, linearity of the trend line of long barrow elevations from across the downs is surprising. Why would the chart of long barrow elevations provide indications of such uniformity? The answer might be related to two facets of the set of long barrow locations. First, there was consistent siting of the mounds upon hilltops and ridgelines within a rather limited range of elevations on the dipslope of the Newhaven and

Culver Chalk formations. Second, 83% of long barrows in the study area are oriented with the up-barrow end directed toward a horizon altitude of less than +1 degree, including 67% of the mounds situated with an up-barrow horizon altitude of less than +0 degree and view of the English Channel. That relationship between mound locations, elevations and southeasterly viewsheds toward an up-barrow level horizon is analgous to a stream profile in which the downstream flow has a certain channel orientation in the upper reaches of a watershed and unobstructed viewshed in the down-valley direction. In the case of the long barrows, it is the up-barrow viewshed including the near-level horizon of the English Channel. For the stream valleys it is the downstream flow direction leading to discharge to the Channel. In other words, the set of barrows sites near hilltops and ridge lines, oriented subparallel with local topographic contours toward the southeast, reflects the orientation of stream valleys and flow direction encountered across the Chase. The location of Wor barrow exemplifies those preferred settings. The long mound was constructed on the dip slope of Seaford Chalk at a relatively low elevation (109 m.) about 5 km downslope from the crest of the Chalke escarpment. The earthen monument was optimally situated and oriented such that the up-barrow view is directed toward the southeast and aligned with the valley of the Crane River and between lowland hills of Tertiary sediments farther southeast, to the English Channel 31 km distant. That line of sight does not appear to be coincidental, given that the locations of two-thirds of long barrows east of the Chalke Escarpment exhibit similar up-barrow views toward the Channel despite the rolling, hilly terrain encountered across the downs and lowlands, hillsides often framing sightlines toward the water.

The topographic, geomorphic, and hydrologic ‘as above, so below’ association between earthen monuments and natural landscape might be indicative of a conceptual reciprocal relationship emphasizing orientation toward the English Channel and skyscape above. Those relationships between the earthen monuments and local and regional geologic, geomorphic, topographic and astronomical conditions at the study area – including orientations of earthen and lithic monuments with respect to topographic features, seascape, and certain astronomical events on the horizon – parallel important aspects of other Neolithic and Bronze Age ritual landscapes in Britain and Europe (Scarre 2002a, 2002b, 2002e; Przybyl 2014; Higginbottom and Clay 2016; Higginbottom 2020). Recognizing the impact that geomorphological, hydrogeological, topographical, paleoenvironmental, and astronomical elements had on development of architectural features of Neolithic earthen and megalithic cultural landscapes demonstrates the need for detailed characterization of the natural environment when investigating the purpose behind creation of ritual landscapes. The relationship could be all the more important for circumstances in which a horizon exhibiting particular topographic features and bodies of water, and marked locations of astronomical phenomena, might have been perceived as a significant, liminal place of transformation (Higginbottom *et al*. 2015; Higginbottom (2020).

5.4 Orientation of Culutal features and the Natural Environment

Identify and quantify orientations (azimuths) of elements of the cultural landscape and skyscape, and evaluate them for statistically significant, common orientations.

Architectural features of cultural elements were identified for quantitative measurement and analysis. Those features included orientation of the longitudinal axes of long barrows, and the curvature, chord length and orientation of the bisector of the Dorset Cursus, including the Gussage and Pentridge cursuses as individual earthen monuments. Orientations of major topographical lineaments including crestlines of interfluves and valley bottoms along streams flowing southeast across the Chase were measured and evaluated with respect to orientations of the architectural features. Azimuths and altitudes of stellar, solar and lunar events were identified using astronomical software with reference to the timeline of long barrows and cursus construction. The results were analyzed for preferred trends and statistically-supported common populations between monument types, natural physiographic features, and events in the skyscape.

The mean of the forty measured up-barrow orientations is 145 degrees (145±48 deg. at 68%), and the mean orientation of the twenty-eight long mounds oriented toward the southeast is 148 degrees (148±15 deg. at 68%). (Table 4.10). Measurements of the eight long barrows oriented toward the northeast or southwest quadrants exhibit a broad range of up-barrow orientations (61±20/241±20 degrees at 68%), with 75% of those long barrows located at peripheral locations of the Chase. Only one long barrow (Martin 1) is oriented up-barrow toward the northwest. Long barrow Donhead St. Mary 4 is situated at the highest elevation (251 m) of all of the long barrows and is oriented up-barrow toward the northeast and the crest of the Chalke Escarpment at Winklebury Hill.

Viewed as linear features of the natural landscape, the mean direction of the nine valleys and interfluves on the Chase between the River Stour and the north end of the Pentridge Cursus have a mean orientation of 146±16 degrees. Statistically, the set of directional vectors drawn from the earthen monuments and natural physiographic features have a common population of directions toward the southeast, with the measured set of long barrow directions reflecting the orientation population of valleys and interfluves. In addition, the bearing (145 degrees) of the perpendicular bisector of the circular curve modeled for the Gussage Cursus is equivalent to the average downstream orientation of stream valleys it crosses and less than one standard deviation of the mean orientation of southeast-oriented long barrows and azimuths of valleys and ridges.

The significance of the perpendicular bisector of the Gussage Cursus to the purpose behind the size, location and orientation of the earthen monument is indicated by the line of the bisector crossing the crestline of the Chalke Escarpment at Winklebury Hill, where an unobstructed view of the skyscape is provided with a 0 degree horizon altitude in all directions. Temporal and spatial relationships are indicated between long barrows oriented toward the southeast, the geometry of the Dorset Cursus and Gussage Cursus in particular, topographic and geographic features apparent along the southeast horizon, and stellar events located between 23 hr. and 3 hr. right ascension, as viewed from the apex of Winklebury Hill during the last centuries of the 4th millennium. Observed from Winklebury Hill between 3460 BC and 3015 BC, Sirius could have been seen at azimuth 130° (alt. 0° to 1°) when the Pleiades (represented by Alcyone) were apparent within 1 degree of the south meridian. Upon temporal conjunction of those two stellar events the Belt stars of Orion could have been observed over the English Channel with Alnilam, the center belt star, located a 148° c. 3350 BC. From that result, and given the mean orientation of the twenty-eight long barrows oriented toward the southeast at 148 degrees (148±15 deg. at 68%), we propose that those mounds might have been purposefully aligned toward the Belt

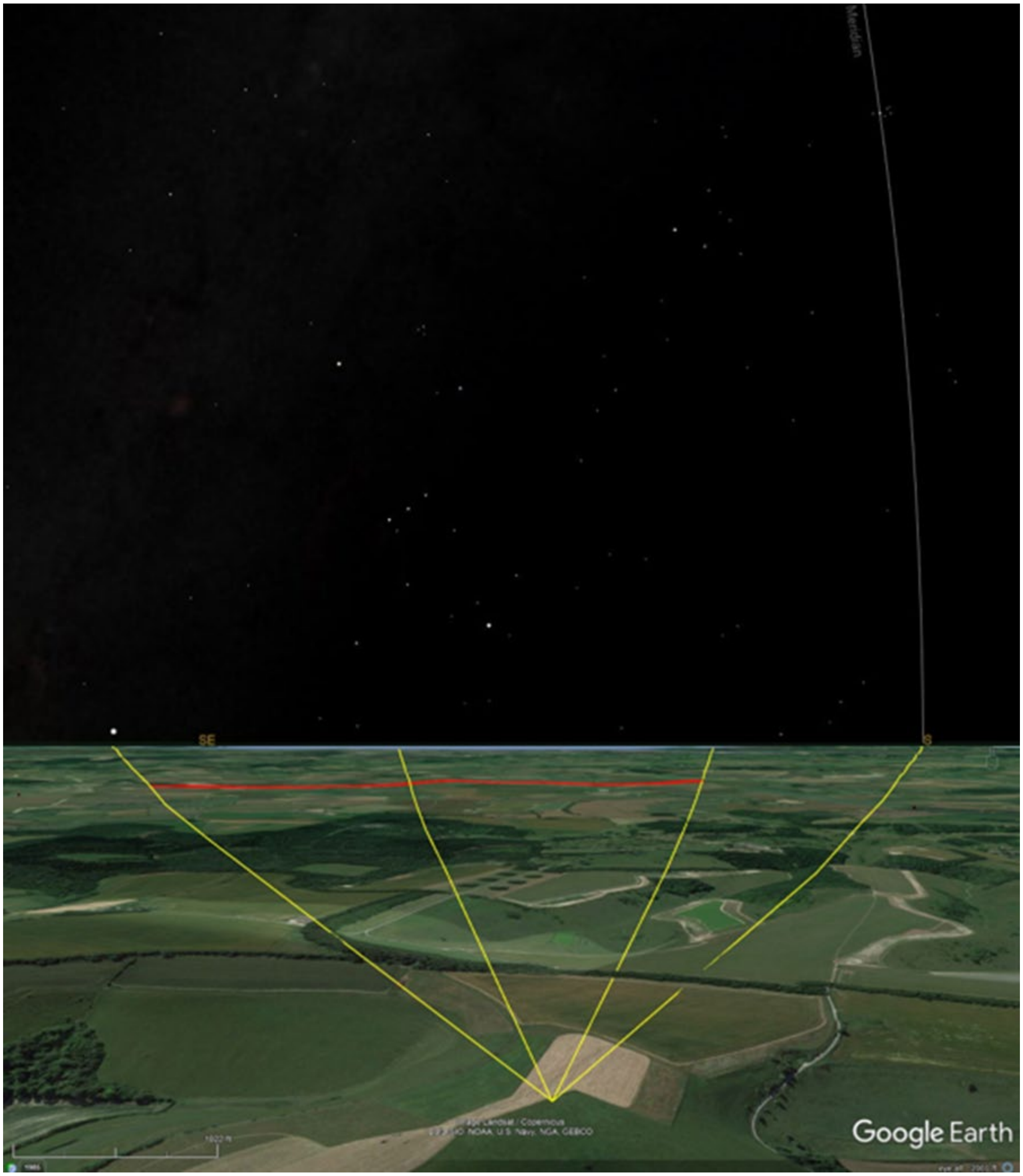


Figure 5.3: View of the landscape and skyscape, looking southeast from behind the apex of Winklebury Hill in 3350 BC at the moment Alcyone culminated at the south meridian. Sirius was at the horizon along an alignment through the north end of Gussage Cursus. Aldebaran was situated above the south end of Gussage Cursus. At that moment the Belt stars of Orion (Alnilam azimuth 147.7 degrees) appeared over the English Channel between the Isle of Wight and the Isle of Purbeck. Gussage Cursus shown in red. South meridian indicated from the horizon up and extending through Alcyone. Yellow ground lines indicate lines of azimuth from the apex of Winklebury Hill through the north end of the cursus, the bearing toward Alnilam, the south end of the cursus, and due South. Landscape graphic is a screen image taken from Google Earth™. Sky map is a screen image taken from Starry Night Enthusiast™ Version 4.5.

stars of Orion. Optimally, each alignment would have been set at the moment when (Figure 5.3):

- the Pleiades arrived at the south meridian (180º az.);
- Sirius appeared on the southeast horizon (130º az., 0.0º alt.) over the north terminus of Gussage Cursus; and
- Aldebaran (167º az., 31º alt.) appeared over the south terminus of Gussage Cursus.

Alcyone crossed the south meridian at the same time Sirius was at 0.0º altitude in 3365 BC. There was an error of ±1 degree difference in azimuth of Alcyone when Sirius was at the horizon between about 3500 and 3230 BC, and ±1 degree difference in altitude of Sirius when Alcyone culminated between about 3600 and 3130 BC. A ±2 degree difference in the referenced azimuths or altitudes occurred within a time ranging between about 3800 to 2900 BC.

Observed from Winklebury Hill circa 3350 BC, Aldebaran appeared above the south end of Gussage Cursus when Sirius could be observed at the horizon above the north end of Gussage Cursus. Contemporaneous with those events, Alnilam ranged between 148º and 150º, within the range of directional vectors associated with mean orientations of long axes of long barrows, the cursus, and natural physiographic features of the Chase and along southeast horizon. Those astronomical events occurred within above-reference ranges of dates for initial construction of the Dorset Cursus and Hambledon Hill causewayed enclosure (Omish and Tuck 2002; Barclay and Bayliss 1999; French et al. 2007:186; Whittle *et al*. 2011:150). Subsequent to 3015 BC, Sirius would have been apparent before the Pleiades was within a degree of the south meridian. By that time, it was possible that continued use of Dorset Cursus for observing the alignments from Winklebury Hill through the end of Gussage Cursus to the horizon and the stars above, was no longer tenable, fell out of favor, and ditches and banks of the monument were no longer maintained by the end of the 4th millennium. French *et al*. (2007) notes that some portions of the cursus' ditches were backfilled with chalk rubble, with infilling of the north ditch possibly almost complete while that in the south only partially backfilled.

The evidence indicates strongly that the length and location of both the Pentridge Cursus and Gussage Cursus relate to spatial and temporal relationships with the Pleiades,

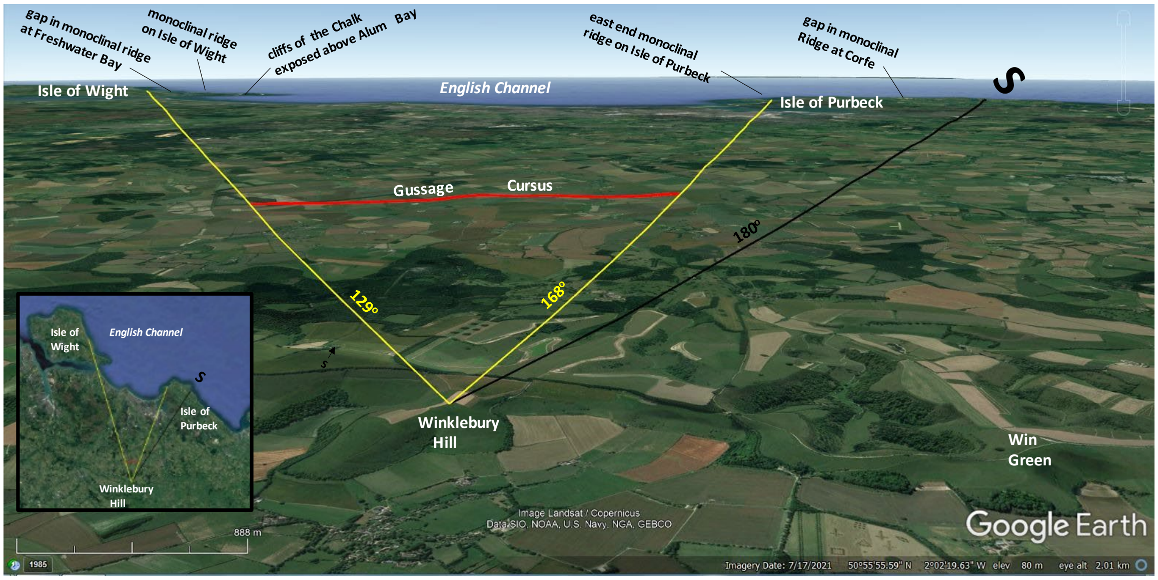


Figure 5.4: Oblique view toward the southeast from above the Chalke Escarpment. Geographic features readily observable along the horizon from Winklebury Hill under suitable atmospheric conditions are indicated. The monoclinal ridges and cliffs of the Chalk define the eastern and western limits of the observable Channel.

Aldebaran, the Belt stars of Orion, and Sirius crossing the southeastern sky when viewed from Winklebury Hill. Those relationships are also associated with ready observation of specific features on the southeast horizon, including the gap in the ridge of the Isle of Wight-Purbeck monocline at Freshwater bay (az. 132°), the west end of the exposed monoclinal ridge on the Isle of Wight (az. 133°), the high cliffs of the Chalk above Alum Bay (az. 136°), the center point of the observable English Channel (az. 150°) between the Isle of Wight and the Isle of Purbeck, the east end of the monoclinal ridge on the Isle of Purbeck (166°), and a gap in the same ridge at Corfe (az. 179°) (Figure 5.4). Those physiographic features are readily apparent from Winklebury Hill under clear daylight conditions. The features, in tandem with observation of Gussage Cursus, could have been used to orient daytime sightlines toward locations at and above the horizon where Sirius, the Belt stars, Aldebaran and the Pleiades were situated at the moment of nocturnal interest.

The time frame of construction of the Dorset Cursus post-dates construction of some portion of Neolithic long barrows in Britain. Nonetheless, the alignment of the cursus has been proposed to have been determined, in part, by locations of several long barrows, leading to the conclusion that the monument is related to a cult of the dead (Castleden 1992). Hambledon Hill causewayed enclosure yielded evidence of burial of as many as 350 individuals, and Mercer (1980) concludes the site had some funerary relationship with the long barrows of the Chase. Wysocki *et al*. (2007) suggests that the pattern of dates for construction of long barrows could indicate monumental commemoration of the dead did not begin until about 3900 cal. BC. Construction and use of earthen long barrows in Britain ended by the 34th century, at the approximate time when most cursus monuments were constructed in southern England (Loveday 2006: 165; Rassmann 2011).

5.5 Comparison of the Study Area and Other British Landscapes

What natural features of the Chase and SHL differentiate the study area from elements encountered at other British landscapes, and how did those differences develop?

As with other chalklands of southern England, the Chalk, overlying Paleogene rocks, and spatially variable sediments of the Chase and SHL exhibit morphological variations and geomorphological features related to lithological controls and alteration by weathering and erosion (Small 1980:56-57; Jones 1999a). However, the study area is uniquely situated in the northwest portion of the Paleogene-age Hampshire Basin, a sub-basin of the larger Wessex Basin where differential uplift, warping and episodic erosion increased the structural complexity and relative topographic relief compared with other regions in southern Britain (Preece *et al*. 1990; Allen *et al*. 1997; Jones 1999a). The chalkland of the Chase is a conspicuous topographic belt between the Paleogene basin of the SHL and the uplifted region to the northwest where Chalk and bedrock strata above and below have been removed by weathering and erosion, producing topographies and drainage patterns that differ from the study area. Geomorphological features of the study area are related to the distinctive structural and stratigraphic history of the northwest portion of Hampshire Basin. Unique features of the Chase and SHL include a NW-SE drainage pattern related to the topography and surface hydrology founded on the underlying structural and stratigraphic framework. The following is a summary of major structural development in the study area and southern England as a whole, with particular emphasis on differences between the study area and surrounding regions. Details of the structural and stratigraphic history of the study area and southern Britain in general are provided in Appendix E.

Locations of thrust faults and transfer faults governed regional morphologies of Wessex Basin's constituent structures as a whole (Chadwick 1986). The structures define several morphotectonic regions, each with a specific structural expression of uplift, warping, sedimentation, and erosion that is consistent with NW-SE oriented shear and anisotropic extension associated with NW-SE oriented wrench faults (Small 1980:56-57; Bally 1982; Jones 1999b). Those structures include sub-basins produced by normal reactivation of the basement thrusts and wrench faults that compartmentalized the basement and initiated development of four centers of deposition (Sellwood *et al*. 1985; Whittaker 1985; Lake and Karner 1987; Jones 1999b). The gross morphology of the sedimentary basins – including Hampshire Basin – is governed by the geometry of pre-existing crustal weaknesses, with the stress field influencing directions of movement along major basin margin faults and affecting orientations of intra-basin faults (Chadwick 1986, Fig. 23).

The Late Cretaceous Wessex-Channel Basin is defined by three extensional structural elements. They include the west-east- trending Pewsey, Wardour-Portsdown, and Abbotsbury-Ridgeway-Purbeck-Wight fault zones forming three distinct structural and topographic expressions of Paleogene inversion (Jones 1999b; Farrant *et al*. 2012). Well-developed inversion axes north of the study area, in the Pewsey Basin and the Wardour-Portsdown fault zones and extending farther west along the W-E -trending Mere fault zone, isolate Salisbury Plain from the Dorset Downs and Cranborne Chase to the south (Small 1980:56-57; Jones 1999b). Rivers and interfluves north of Pewsey Basin flow east within the Thames watershed and toward the London Basin. To the west, weathering and erosion have removed the Chalk across the Vale of Wardour west of the Fovant Escarpment where few Early- to Middle-Neolithic earthen monuments are known. The eastward extent of the Bristol Channel Basin is located about 12 km northwest of the Fovant Escarpment and adjoins the Stour River watershed situated to the south. South of the Stour River, chalk streams including the Piddle and Frome rivers on the Dorset Downs generally flow east along the north side of the Abbotsbury-Ridgeway-Purbeck fault zone and discharge into Poole Harbour. The topographic prominence of the Abbotsbury-Ridgeway-Purbeck-Wight fault zone serves not only as a drainage divide but also obscures observation of the Channel from upland areas of the Dorset Downs drainage basin. The Channel Basin is located beneath the English Channel, south of the Abbotsbury-Ridgeway-Purbeck-Wight fault zone.

The northeastern extent of Hampshire Basin follows the west-east trend of downlands from Cranborne Chase, across the southern limit of Salisbury Plain, to the South Downs south of the Weald Basin east of Hampshire Basin (Jones 1999b). The Weald, located in the northeast portion of Wessex Basin and east of the study area, is a complex horst structure distinct from the North Downs (to the north), the South Downs (to the south), and the Dorset Downs and South Hampshire Lowlands to the west, including the study area. The Weald is set apart from the basement of the Hampshire-Dieppe Basin as a result of late Neogene - Quaternary uplift by the Wardour-Portsmouth inversion and movements farther east (Jones 1999b, Figure 7). Contrary to the NW-SE -orientation of streams (and interfluves) of the study area, rivers such as the Darent, Great Stour and Little Stour located on the north side of the west-east -trending Weald flow north, while rivers such as the Arun, Adur, Ouse and Cuckmere flow southward from the crest of the Weald to the English Channel. Farther west, rivers including the Test, Itchen and Meon flow south-to southwest from chalklands off the western nose of the horst and cross the SHL from the northeast.

In tandem with the overall southeasterly dip of bedrock in the study area, there are several fault systems extending northwest from the Isle of Wight that likely contribute to the geomorphology, topography and surface hydrology of the study area, including the predominant NW-SE orientation of interfluves and stream valleys that cross the Chase and SHL. Deformation structures include thrust faults, NW-SE trending strike-slip - transform faults, and NE-SW trending strike-slip faults defining boundaries of lateral accretion and loss. The sets of W-E and NW-SE trending faults impacted the thickness of basement rock beneath the Chalk, and affected the extent and shape of the basin from Salisbury Plain, north of Cranborne Chase, to the nearly vertical Purbeck-Isle of Wight monocline along the coast of Dorset and across the central area of the Isle of Wight (Allen and Crane 2019). The Purbeck-Wight fault zones are the most important structural elements affecting the Isle of Wight area, their topographic expression readily apparent from more than 60 km to the northwest, along the crest of the Chalke Escarpment, in the northwest portion of Cranborne Chase (Farrant *et al*. 2012). Several synclines, anticlines and fault zones extend

NW-SE across the study area, between the Chalke Escarpment and the Purbeck-Isle of Wight monoclines. Important structures specifically pertinent to development of the landscape of the study area include the following:

- the northwestward-trending Bray Fault Zone along the northeast perimeter of the study area, linked to Purbeck-Isle of Wight monoclinal structures bounding the south of the study area (Mortimore & Pomerol, 1997; Evans and Hopson 2000);

- the Bouldnor syncline extending west-northwest from the Isle of Wight, across the Solent, and continuing at least 32 km across the SHL (Evans *et al*. 2011).

- the Porchfield Anticline, subparallel with the Bouldor Syncline, trending northwestward across the Solent and overlying a northwest-southeast -trending down-to-the-north syndepositional fault concealed by the Chalk and Paleogene strata of the SHL (Evans *et al*. 2011, Fig. 2; Chadwick and Evans 2005, Fig. 4; Farrant 2012);

- the west-northwest-trending fault complex breaking through the Chalk along the alignment of the Cheverton Fault, subparallel to the southwest edge of the Cranbourne–Fordingbridge High extending northwest across the Solent and farther northwest beneath Cranborne Chase (Hamblin *et al*., 1992; Mortimore 2011; Farrant *et al*. 2012);

- the Cranborne Fault extending northwest from north of Bournemouth toward Cranborne Chase, likely the source of local tectonic movements generating trough and mound structures across the Upper Chalk (Newell 2000, Figure 2; Newell 2017); and

- the NW-SE -trending Christchurch Fault underlying the River Stour valley, along the south side of the study area (Newell 2000; Evans and Hopson 2001).

A result of tectonism and geomorphological processes across the northwest area of Hampshire Basin – between Salisbury Plain and the English Channel – is the drainage basin delineated by the Fovant and Chalke Escarpments along the northwest side of the Chase, the axis of the basin east of Wareham including Poole Harbour and the Solent, and the south limb of Hampshire Basin continuing southward to the Purbeck-Isle of Wight Monocline. Upper reaches of the Chase's drainage basin are located southeast of the crest of the Chalke Escarpment between the Stour and Avon rivers, with surface waters flowing southeast toward the confluence of those rivers near Hengistbury Head. Relict stream valleys associated with former drainage of the Chase under periglacial conditions are evident by trellis-like drainage patterns now occupied by extant dry valleys and combes. The NW-SE -trending orientation of rivers, brooks and interfluves encountered across the Chase are likely related to lithological and structural controls including the above-referenced NW-SE fold and fault structures, and alteration of the Chalk and Paleogene cover by weathering and erosion. (Jung *et al*. 2015). Lake (1975) states that fissure patterns in the downs are related to geomorphological conditions and underlying geological structure in the Chalk, including open stress-relief fissures, cambering, and other processes along crests of anticlines and sides of Chalk valleys, and therefore impacting water transmissibility through the limestone. Drainage across the Chase flows down the NW-SE and NE-SW -oriented lattice-like stream channels, the dip slope of the Chalk ultimately directing flow across the Paleocene sediments to the Solent and the English Channel.

In summary, the complex set of structural and stratigraphic conditions affected the shape and lateral extent of Hampshire Basin, and the study area in particular. Weathering and erosion enhanced along orientations of folds, faults and join orientations led to the predominant NW-SE orientation of chalk-cored stream valleys and interfluves situated between the Stour and Avon rivers, with waters flowing from upper reaches of the dip slope southeast of the Chalke Escarpment to the Solent. The drainage pattern is unique to southern England, with significantly different structural, stratigraphic and hydrogeologic frameworks exhibited beyond the study area. Those frameworks form the foundations of landscape geomorphologies that developed across southern Britain that are different that those of the Chase and SHL. However, the NW-SE orientation of geomorphic, topographic and hydrologic features that dominate across the Chase do not solely account for the NW-SE orientation of the long barrows. Similarly, the SW-NE orientation of the Dorset Cursus – notably sub-perpendicular to the mean orientation of long barrows, stream valleys and interfluves in the study area – is not entirely accounted for by locations and orientations of gross topographic and hydrologic features of the landscape.

5.6 Influence of the Skyscape on Earthen Monumental Architecture

What influence did astronomical events (e.g., solar, lunar, stellar, or other) have on the siting and architecture of those monuments?

Results of the archaeoastronomical analysis indicate that the set of southeast-oriented long barrows were architecturally aligned with valleys and interfluve ridges of the Chase, natural features of the study area and beyond, including the English Channel, and oriented toward the Belt of Orion when the Pleiades were at culmination and Sirius appeared at the horizon c. 3365 BC. Thirty-five (85%) of the 39 long barrows on the Chase are oriented with the up-barrow end directed toward a horizon altitude of less than +1 degree, while locations of twenty-eight (67%) of the mounds exhibit a horizon altitude of less than +0 degree with a southeasterly up-barrow view of the English Channel (Table 4.1). Indeed, most southeast-oriented long barrows in the study area are situated and oriented to have provided observation of the Belt stars over the English Channel as the Pleiades approached culmination. Similarly, the location, size and orientation the Dorset Cursus, and Gussage Cursus in particular, is coincidental with azimuths of those same stars viewed from Winklebury Hill, the termini of Gussage Cursus defining sightlines toward Sirius and Aldebaran. At that moment, the Belt stars of Orion were situated above the visible English Channel between the Isle of Wight and the Isle of Purbeck. The association between the common set of orientations of architectural elements of the earthen monuments toward the southeast, the statistically similar orientation of natural landscape features, and alignment of the cultural landscape with Sirius, the Belt stars and Aldebaran, fixed temporally by the Pleiades crossing the south meridian, strongly suggests that the purpose for orienting the majority of earthen monuments at the Chase toward the southeast is related to a cultural interest in orienting the dead toward the Belt stars and orienting site lines for the living for observing that phenomenon when those stars appeared above the English Channel.

As the azimuth of the rising and setting of Sirius progressed northward during the latter half of the 4th millennium, conjunction of rising and setting azimuths of Sirius and the Sun occurred only a few decades before Sirius reached the eastern horizon at the same moment Alcyone culminated in 3365 BC (Figure 3.20c). Also during that time frame, at winter solstice Sirius, the Sun and Moon would have risen at approximately the same location on the southeastern horizon, in alignment with the north terminus of Gussage Cursus. Together, those events could have provided increased incentive for siting the north end of Gussage Cursus where it was constructed, although the common alignments would have ended within only a few decades.

Significantly the orientation of twenty-one (75%) of SE-oriented barrows exceeds 143 degrees. Therefore, three-fourths of those long mounds are oriented south of the ecliptic and lunar declinations, and could not have aligned with solar or lunar risings, including winter solstice and lunar standstills. This finding indicates the orientation of long barrows at Cranborne Chase and the SHL is not related to solar and lunar cycles. In addition, none of the forty long barrows with quantified orientations is aligned within less than 4 degrees of any of the four cardinal directions. Therefore, none of the long barrows was oriented toward the equinoxes, south meridian or true north.

The idea that Neolithic architectural remains in the British Isles served astronomical purposes has been studied since the early 20th century (Lockyer 1906; Heggie 1981:179-82; Gough 2012; Hollestelle 2016). Those investigations demonstrate that the architecture is related to cosmology, as well. For example, many megalithic monuments constructed during the Irish Neolithic, roughly c. 4000-2500 BC have alignments with each other, or with objects within the landscape, and with temporal relationships with astronomical events, some monuments expressing concepts of crossing physical and symbolic thresholds (Harris 2015; Moore 2016). Alinei and Benozzo (2008) suggests the cosmological association between megalithic monuments and rebirth and fertility in Mesolithic-Neolithic Europe likely originated fertility cults including those in central France where megaliths served as markers of burial mounds and represented borders between the two worlds of the living and the dead. Gebauer (2015) emphasizes that repeated construction of megalithic funerary monuments reinforced the importance of the burial site, the tomb, and its social and cosmological connotations, while Last (2015: 275) suggests that

Neolithic longhouses in Central Europe might have been important through establishment of homologies between human society and cosmological principles. Knowledge of the ecliptic and paths of stars might be evident in the orientation of gaps in Middle-Neolithic roundel palisades oriented toward astronomic and topographic targets (Michel *et al*. 2016). The possible celestial targets include the rising of Sirius and stars of Orion's Belt.

Paralleling results of the current study, analysis of Neolithic/Bronze Age monuments in western Scotland by Higginbottom *et al*. (2003) finds that the coincidence of landscape features and astronomical phenomena can be seen only from a certain location and angle, supporting the theory of purposeful siting of monuments. Indeed, variables of the visible landscape-skyscape potentially were linked to those locations as early as the Mesolithic (Higginbottom 2016; Higginbottom and Clay 2016). Further, Higginbottom *et al*. (2015) concludes that the monuments were associated with liminal properties and transformations related to topographical positions and movement within the surrounding landscape, the horizon serving as a significant, liminal place where particular topographic features and bodies of water marked locations of astronomical phenomena.

Higginbottom (2020) proposes that Bronze Age megalithic monuments in western Scotland were constructed at places charged with dramatic visual events by combining features of stone, water, the landscape, the cremated dead, and certain astronomical phenomena. The combination of those elements is reflected in the relationships between earthen monumental architecture, landscape and skyscape of the early-to Middle-Neolithic Chase and SHL. Common features of those cultural landscapes include water occurring in the south; the northern horizon is closest; the southern most distant; the northern horizon has a higher general profile or the highest vertical extents in the profile; the southern horizon has a very distinct dip (concave) or a lower general profile than the northern; the highest areas of the northern and southern horizons focus around the four ordinal directions of NW, NE, SW and SE; the highest points of the horizon profiles are usually located near, or at, those compass points; and, a site most often forms an alignment internally, or with another site, with apparent astronomical orientation. Further, there are specific aspects of the cultural and natural features of the study area that are similar to associations found between Neolithic long barrows and the natural landscape in southwestern Poland (Przybyl 2014). Those common features include locating barrows at the highest parts of the hills or hillsides; preference for hillsides facing or oriented toward the south and southeast; locating barrows along a NW–SE or W–E axis; and positioning the highest parts of the monuments facing south or southeast.

Orientations of Neolithic sanctuaries in the British Isles such as Newgrange, Stonehenge, Maes Howe and other burial monuments such as long barrows, symbolically equivalent to caves, embodied astronomical knowledge, and demonstrate a complex structure of astronomical understandings reminiscent of well-documented astronomical knowledge in ancient Egypt and the Near East (Hayden and Villeneuve 2011). Sims (2020) applied archaeology, anthropology, comparative Eurasian mythology and archaeo-astronomy during the study of a subsidiary henge at the Sanctuary (c. 3300-900 cal BCE) near Avebury, in north Wiltshire. He concluded the purpose of the Sanctuary was associated with death and resurrection aided by simulated ritual journeys to and from the underworld analogous with Neolithic mythologies from the Mideast.

Associations between the earthen monuments of the study area, the surrounding landscape, and skyscape, are similarly found in numerous ethnographical analogies related to other ancient and indigenous cultures around the world. Many of those relationships were likely conceived, developed in mythologies, and built into architecture around the world well-before the historical record. Norris and Norris (2021) concludes that a story associating the Pleiades asterism with the Orion constellation developed in Africa in about 100,000 BC and, via migrations, subsequently was carried forward across Europe, Asia, Australia and other nations. Seyfzadeh and Schoch (2019) propose that architectural indicators of Pre-Pottery Neolithic (c. 10th millennium BCE) cosmology are included on T-shaped pillars symbolically representing a god (possibly associated with a bull) guarding the transition to the afterlife at Göbekli Tepe and potentially related to astronomical observation of Orion, Taurus and other constellations. Campbell (1991:47) notes that Egyptian myths of the dead and resurrection of the god Osiris resemble Mesopotamian myths regarding Tammuz, both being variants of a common, late Neolithic and early Bronze Age theme. Osiris, the ancient Egyptian god of agriculture, fertility, rebirth and the afterlife, was associated with the heliacal rising of Orion and Sirius, the relationship likely originating in Predynastic times (5500-3100 BC) (Griffiths, 1980: 44; Redford, 2003: 302-307; Strudwick 2006: 118-119; Magli 2009). Shaltout *et al*. (2005, 2007) demonstrate that certain stars including Sirius were significant factors in the location, design and construction of Egyptian temples, and stress that astronomical orientations were related not only to the skyscape but the terrestrial landscape, as well. The importance of heliacal rising and setting of Sirius in ancient Egyptian religion and timekeeping is without question (Shaltout *et al*. 2005). The two shafts built into the south-facing side of the Great Pyramid were aligned to Sirius and the Belt stars of Orion, those regions serving as architectural signposts directing the soul of the pharaoh along symbolic corridors to the afterlife (Magli 2009).

Belmonte and Garcia (2013) analyzed dolmens of the megalithic necropolis of Djebel al Mutawwaq on the Transjordan Plateau, and propose that the orientation of tumuli was keyed on the rising of the Orion constellation associated with Near Eastern mythology and an indication of the calendrical season, with the dominant visual orientation directed from inside looking out of the monuments. That visual orientation parallels that of the southeastward up-barrow orientation of long barrows at the Chase and SHL, and the view from Winklebury Hill across Gussage Cursus and the study area toward the southeastern skyscape. Polcaro and Polcaro (2006) notes that the most prominent southern constellations visible from Jordan by the Early Bronze Age (c. 3200-1950 BC) during the winter included Orion, the Pleiades and Sirius, in addition to Leo and Scorpius, the stars serving as targets for orienting tumuli along the meridian. They argue that Early Bronze Age Dolmens in Jordan were oriented southward along the meridian and the culmination, or other peculiar position, of Orion near the date of winter solstice in association with funerary customs of the region at that time.

D’Huy and Berezkin (2017) provides a statistical analysis of motifs highlighting the evolution of the mythology concerning the Pleiades, “the most frequently and prominently recognized constellations among the hunter-gatherer societies of both hemispheres” (Hayden and Villeneuve 2011; Aveni 2019). References to the Pleiades appear in numerous ancient and indigenous cultures, including Mesopotamian and Chinese writings dated 3000 BC and 2357 BC, respectively, as well as in early Egyptian hieroglyphics, Hindu writings, the Talmud, the Koran, the Bible, and Homer's Iliad and Odyssey (Ceci 1978). Ceci (1978) attributes extensive spatial and temporal observation of the Pleiades to the high visibility and distinctive configuration of the asterism in tandem with the periodicity of their apparent movement in proximity to the ecliptic. Belmonte and Edwards (2010) applies archaeoastronomical fieldwork and ethnographic information to establish the importance of the Pleiades and Orion's Belt in the island traditional culture of Raapa Nui (Easter Island), including creation of a calendar based on visibility or invisibility of those asterisms during the year. Using archaeo-and ethnoastronomical data, Edwards and Belmonte (2004) identify orientations to Tautoru (Orion‘s Belt) as one the most important asterisms in Rapanui mythology, and together with Matariki (the Pleiades), they were key instruments for controlling time. Documentary, ethnographic, and archaeological evidence demonstrates that Iroquois and Algonquian tribes of northeastern North America observed the Pleiades with regard to seasonal limits of frost-free climatic conditions (Ceci 1978). Celestial movements are known in detail for every day of the year in Saami culture, with time estimated based on positions of stars including Ursa Major and the Pleiades (Hayden and Villeneuve 2011). The Alutiiq culture along the coast of northwest North America developed a 12-month calendar, beginning with the arrival of Pleiades in August, followed by Orion in September (Hayden and Villeneuve 2011).

Neolithic monumental architecture constructed from the Fertile Crescent and Nile River valley to across Europe and the British Isles demonstrate the importance of stars in the constellations of Canis Major, Orion and Taurus, and geomorphological features with respect to spatial and temporal relationships between the living and the dead. Interest in the stars of Orion is evident at Neolithic sites in England and Scotland. Harding *et al.* (2006:40, 47) identifies the setting of Orion's Belt framed by the western terminal of the complex of henges at Thornborough, speculating that a relationship between monuments and the stars of Sirius and Orion's Belt – potentially symbolically emphasized by the building of three aligned henges – might also have been associated with a local or regional cult. Harding (2015) proposes that the monumental complex was "a carefully planned and long-term vision – or religious imperative" during the Mid- to Late Neolithic in which observation of Orion's Belt might have been linked with beliefs, behaviors, and spiritual aspects of cosmogony that "collectively enlivened the complex and transformed it into a place of special religious poignancy." Henty (2014; 2016) concludes that observation of Orion might have been important at the recumbent stone circle at Tomnaverie, Scotland. In addition, the concentration of megalithic tombs and monuments along coasts of the

British Isles and the Atlantic façade is evidence of a significant influence of Neolithic seascapes on not only mundane subsistence and physical danger, but as a source of myth and reference to the Otherworld of the dead (Brown *et al*. 2015:42-43). Loveday (2006:140) notes a pattern of north-south oriented cursus alignments and the proximity of cursus monuments with river confluences, and suggests a possible link with observation of the star Sirius and the Belt stars of Orion that could have represented a metaphor for cursus monuments.

As stated in Appendix F, the hypothesized purpose of cursus monuments has often been related to procession along the interior of the banked area, possibly related to veneration of the dead or astronomical observations (e.g. Lockyer 1906; Stone 1947: 18; Penny and Wood 1973; Megew and Simpson 1979:94-5; Tilley 1994; McOmish 2003; Loveday 2006; Fowler and Scarre 2015; Brophy 2016: 19). However, Brophy (2016:171) concludes that, “On balance, the evidence to date suggest that cursus builders and users were more concerned with looking towards cursus monuments, than away from them.” Harding (1999:34) concludes that cursus monuments were associated with layers of meaning communicated based on a person’s location in the landscape. Maguire’s (2015) GIS assessment of the cultural landscape in the Upper Thames valley supports that idea. Maguire (2015) evaluates the potential for cursus monuments to link earlier structures with certain topographical settings. She concluded that:

- cursus monuments may have been situated proximal to areas of higher topography that could serve as ‘viewing platforms’ providing views toward the structures;

- cursus placement and orientation may be intentionally related to locations of rivers or streams; and

- aspects of the natural landscape were utilized to enhance or restrict views from cursus termini.

Maguire’s (2015) proposal that areas of higher topography could serve as “viewing platforms” providing views *toward* cursus monuments is a significant departure from many of the hypothesized uses of cursus monuments. Rather than features of the landscape or skyscape being observed from inside the corridor of the cursus, Maguire suggests that the cursus itself might have been intended to be observed from a specific location beyond the monument. That idea would support consideration of the purpose and use of cursuses in the context of large monuments set within the larger environment – the landscape, and skyscape – not as outrageously-sized structures, not so completely cut off from temporal and spatial human experience, but monuments potentially in tune with the macro-scale of worldviews.

Results of the current study support the conclusions of Harding (1999:34), Brophy (2016: 171) and Maguire (2015), in addition to a number of proposals by others regarding the possible purpose and use of cursus monuments, and Dorset Cursus in particular. While the purpose and use of Dorset Cursus might have been multiple and varied, results of this study strongly indicate that the monument best communicated its purpose in association with the surrounding environment by being viewed from vantage points along the crest of the Chalke Escarpment, centered at Winklebury Hill. From that perspective, use of the cursus was related to looking toward and across the length of the monument, with particular focus on alignments along the cursus' termini and centerline above which were located certain physiographic features and stars that provided both spatial and temporal references to a cosmology that likely related landscape to skyscape, and life on Earth to the Otherworld in the cosmos. As such, the cursus needed to be situated proximal to the higher topography of the escarpment serving as a 'viewing platform'with southeasterly views toward the monument, the study area, physiographic features of the horizon with an altitude of 0°, and the skyscape above. The cursus' size, location and orientation appear to have been intentionally related to observation of the monument from Winklebury Hill, set perpendicular to interfluves, rivers or streams, and serving as a signpost directing attention downstream toward and above the English Channel. The natural topography and vista from the escarpment were utilized to enhance views of the cursus, its termini, landscape and skyscape.

In summary, spatial and temporal relationships between Neolithic megalithic and earthen monumental structures and certain elements of the surrounding landscape, seascape, and skyscape may be key to recognizing and understanding the symbolism expressed by the architecture, and whether it is related to a hunter-gatherer cultural substrate or brought forth by aspects of Neolithic culture reminiscent of astronomical knowledge in the Near East and Egypt. Campbell (1991:48) notes evidence in well-established cultures of "diffused techniques, artifacts, and mythological motifs . . . characterized by well-defined general stages, though rendered by way of no less well-defined local styles." It is evident that architectural elements of British Neolithic megalithic and earthen monuments include symbolism linking not only the land, sea and sky, but cultural concerns about the afterlife that in some ways reflect similar concerns and conceptions in Europe and farther afield. The earthen architecture exhibited by extant long barrows in the study area, in tandem with Dorset Cursus and Hambledon Hill causewayed enclosure, are indicative of purposeful monumental constructions that reflect aspects of the environment above and below the horizon, including spatial and temporal relationships with astronomical events, some monuments expressing concepts of crossing physical and symbolic thresholds associated with the dead, and others perceived by the living.

5.7 Long-term Development of the Cultural Landscape

Does the spatial pattern and orientation of monuments reflect a process of purposeful long-term development of the landscape? If so, are the patterns of monument siting and architectural elements related to ritual functions of the landscape?

Physiographic locations and orientations of long barrows in the study area, in tandem with the geometry and location of the Dorset Cursus, provide strong evidence for purposeful long-term development of the earthen monuments across the landscape that was sympathetic to the topography, geomorphology, shallow stratigraphy and surface hydrology of the study area. The architectural form, orientation and use of earthen materials in construction of the monuments are significant factors to consider for understanding the purpose for the unique NW-SE orientation of long barrows and elements of the surrounding environment. Minerals have been associated with studies of materiality, identity, cosmology and spirituality related to Neolithic earthen and megalithic monuments (Boivin 2004; Owoc 2004; Saunders 2004; Cummings 2011).

The Chase has one of the highest densities of Neolithic earthen long barrows in Britain (Ashbee, 1970). It also includes the largest cursus in the British Isles, while earthworks of Hambledon Hill causewayed enclosure are situated just south of the Chalke Escarpment, along the Stour River. Those facts alone demonstrate the exceptional archaeological importance of the study area for understanding long-term, Early- to Middle-Neolithic development of that unique cultural landscape. Long-term development of the landscape is evident by construction of the set of earthen monuments over the course of most of the 4th millennium. While few long barrows in the study area have been dated (Wor Barrow and Hambledon Hill South date to the 37th century BC (Mercer *et al*., 2008; Allen *et al*., 2016), construction of long barrows in southern Britain likely did not occur prior to the second half of the thirty-eighth century BC, and the tradition ended by 3300 BC (Whittle *et al*., 2007; Allen et al., 2016). Construction of long barrows and the earthworks at Hambledon Hill are believed to have continued in concert with construction and use of the Dorset Cursus (French *et al*., 2007:186), with British traditions related to construction of each of those monumental earthen topologies ending by the end of the 4th millennium, possibly by the 32nd century BC (Tilley, 1994; Barrett *et al*. 1991a; Bradley, 1986; French, 2007: 186; Mercer and Healy, 2008). Thus, the spatial pattern of long mounds, causewayed enclosure and cursus in the study area developed over the course of half of a millennium, or more.

Results of the archaeoastronomical analysis indicate that the set of southeast-oriented long barrows might have been conceptually and architecturally aligned with valleys and interfluve ridges of the Chase, natural features of the study area and beyond, including the English Channel, and oriented toward the Belt of Orion at the moment the Pleiades culminated. Further, the location, size, and alignment of the Dorset Cursus might have been designed to signify a very precise moment in time and space, directing attention toward the Belt stars above the threshold of the English Channel – the boundary between the Earth and sky – at the moment the Pleiades culminated and Sirius appeared at the horizon. The location, size and orientation the Gussage Cursus appear to have been designed such that the termini, when observed from Winklebury Hill, were coincidental with azimuths of Sirius and Aldebaran when the Pleiades culminated. The cursus' design, therefore, was related to elements of the natural landscape, seascape, skyscape, and long barrows similarly aligned toward the southeast, and possibly referencing the flow of rivers toward the Channel. Scarre (2002d:86) suggests the sea provided an important visual feature when viewed from Neolithic tombs. Monuments constructed near the sea, such as Holdenhurst long barrow, might have been situated proximal to a particular spatial and temporal threshold, serving as portals providing access or restricting entry to a special place (Whittle 2002: 195). In addition, causewayed enclosures represented liminal zones at focal points accessible by road or watercourse allowing contact with the spirit world (Gebauer 2015). Similarly, orienting long barrows toward features of the skyscape such as the Belt stars and the Channel horizon indicate the monuments were conceived to focus attention toward the liminal zone between landscape and skyscape, the living and the dead. Therefore, the relationship between siting and orientation of earthen monuments and the natural environment may be associated with a cosmology referencing liminal transitions between the landscape, seascape and skyscape.

Previous studies of earthen and megalithic monuments at other landsacapes suggest that the architectures might symbolize cosmological beliefs related to perceived unification of the living, the dead, Earth and cosmos, in tandem with the boundary between land and sea conceived as symbolic of a liminal zone between earthly life and the world of the dead (Scarre 2002d: 100; Gebauer 2015; Harris 2015). Neolithic tumuli such as long barrows in southern Britain have been proposed to symbolize a pan-regional set of cosmological beliefs including social interactions between the living and the dead, and signifying the means of transition across a tiered cosmos (Lewis-Williams and Pearce 2005:184; Ahlers 2018:i). Congruence between long barrow orientations and the geometry of Dorset Cursus, associated with perceived alignment of geomorphological aspects of the landscape and the skyscape, indicates the monuments were designed and constructed to direct attention along similar alignments, particularly with reference to the Belt of Orion observed over the English Channel. Siting monuments to emphasize views of the surrounding landscape and skyscape reinforced relationships between the living, the dead, and the World (Owoc 2004). Those alignments might represent corridors for spirits coursing toward the Otherworld, as proposed by Devereux (2003: 69-72) with regard to alignments of cursus monuments in general. That idea may help explain the purpose for alignments from Winklebury Hill through the ends of Gussage Cursus to the horizon and stars above.

However, once the star positions appeared to be out of alignment with orientations of extant long barrows and the configuration of the cursus, the geometrical correspondences between monuments, landscape and skyscape would have lost significance.

The spatial pattern and dominant NW-SE orientation of long barrows in the study area, primarily on the downs, are further evidence of purposeful long-term development of the landscape. Thirty-three (92%) of the long barrows on the Chase, as well as the Dorset Cursus, are located in the 4 km wide corridor of monuments extending across the dip slope of the Chalk. Thirty-eight (93%) of the long barrows in the study area are located on or proximal to the crestline of a ridge, interfluve or hilltop, the long axis of most mounds oriented subparallel with contours of the local topography. Soils at those locations predominantly consist of shallow rendzinas allowing ready access to underlying frost-shattered chalk, with only one long barrow on the Chase constructed in an area underlain by deeper sediments such as Head, organic sediments, remanié clays, river terrace sediments or alluvium. Also, none of the long barrows appear to have been constructed over karst features. Further, about 80% of the Dorset Cursus was constructed where the Chalk is encountered immediately beneath rendzinas. Those results suggest there was likely some degree of planning to ensure that near-surface conditions beneath each monument would satisfy the need for an adequate supply of readily-available chalk for mound or bank construction, reduced concern for undue erosion or flooding, and long-term stability of the structures. Exceptions include portions of Dorset Cursus where it crosses floodplains at which fluctuating water levels could affect stability and erosion of lateral banks, and evidence of naleds where the monument crosses the Allen River floodplain. Assuming the cursus was constructed for the purpose of delineating the above-referenced stellar and physiographic alignments, as seen from Winklebury Hill, the stream crossings might have been unavoidable and the associated hydrologic and subsurface conditions acceptable for the intended purpose without mitigative measures.

Dorset Cursus was constructed as a series of relatively straight sections of lateral banks and ditches connected by shorter curvilinear sections, including the two S-curves. It should be noted that cursus monuments encountered across Britain are comprised of banks and ditches that approximate straight lines from one end of the monument to the other, each cursus being shorter than the Dorset Cursus. Therefore, it should not be surprising that the Dorset Cursus was constructed in similarly straight sections. However, the fitting of a circular curve between the lateral banks for almost the entire length of the cursus is surprising. Dorset Cursus was constructed upon the dip slope, crossing interfluves and river and stream valleys eight- to nine kilometers from the crestline of the cuesta. The bearing of the perpendicular bisector of the circular curve modeled for the Gussage Cursus is equivalent to the average downstream orientation of the stream valleys it crosses and less than one standard deviation of the mean orientation of southeast-oriented long barrows and azimuths of valleys and ridges. Statistically, then, directional vectors drawn from the earthen monuments and natural physiographic features have a common population of directions toward the southeast (Table 4.10). Given the superior topographic position of the Chalk Escarpment along the northwest side of the Chase with development of the Neolithic ritual landscape on the dip slope to the southeast, the viewscape toward the southeast direction appears to have been an important aspect of the landscape, in tandem with the above-referenced, stellar alignments, serving as a template for orientations of earthen structures constructed on the Chase and SHL. Evidence for this includes:

- the location of the Dorset Cursus and all but two (95%) of the long barrows in the study area located southeast of, and lower in elevation than, the crest of the Chalke Escarpment;

- thirty (71%) of the barrows oriented up-barrow toward the southeast;

- the two sets of directional vectors of the SE-oriented long barrows, and the valleys and ridges on the Chase, are drawn from the same common population in orientation;

- thirty-five (83%) of the barrows are situated with an up-barrow orientation directed toward a southeastern horizon of less than +1 degree; and

- twenty-eight (67%) of the long mounds are situated with southeasterly views of the English Channel.

It may be significant that the end of long barrow construction in Britain generally coincides with the construction date of Dorset Cursus and the period when the Pleiades culminated at the moment Sirius was at 0.0° altitude, c. 3365 BC. Results of this study indicate that Winklebury Hill may have served as the key location for observing the sequence of temporal and spatial relationships between the Dorset Cursus, the southeast horizon and related topographic and geographic features, and stellar events located between 23 hr. and 3 hr. right ascension, during the last centuries of the 4th millennium. Observation of the termini of Gussage Cursus out of alignment with the star positions of Sirius and Aldebaran when the Pleiades were at culmination would have occurred before the end of the millennium. Nonetheless, construction of the earthen monuments and purposeful development of the ritual landscape had proceeded during the course of hundreds of years before the landscape was altered again by introduction of henges and other earthen constructions during the late Neolithic.

It is possible that no end point in design and construction was intended or achieved in terms of the number of such earthen monuments constructed on the Chase. Certainly the areal extent of the Chase and SHL offered many more locations for siting additional earthen structures, and reasons for terminating construction and use of the monuments remain to be identified. However, results of this study suggest that the spatial pattern and orientation of monuments was purposeful and related to temporal or spatial attributes of the surrounding environment including observable features of the skyscape. While geomorphological changes in the landscape over the course of the 4th millennium do not necessarily appear to have impacted construction and use of earthen monuments in the study area, temporal changes in star positions relative to architectural orientations might have effected a loss of interest in further development and maintenance of long barrows and the cursus.

Chapter 6. Conclusions

This chapter presents conclusions of this study and suggestions for further investigation of relationships between monumental earthen architecture and the environment in the study area and other Neolithic cultural landscapes across the British Isles.

This study began by stating the difficulty the modern world has understanding the purpose of large Neolithic earthen monuments with respect to environmental settings and elements of their architecture. Studies in Britain have yielded little agreement regarding common physical attributes of place, design and location of British earthen long barrows. Previous studies of earthen monuments in the study area have generally lacked quantitative analysis including measurement of architectural details (residual as they may be) such as alignments between elements of the cultural landscape and skyscape.

The Mesolithic-Neolithic transition in Britain likely involved a complex and irregular geographic and demographic distribution that might be evident by the range of variability in material characteristics and architectural form of long barrows (Whittle 207:124; Ahlers 2018:4). While it is well-known that natural physiographic and celestial features of the environment had significant roles in development of ritual landscapes during the British Neolithic, site-specific reasons for constructing large – in some cases over-sized – earthen monuments have remained in question. However, as suggested by results of this study, the purpose for sizing prehistoric earthen monuments such as the Dorset Cursus, Neolithic long barrows, and causewayed enclosures to such massive proportions might not be so bewildering when we consider that architectural features of each monument relate to elements of the surrounding environmental context at various scales. Recognizing and understanding the relationship between environmental context and earthen (and megalithic) monuments then becomes a matter of identifying the parameters of cultural reference (Kinnes 1992).

This study investigated the known set of long barrows and the Dorset Cursus for evidence related to the state of the cultural landscape during the 4th millennium, and the geological, paleoenvironmental and social processes that contributed to the relict cultural pattern we see today. Specifically, this study was conducted to identify aspects of the

Cranborne Chase environment that contributed to the predominant NW- SE long mound orientation exhibited at the study area, as well as the siting, size and SSW-NNE orientation of the Dorset Cursus. The type, size, location, orientation and pattern of earthen long barrows and the Dorset Cursus are assumed to have been constructed with purpose as integral parts of Neolithic life in southern Britain. The Early- to Middle-Neolithic landscape, skyscape, and local cultural behaviors provide the context within which the cultural landscape developed. This study argues that:

- the pattern of monument sites on Cranborne Chase is related to a limited range of preferred subsurface conditions allowing ready access to chalk as a construction material and helping ensure a long-term lifespan for each monument;

- the set of long barrow barrow sites near hilltops and ridge lines, oriented subparallel with local topographic contours toward the southeast, reflects the orientation of valleys and stream flow directions encountered across the Chase;

- long mound sites typically included an open viewshed featuring peripheral areas of the surrounding environment, most often including a level horizon in the up-barrow direction, toward the southeast and the English Channel;

- southeast-oriented long mounds are aligned with spatial and temporal relationships including local topographic contours, regional geomorphic and hydrologic features, and astronomical events highlighted by orientation toward the Belt stars of Orion perceived above the Channel between the Isle of Wight and the Purbeck Hills;

- an ‘as above, so below’ association between long barrows constructed on hilltops and interfluves and southeast-oriented stream valleys of the natural landscape could indicate a conceptual reciprocal relationship emphasizing orientation of the living and the dead toward the English Channel and skyscape above;

- the size, orientation, alignment and location of the Dorset Cursus is sympathetic to physiographic and topographic features of the landscape and temporal stellar events associated with Sirius, Belt stars of Orion, Aldebaran and the Pleiades when observed from upper elevations of the chalk plateau centered at Winklebury Hill, the Ox Drove alignment and environs possibly serving as a viewing platform;

- observed from the study area, the Pleiades (represented by Alcyone) crossed the south meridian at the same time Sirius appeared on the eastern horizon at 0.0º altitude c. 3365 BC. That time frame corresponds with the date of construction of the Dorset Cursus determined by radiocarbon analysis by others, indicating observation of those simultaneous astronomical events from Winklebury Hill – with the Belt Stars of Orion suited above the English Channel – may have been the purpose behind design, construction and use of the monument;

- the conjunction of risings of Sirius and the Sun (and Moon) during winter solstice c. 3365 BC might also be associated with positioning of the north end of Gussage Cursus as seen from Winklebury Hil; and,

- the size, orientation and location of the Dorset Cursus are physically and symbolically related to long barrows exhibiting similar orientations of mound axes toward the southeast.

Results of this study demonstrate that spatial and temporal relationships between the earthen monumental structures and elements of the surrounding landscape, seascape, and skyscape are key to recognizing and understanding the symbolism and signification expressed by the architecture. The cultural landscape – including the pattern of both natural features and earthen monuments at Cranborne Chase, the South Hampshire Lowlands, and surrounding region – expresses spatial and temporal unification by alignment between Earth and sky, and the living and the dead. In that way, the cultural landscape is related to a Neolithic cosmology emphasizing certain elements of the observable landscape and skyscape, and belief in an astral afterlife.

Lifeways in southern Britain and other regions along the Atlantic façade during the 4th millennium entailed an increasing network of interregional transportation and communication, and deepening interest in siting the dead with reference to features of the surrounding environment (Thomas 2015:1078-1086). Those lifeways likely were products of ancestral Mesolithic and Neolithic cultural interactions in Central, Southern and Western Europe, including development of megalithic and earthen monumental constructions along the Atlantic façade. Cultural significance of alignments between earthen moments and the observable landscape and skyscape might have been influenced by ancestral cultural astronomy. Relationships between Sirius, the Belt stars of Orion, the Hyades and Pleiades, and ancient architectures and cosmologies of many ancient and indigenous cultures around the world are well-known (e.g. Campbell 1991:47; Shaltout *et al*. 2005; Harding *et al*. 2006:40,47; Hayden and Villeneuve 2011; Harding 2015; Michel *et al*. 2016, D'Huy and Berezkin 2017; Aveni 2019). In that light, the spatial and temporal relationships identified between the cultural landscape and skyscape in the study area should not be surprising. The set of similar, statistically significant orientations of long barrows, physiographic features, and stellar alignments identified for the study area represent further evidence of a strong association with those stars over the course of hundreds of years, in addition to similar design and construction features and viewscapes related to the Dorset Cursus. Similar evidence of those relationships are noted at other Neolithic sites across Britain (Hughes 2005; Harding *et al*. 2006:40, 47; Henty 2016) In addition, the concentration of megalithic tombs and monuments along coasts of the British Isles and the Atlantic façade is evidence of a significant influence of Neolithic seascapes referencing the Otherworld of the dead (Brown *et al*. 2015:42-43).

The Dorset Cursus might have been a cultural response to deteriorating climatic and agricultural conditions during of the mid- to later 4th millennium (Whittle *et al*. 2011:724–6; Thomas 2015: 1075; Loveday 2016; Brophy 2016: 31). While individual long barrows may relate entombments to site-specific locations for observation of stellar events, the Dorset Cursus provided a more extensive, landscape-wide representation of the relationship between the living on Earth and the dead in transition to the Otherworld – the perceived relationship indicated by observing alignments of the cursus and stars from Winklebury Hill. In particular, the size, orientation and placement of Gussage Cursus across the downs provide strong evidence for that relationship. Pentridge Cursus might have been constructed to extend the relationship to the northern portion of Cranborne Chase, north of Pentridge Hill between the Chalke Escarpment and the Avon River Valley. The timeframe for initial construction of the Dorset Cursus and Hambledon Hill causewayed enclosure approximate the period between 3500 and 3200 BC when Sirius could have been seen within a degree of the eastern horizon while the Pleiades were within 1 degree of the south meridian. Correspondence between the rise of Sirius and simultaneous culmination of the Pleiades in 3365 BC supports the date of construction of Gussage Cursus based on radiocarbon analysis (French *et al*., 2007, p. 186), and the possibility that construction of Gussage Cursus was directly related to observation of those astronomical events. However, by to 3015 BC Sirius would have been apparent before the Pleiades was within a degree of the south meridian, giving reason for discontinuing use of the Dorset Cursus for observing the alignments by the end of the 4th millennium.

Natural physical processes created elements of the study area's landscape that differentiate it from physiographical characteristics and Neolithic monumental architectures encountered at other British landscapes. Physiographic characteristics of the study area provide a unique set of geological, topographical, and hydrogeological features that are products of the structural and stratigraphic history of the northwest portion of Hampshire Basin. Unlike other Neolithic ritual landscapes in Britain, the monumental earthen architecture on the Chase was constructed to simulate and emphasize NW-SE-oriented interfluves and stream valleys of the Chase and highlight a southeasterly view from each monument, including the English Channel between the Isle of Wight and Purbeck monoclines, in tandem with observation of the above-referenced stellar events at a specific moment in time. Incorporation of turf, sediment and bedrock resources in mound construction, excavation of ditches, preferred architectural orientations, and use of limited architectural forms similar to natural landforms of the landscape are evidence that cultural features of the Chase were conceived and developed as elements of an abstract model of spatial and temporal design. Geographical and geometrical relationships between the cursus, features of the natural horizon, and stellar events viewed from Winklebury Hill appear to unify the ideational, conceptualized and constructed cultural landscape sympathetic toward the southeastern skyscape.

Results of this study point toward further avenues of research that may shed additional light on relationships between Neolithic earthen monuments and physiographic elements of Cranborne Chase and the SHL. Some long barrows have experienced significant degradation as a result of agricultural practices since the mid-twentieth century. Detailed archaeological investigation should be conducted at mounds that have suffered most, while efforts to protect earthen monuments from further degradation should be redoubled. The investigations might provide further evidence and improved resolution of parameters associated with external and internal architectural elements including measurement of barrow alignment beyond the apparent orientation of the spine of the respective relict barrow.

Additional analysis of relationships between long barrows oriented to the NE, NW and SW and elements of the surrounding landscape and skyscape may provide further evidence for the purpose of such mound orientations. Results of this study indicate mound orientations are related to up-barrow physiographical features at and beyond the study area, in tandem with astronomical events. Identifying the set of barrows constructed as tumuli or that contain artifacts of other cultural or ritual significance would help in evaluating the purpose of orienting long barrows with respect to the overall pattern of monuments, noting that most barrows not oriented toward the SE are situated at peripheral areas of the study area. Those orientations are likely related to cultural preferences and environmental constraints unrecognized to date, although results of this study would suggest both landscape and skyscape are integral to understanding those orientations and potential alignments.

Ruggles and Barclay (2000) finds no overriding pattern of development between monuments and celestial events, but regional patterns that evolved through time. They note monuments aligned with certain natural and cultural features in the landscape and/or skyscape helped to organize the landscape in accordance with cosmological principals that integrate the people with land and sky. Such landscape organization is demonstrated in this study of Cranborne Chase. Architectures of long barrows and the Dorset Cursus are directly related to unique spatial and temporal characteristics of the landscape and skyscape observed in the study area. Results of this study illustrate the need to conduct similar scopes of investigation at other Neolithic ritual landscapes to identify potential geomorphic, topographic, hydrologic and astronomical relationships between earthen monuments and their environment. While specific elements of those relationships may differ from those identified for this study, we may speculate that long barrow construction in Britain was associated with an over-arching, pan-regional set of cosmological beliefs. The monumental architecture may have referenced certain spatial and temporal features of the surrounding environment at micro-, meso-, or macro-scales in ways that allowed local ideologies and perceptions to be expressed by the building materials, location, size, orientation, and temporal and spatial functioning of each earthen monument. A holistic approach including methods of geology, geoarchaeology, landscape archaeology, architectural analysis, comparative ethnography and archaeoastronomy can help us recognize and understand the purpose and meaning built into those prehistoric cultural landscapes.

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Appendices

Appendix A

Analysis of Monument Orientation and Alignment with respect to Local Physiography and Astronomical Events

Orientation of the long axis of each long barrow was evaluated with respect to readily apparent natural geomorphic features situated in up-barrow and down-barrow directions. Similar studies of relationships between topographic features of landscapes, long barrows and cursus monuments have been conducted previously by others. The extent of analysis was often limited to individual monuments (e.g., Penny and Wood, 1973; Chapman, 2005; Loveday, 2006), while other studies have addressed such relationships for sets of Neolithic or Bronze Age monuments (Higginbottom and Clay 2016; Higginbottom 2020a; Marshall 2021).

The size, shape and orientation of each Neolithic long barrow upon completion of the respective construction are generally unknown because of weathering and erosion of the mound and subsequent on-site land use over the course of millennia, including plowing of mounds to various extents during the course of agricultural activities, and disturbance or removal of mounds in association with excavations. Nonetheless, most long barrows in the study area include a remnant, extant mound allowing measurement of the apparent primary (longitudinal) axis orientation of the barrow using a Brunton standard pocket transit (azimuth 0°-360°).

Romain (2020) references accuracies related to use of the magnetic compass, with theoretical accuracies of ±0.25° (Belmonte, Shaltout and Fekri 2009:220), while Brunton states an accuracy of the 5006 LM pocket transit as ±0.5° with a graduation interval of 1° (https://www.opticsplanet.com/brunton-compasses-international-pocket-transit.html). Nonetheless, as a practical matter and based on field experience, the accuracy limit of the prismatic compass such as the Brunton model used during this study can lead to errors of 1° to 2° (Munro and Malville 2010; Romain 2020). Therefore, field measurements of twenty-nine long barrow orientations using a Brunton compass for this study are assumed to be accurate to within 2 degrees of arc (±2°). Lacking intrusive investigation of the structure and orientation of internal features of the barrows, the field measurements are assumed to approximate the original mound axis orientation within that amount of error.

Locations of long barrows and the Dorset Cursus were digitized and plotted as layers onto the DEM of the project area using ArcGISPro 1.4.1 and digitized aerial photographs provided on Google Earth Pro version 7.3.4.8248 (32-bit). The DEM was used to develop ground surface profiles along the length of the Dorset Cursus and across the Chase, between the crest of the Chalke Escarpment and the English Channel. Orientations of nine long barrows were measured using the Ruler Tool provided in the Google Earth software program. Romain (2020) assesses the accuracy of the Ruler Tool with regard for 'heading' data. The analysis concludes that the heading data accuracy can exceed results provided by use of magnetic compases, and could be better than 1° (Sinachopoulos 2019:222). Goudarzi and Landry (2017) assesses horizontal positional accuracy of Google Earth compared to a set of GPS points with precise coordinates, and found that true positions may be distorted by up to several meters as an effect of topography. Romain (2020) notes that while algorithms for orthorectification and seamless stitching in the creation of photo mosaics continues to improve, there remains a lack of transparency regarding spatial resolution for individual digital aerial photographs provided by Google Earth.

Inspection of Google Earth Pro digital images of the study area (the car park at Win Green, imagery date 09/13/2020, and vehicles parked on streets at the village of Cranborne, imagery date 07/152021) indicated that shapes of cars can be made out clearly, and while windshields are poorly defined, side-mirrors of some vehicles are just visible. Romain (2020) suggests those conditions are indicative of a spatial resolution of about 0.15 meters (Figure A1). Therefore, measurement of a line 0.55 km long at a bearing of 251.28° from a side-mirror of a vehicle in the car park to the

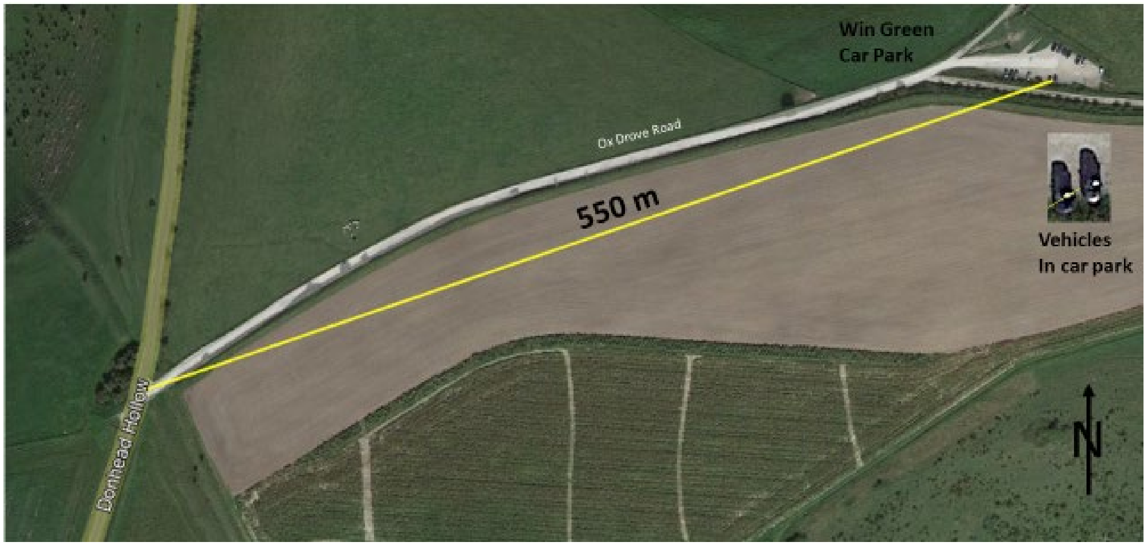

Figure A1: Measured line using the Google earth Ruler Tool. The line is 0.55 km long and bearing of 251.28° from side-mirror of vehicle in the Win Green car park to the intersection of Ox Drove Road and Donhead Hollow Road. Estimated error of the bearing is about ±0.16°.

intersection of Ox Drove Road and Donhead Hollow Road southwest of the vehicle using the Google Earth Ruler Tool results in an error of about ±0.16°.

Similarly, a line 15.09 km long at a bearing of 117.17° from the same side-mirror of the vehicle in the car park to an apparent side-mirror of a vehicle parked at Cranborne Middle School results in an error of about ±0.001°. Based on those results, error of measurements using the Google Earth Ruler Tool for this study are assumed to be less than ±0.2°. Exceptions are made for measured orientations of long barrows when using the Google Earth Ruler Tool, with apparent orientation of the respective mound based on spatial resolution of shadows, vegetation, pathways or other features that indicate the approximate location and orientation of the spine of the barrow, in which case orientations are assumed to have an error of ±1°, equivalent to an error of about 1.7 m measured along a 100 m long mound. A similar error is assumed for measurement of orientations associated with locations of the south terminus of the Gussage Cursus exhibiting a shape similar in size and profile as long mounds. An assumed spatial resolution of 0.15 meters is applied for digital images of the Dorset Cursus provided in Google Earth Pro based on the discussion above. Delineation of the north terminus of Gussage Cursus and the north terminus of Pentridge Cursus is based on measurement of the width and length of the soil mark or crop mark associated with those features apparent on the digital images, and dividing those values by 2 to mark the center point of the termini used for this project.

This study included a quantitative evaluation (Davis, 2002) of the measured long barrow orientations reflecting the circular nature (azimuths measured from North) of the data, where the X- and Y- coordinates of the end point of the unit vector for each measured direction given by angle θ are:

$$X_i = \cos \theta_i$$

$$Y_i = \sin \theta_i$$

The vector resultant R is the sum of the sines and cosines of *n* vectors:

$$X_r = \sum_{i=1}^{n} cos\theta_i$$

$$Y_r = \sum_{i=1}^{n} sin\theta_i$$

The mean direction $\bar{\theta}$, or angular average of all vectors in the sample, is:

$$\bar{\theta} = \tan^{-1} (Yr/Xr)$$

The body of measurements (*n* = number of measurements) was plotted as points on a projection of a hemisphere (rose diagram), and analyzed statistically to evaluate the dominant direction (vector resultant, *R*), where:

$$\mathrm{R} = \sqrt{X_r^2 + Y_r^2}$$

The resultant provides a measure of the average direction of the long barrow orientations and the spread of the bearings about that average. The standardized resultant length is:

$$\bar{R} = \frac{R}{n}$$

The result was then tested for randomness in direction (i.e. there is no preferred direction, or the probability of occurrence for all directions is the same). The von Mises distribution is a continuous distribution equivalent to the normal distribution for data defined with 2-dimensional directional coordinates, utilizing two parameters: mean direction (θ), and a concentration parameter (κ). Assuming a finite normal distribution with the x-axis being in the range [0,2π], the von Mises distribution was applied to the hypothesis that the directional observations are random (H_0). This is equivalent to the concentration parameter equal to 0 because the distribution of directions (long barrow orientations) becomes circular uniform.

$$H_0: \kappa = 0$$
$$H_1: \kappa > 0$$

Under those conditions κ was estimated from the standardized resultant length of the sample measurements ($\bar{R}$). That statistic was compared to a critical value of $\bar{R}$ for the desired level of significance (Mardia, 1972). If the computed value of $\bar{R}$ well exceeds the critical value, then the null hypothesis is rejected, the concentration parameter must exceed 0, and the long barrow orientations must have a preferred trend.

Results of the analysis were used to assist identifying the potential target or targets of the long barrow architecture. Based on results of the analysis a list of those features were compiled and evaluated to determine if a common theme (such as topographic highs or lows, hydrologic features such as river valleys, average surface gradient to horizon, or other) of those features is indicated. In addition, long axis orientations of long barrows on the Chase were evaluated with respect to astronomical events that would have been readily apparent using naked eye observations during the mid- to late 4th millennium.

Orientations of the long axes of the long mounds were evaluated with respect to stellar, solar and lunar events, with particular interest in the up-barrow and down-barrow directions. The analysis included use of astronomical software (Starry Night Enthusiast, version 4.5) to model the skyscape c. 4000 to 3000 BC to identify temporal and spatial astronomical events within the range of measured long axis bearings, including solar and lunar risings and settings, and risings and settings of stars within the range of declinations corresponding to the angular average and spread of the measured long axis bearings. Results of the evaluation were compared to results of similar analyses of Neolithic ritual monuments in Britain where correspondences between architectural features and astronomical events have been previously identified (for example, Penny & Wood, 1973; Loveday, 2006: 137-42; Henty, 2016).

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Appendix B

Archaeoastronomy

The mean orbital inclination of the Moon to the ecliptic is 5.145 degrees (5° 08' 42"). The actual lunar inclination can exceed the mean by up to about 0° 09'. North (1996: 563-588) describes and illustrates conditions in which extreme values of the Moon's declination occur during major northern and southern standstills, when the Moon's range of declination, and therefore the azimuthal range at moonrise and moonset, attains a maximum. The Moon's declination (obliquity + lunar inclination) is the angle between the celestial equator and lunar orbital plane. A major lunar standstill occurs when the Moon's range of azimuth at moonrise and moonset (and its associated declination) is at a maximum. A standstill occurs gradually between northern and southern limits of the lunar declination during half of a two week (13.66 days) sidereal month. One major (and one minor) lunar standstill occurs every 18.6 years as a product of the precessional cycle of lunar nodes, when the orbital plane of the Moon intersects the ecliptic. Several adjustments related to solar, lunar and Earth's kinetic relationships are necessary in the calculation of extremes in lunar inclination. One result is that an additional 13.8' must be added to the Moon's inclination during a major lunar standstill (North 1996: 568). The calculated azimuth of the major southern lunar standstill at moonrise c. 4000 - 3000 BC in southern Wiltshire ranges from about 142° to 143° 15' (North 1996:570-571).

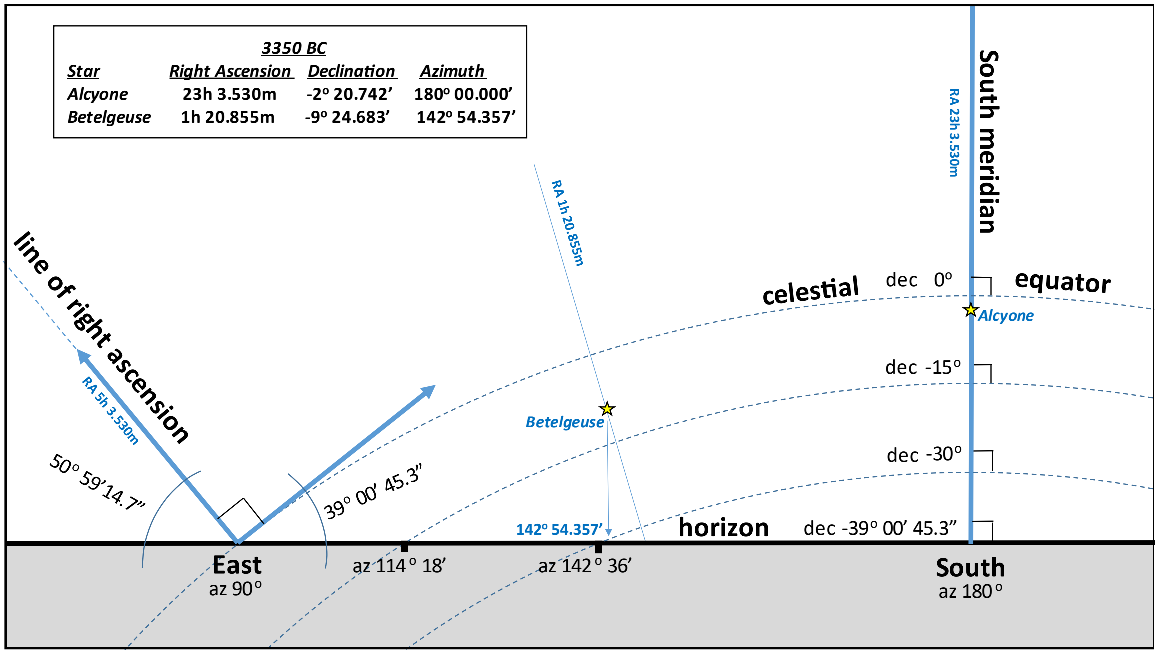
The annual heliacal rising of a star, when it first becomes visible above the eastern horizon before sunrise, after some number of days when it was invisible as a result of being behind the Sun or below the horizon, has been used by many cultures as a marker of seasons and implications for agricultural practices and cultural behaviors (e.g. Ceci 1978; Alinei and Benozzo 2008; Belmonte and Edwards 2010; Hayden and Villeneuve 2011; Last 2015: 275). For example, a cosmological association between southeasterly long barrow orientations and birth, fertility, or an agricultural calendar remain possibilities. No more than 2000 stars are visible to the naked eye (Moore 2000:164; Bender 2011), and they generally cannot be observed at a horizon of 0 degrees as a result of atmospheric extinction related to altitude, pressure, humidity and air pollution at mid-latitudes. In general, an empirical rule (Thom's Law) states that a star having a visible apparent magnitude M cannot be observed with the naked eye until it is at least M° above the horizon (0°) (Magli 2016). For example Sirius, the brightest star (visual magnitude -1.47), is bright enough to be observed slightly above the horizon under clear atmospheric conditions, and is known to be conspicuous because of its visual apparent magnitude and variability in color especially when the star is near the horizon (Ceragioli 1993).

Of the 100 brightest stars viewed from Earth today, 87 were visible from the latitude of the study area during the referenced time frame. Table B.1 includes a list of the 39 brightest stars with magnitude less than +2.50 (determined by the maximum visual magnitudes as viewed from Earth) with declinations within the specified range. The list includes 10 first magnitude (<1.5) stars, 26 second magnitude (1.5 to 2.5) stars, and 4 third magnitude (>2.5) stars. The list includes the brightest stars that, while some are currently known to be binary or multiple star systems, appear to the naked eye as single stars. Table B.1 lists the star names, apparent magnitude, right ascension in hours, declination in degrees, and azimuth in degrees. Table B.2 includes the same data as Table B.1 but ordered by star right ascension. Most proper names in this list include those approved by the Working Group on Star Names of the International Astronomical Union. The list also includes the Pleiades. While Alcyone, the brightest star of the Pleiades asterism, has an apparent magnitude of 2.84, the open cluster as a whole has a brightness of magnitude 1.6.

The skyscape of the southeast quadrant is observed along azimuths of 90 to 180 degrees, along and above one-fourth of the horizon. Those azimuths correspond to 6 hours (one-fourth) of the total of 24 hours of right ascension related to star positions based on the distance from the vernal equinox, specifically a point east of the First Point of Aries measured along the celestial equator. Right ascension is normally expressed in hours, minutes, and seconds, but is indicated by hour equivalents in Table B.1 and Table B.2. Stars in Table B.2 are grouped into six bins of 4-hour right ascension intervals (23-3 hr, 3-7 hr, 7-11, hr, 11-15 hr, 15-19 hr, 19-23 hr).

When viewed along an azimuth of 180 degrees (due South), the orientation of any line of right ascension – from the horizon to the zenith point (the south meridian) – is perpendicular to a level plane at the horizon. That geometry is illustrated in Figure B.1. The angle is defined by the line of right ascension and a level horizon with decreasing azimuths east of the south meridian. At an azimuth of 90 degrees (due East), the angle of a line of right ascension and a level horizon with 0 degree altitude is equivalent to the latitude of observation. At Winklebury Hill in 3350 BC that angle is 50° 59’ 14.7”. The complementary angle (39° 00’45.3”) is the angle between a level horizon at 0 degree altitude and the line of the celestial equator intersecting the horizon at an azimuth of 90 degrees. In other words, the celestial equator (declination 0° 00’ 00”) intersects the horizon due East of Winklebury Hill at an angle of 39° 00’45.3”. Therefore, each angle of azimuth measured in the southeast quadrant may be coupled with a measure of declination. At azimuth 90° 00’ 00” the equivalent declination at the horizon is 0 degrees. At azimuth 180° 00’ 00” the equivalent declination at the horizon is -39° 00’45.3”.

The declination and right ascension of each star changes overtime because of precession of the equinoxes, a function of Earth’s changing axial tilt. Declinations of stars rising along the southeast portion of the horizon during 3350 BC ranged from 0° at azimuth 90° (East) to -39° 00’ 45.3” at azimuth 180° (South). Conversely, stars rising from the horizon from the due East direction appeared to move up at an angle of 39° 00’ 45.3” relative to a level horizon, while stars along the south meridian always move parallel (0° angle) relative to a level horizon before dropping in altitude toward the western horizon. The location of Alcyone observed at its culmination sets a specific moment in time when the location of another star above the horizon was uniquely defined by its azimuth and altitude. For example, at Cranborne Chase in 3350 BC Betelgeuse was located



3350 BC

Star	*Right Ascension*	*Declination*	*Azimuth*
Alcyone	23h 3.530m	-2° 20.742’	180° 00.000’
Betelgeuse	1h 20.855m	-9° 24.683’	142° 54.357’

Figure B.1: Geometry of Stellar Declinations in the Southeast Quadrant c. 3350 BC.

at a specific altitude above the horizon at azimuth 142º 54.357’ when Alcyone culminated at the south meridian. Therefore, orientation by azimuth and altitude of Betelgeuse or any other observable star from a given location, including the study area, defines the direction toward a star’s celestial coordinates of right ascension and declination for that timeframe.

Table B.1
List of Brightest Stars seen from Winklebury Hill c. 3350 BC
(declination of 0 to -39 degrees)

Name	Apparent Magnitude	Right Ascension (Hour)	Declination (degree)	Azimuth at Rising (degree)
Sirius	-1.47	2.85638	-23.75	129.79
Alpha Centauri - A	- 0.01	10.35038	-33.38	150.94
Rigel	0.12	1.10433	-27.67	137.52
Betelgeuse	0.58	1.34758	-9.42	105.06
Hadar	0.6	9.57660	-32.03	147.42
Acrux	0.81	8.69838	-36.52	160.95
Aldebaran	0.85	23.90443	-7.00	101.17
Antares	1.09	11.64587	-1.90	93.02
Betacrux	1.297	8.82953	-32.58	148.82
Alpha Centauri – B	1.33	10.34150	-34.08	152.90
Adhara	1.513	3.55892	-34.68	154.71
Alcyone	1.6	23.05882	-2.35	93.75
Shaula	1.62	12.2952	-16.27	116.43
Gacrux	1.63	8.60145	-30.25	143.17
Bellatrix	1.64	0.90623	-13.12	111.13
Alnilam	1.7	1.27683	-19.15	121.40
Alnitak	1.79	1.37085	-19.40	121.85
Kraus Australis	1.8	13.03323	-17.85	119.14
Wezen	1.8	3.59475	-31.35	145.75
Sargas	1.842	12.18078	-22.03	126.57
Mirzam	1.862	2.56013	-29.40	141.23
Hamal	1.98	21.53845	-4.83	97.70
Saiph	2.004	1.71030	-25.77	133.68
Nunki	2.049	13.69135	-13.68	112.07
Menkent	2.058	9.60357	-7.27	101.61
Noas	2.06	4.97597	-36.17	159.66
Lamda Velorum	2.21	5.92735	-32.15	147.70
Mintaka	2.226	1.18418	-18.70	120.63
Epsilon Centauri	2.23	9.29325	-25.37	132.90
Alpha Lupi	2.265	9.99607	-19.12	121.35
Wei	2.276	11.85423	-10.62	107.03
Eta Centauri	2.29	9.93377	-13.83	112.32
Girtab	2.322	12.35670	-18.72	120.66
Aludra	2.375	3.94673	-31.95	147.21
Enif	2.4	17.27418	-1.07	91.68
Markab	2.404	18.61217	-4.05	96.44
Zeta Centauri	2.49	9.44545	-18.98	121.12
Menkar	2.515	22.50698	-23.6	129.50
Delta Centauri	2.56	8.24255	-25.33	132.84
Arneb	2.561	1.72168	-34.7	154.75

Table B.2
List of Brightest Stars seen from Winklebury Hill ordered by Right Ascension
(declination of 0 to -39 degrees, c. 3350 BC)

Name	Right Ascension (Hour)	Declination (degree)	Azimuth at Rising (degree)	Apparent Magnitude
Alcyone	23.05882	-2.35	93.75	1.6
Aldebaran	23.90443	-7.00	101.17	0.85
Bellatrix	0.90623	-13.12	111.13	1.64
Rigel	1.10433	-27.67	137.52	0.12
Mintaka	1.18418	-18.70	120.63	2.226
Alnilam	1.27683	-19.15	121.40	1.7
Betelgeuse	1.34758	-9.42	105.06	0.58
Alnitak	1.37085	-19.40	121.85	1.79
Saiph	1.71030	-25.77	133.68	2.004
Arneb	1.72168	-34.7	154.75	2.561
Mirzam	2.56013	-29.40	141.23	1.862
Sirius	2.85638	-23.75	129.79	-1.47
Adhara	3.55892	-34.68	154.71	1.513
Wezen	3.59475	-31.35	145.75	1.8
Aludra	3.94673	-31.95	147.21	2.375
Noas	4.97597	-36.17	159.66	2.06
Lamda Velorum	5.92735	-32.15	147.70	2.21
Delta Centauri	8.24255	-25.33	132.84	2.56
Gacrux	8.60145	-30.25	143.17	1.63
Acrux	8.69838	-36.52	160.95	0.81
Betacrux	8.82953	-32.58	148.82	1.297
Epsilon Centauri	9.29325	-25.37	132.90	2.23
Zeta Centauri	9.44545	-18.98	121.12	2.49
Hadar	9.57660	-32.03	147.42	0.6
Menkent	9.60357	-7.27	101.61	2.058
Eta Centauri	9.93377	-13.83	112.32	2.29
Alpha Lupi	9.99607	-19.12	121.35	2.265
Alpha Centauri – B	10.34150	-34.08	152.90	1.33
Alpha Centauri - A	10.35038	-33.38	150.94	- 0.01
Antares	11.64587	-1.90	93.02	1.09
Wei	11.85423	-10.62	107.03	2.276
Sargas	12.18078	-22.03	126.57	1.842
Shaula	12.29520	-16.27	116.43	1.62
Girtab	12.35670	-18.72	120.66	2.322
Kraus Australis	13.03323	-17.85	119.14	1.8
Nunki	13.69135	-13.68	112.07	2.049
Enif	17.27418	-1.07	91.68	2.4
Markab	18.61217	-4.05	96.44	2.404
Hamal	21.53845	-4.83	97.70	1.98
Menkar	22.50698	-23.60	129.50	2.515

Appendix C

Check of Astronomical Program Accuracy for Star Positions

Archaeoastronomical analyses for this study applied astronomical modeling software Starry Night Enthusiast, version 4.5 (SNE) to identify locations of solar, lunar and stellar events along and above the horizon c. 4000 to 3000 BC. Data provided by SNE included azimuth, altitude, right ascension and declination of the Sun, Moon and stars that would have been apparent in the skyscape at Cranborne Chase, specifically from the apex of Winklebury Hill. Quantifying the location of a stellar body observed from Earth requires consideration of effects of gravitational interactions between Earth and other bodies within the solar system, precession of the equinoxes (the vernal equinox defined by the intersection of the celestial equator and ecliptic and resulting in an apparent westward regression along the ecliptic at 50.26” per year (Carroll and Ostlie 1996, p. 15), and proper motion of the star (the intrinsic movement of a star expressed as an angular velocity, commonly in arcsec per year). In addition, Earth’s atmosphere affects the apparent position of celestial bodies, distorting observations as a result of refraction and diffusion of light, particularly when the body is near the horizon.

De Lorenzis and Orofino (2018) compares commercial astronomical programs to evaluate the software’s ability to account for stellar positions with respect to precession of the equinoxes and proper motions of stars. Data obtained from the programs was compared with output provided by the Orion program written by Patrick Wallace of STFC Rutherford Appleton Laboratory, UK, and considered to be “the most reliable instrument for the determination of past stellar coordinates” (De Lorenzis and Orofino 2018). Results of the comparison found that inaccurate estimations of positions of stars is especially evident for very remote epochs in the past. For example, Starry Night Pro (SNP) yielded noticeable differences in the accuracy of star positions analyzed for epochs earlier than 6000 BC. Specifically, the study produced a deviation between the declinations of Orion and SNP for the star Sirius (alpha Canis Majoris) of -0.02° for the epoch 2500 BC, -0.04° for 4500 BC and 6000 BC, -0.42° in 8000 BC, and 0.10° in 10,000 BC.

As a check for the accuracy of star position data provided by SNE software used for this study, celestial coordinates (right ascension and declination) for the position of Sirius in 3250 were calculated using the method described by Meeus (1998, pp. 134-135) and compared to values provided by SNE. The method provides a rigorous procedure for converting the right ascension α and the declination δ of a star for a given epoch and an equinox to corresponding mean values for another epoch and equinox. The standard epoch for the calculation of astronomical ephemerides is January 1, 2000 (designated J2000.0), corresponding to JDE 2451545.0, based on the astronomical reference frame adopted by the International Astronomical Union (IAU 1976). The following is a summary of the rigorous method for the calculation as described in Meeus (1998).

Let T be the time interval in Julian centuries between J2000.0 and the starting epoch, and let t be the interval, in the same units, between the starting epoch and the final epoch.

Then, $$T = \frac{(\mathrm{JD})_o - 2451545.0}{36525} \qquad t = \frac{(\mathrm{JD}) - (\mathrm{JD})_o}{36525}$$

Numerical expressions for quantities ζ, z and θ which are needed for the accurate reduction of positions from one equinox to another are:

$$\zeta = (2306''.2181 + 1''.39656T - 0''.000139T^2)t + (0''.30188 - 0''.000344T)t^2 + 0''.017998t^3$$
$$z = (2306''.2181 + 1''.39656T - 0''.000139T^2)t + (1''.09468 + 0''.000066T)t^2 + 0''.018203t^3$$

$$\theta = (2004''.3109 - 0''.85330T - 0\,''.000217T^2)t - (0''.42665 + 0''.000217T)t^2 - 0''.041833t^3$$

If the starting epoch is J2000.0, $T = 0$ and expressions for ζ, z, and θ reduce to:

$$\zeta = 2306''.2181t + 0''.30188t^2 + 0''.017998t^3$$
$$z = 2306''.2181t + 1''.09468t^2 + 0''.018203t^3$$
$$\theta = 2004''.3109t - 0''.42665t^2 - 0''.041833t^3$$

Then, the rigorous formulae for the reduction of the given equatorial coordinates α_o and δ_o of the starting epoch to the coordinates α and δ of the final epoch are:

$$A = \cos\delta_o \sin(\alpha_o + \zeta)$$
$$B = \cos\theta \cos\delta_o \cos(\alpha_o + \zeta) - \sin\theta \sin\delta_o$$
$$C = \sin\theta \cos\delta_o \cos(\alpha_o + \zeta) + \cos\theta \sin\delta_o$$
$$\tan(\alpha - z) = \frac{A}{B} \qquad \sin\delta = C$$

The angle $\alpha - z$ can be obtained in the correct quadrant by applying the 'second' arctangent function ATN2 to the quantities A and B, or by another procedure (Meeus 1998: Chapter 1). If the star is close to the celestial pole, the declination should be calculated by means of the formula $\cos\delta = \sqrt{(A^2 + B^2)}$ instead of $\sin\delta = C$. Before making the reduction from α_o, δ_o to α, δ, the effect of the star's proper motion should be calculated.

The following input was used to calculate right ascension and declination of Sirius:

J2000.0 starting epoch, (JD)o = 2451545.0
α_o = 06h 45m 08.91728s = 101.28716 degrees (van Leeuwen 2007)
δ_o = -16 42' 58.0171" = -16.71612 degrees (van Leeuwen 2007)

Annual proper motion of Sirius (van Leeuwen 2007):

right ascension rate, arcsec/yr = -0.54601 seconds of arc = -0.036400667 seconds time

declination rate, arcsec/yr = -1.22307 seconds of arc

J(-3250.0) final epoch: (JD) = (JD)o - (-5250 x 365.25) = 533982.5

The input was entered onto an Excel spreadsheet and the rigorous method was applied to convert the right ascension α and the declination δ of Sirius from the starting epoch and equinox (J2000.0) to the corresponding mean value for the year 3250 BC using the J2000 equinox as reference. The following table summarizes results of the rigorous method compared with data provided by the SNE software.

Item	SNE data	Meeus (1998)	Difference
α	6h 48.442m	6h 48.92m	+0.478m = 7.17' = 0.1195°
δ	-14° 55.959'	-14° 55.95'	-0.009' = 0.00015°

The resolving power of the human eye is defined as the minimum angular distance between two point sources such that they may be seen as two distinct objects (De Lorenzis and Orofino 2018). Normal visual acuity (sharpest in the fovea centralis of the human eye) is generally considered to be the ability to recognize an opotype subtending 5 minutes of visual angle (Snellen 1862), while the maximum angular resolution of the human eye is 0.47 arc minutes (Deering, undated). De Lorenzis and Orofino (2018) states that, depending upon sky conditions and the observed stellar sources of interest, the resolving power of the human eye could vary between 5 and 10 arcmin, or 0.08◦ and 0.17◦ (Silvestro, 1989) while under favorable conditions it may be as little as 3 arcmin, or 0.05◦ (Herrmann, 1975; Gribbin and Gribbin, 1996).

The difference in the calculated value of right ascension using Meeus' rigorous method approximates the limit of resolving power of the human eye, while the difference in declination is much less than the visual angle the human eye can detect. Therefore, we may conclude that values of α and δ given by SNE not only approximate results of the rigorous method of calculation for the epoch 3250 BC, but the difference in those values are less than the ability of the human eye to detect. In addition, values of the difference in right ascension and declination are much less than the assumed error during measurement of long barrow orientations (+2^{o} of arc) and observation of sightlines between Winklebury Hill, termini of Dorset Cursus, and geomorphic features on the southeast horizon.

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Appendix D

Tables Listing Star Positions between 4000 BC and 3000 BC

Table D.1: Star Positions in Azimuth and Altitude, 4000 BC to 3000BC

Star positions when Alcyone approaches culmination (az. 180°)
and when Sirius approaches the eastern horizon (alt. 0°)

Year	Star	Azimuth		Altitude	
4000	Alcyone	179 59.999	179.999983	33 10.075	33.167917
	Aldebaran	165 55.280	165.921333	27 23.064	27.384400
	Alnilam	148 35.895	148.598250	10 32.771	10.546183
	Sirius	130 23.628	130.393800	-2 42.533	-2.708883
	Sirius	134 52.933	134.882217	0 0.003	0.000050
	Alcyone	186 56.408	186.940133	32 56.697	32.944950
	Aldebaran	172 22.223	172.370383	28 4.683	28.078050
	Alnilam	153 47.902	153.798367	12 19.230	12.320500
3800	Alcyone	180 0.004	180.000067	34 13.555	34.225917
	Aldebaran	165 43.657	165.727617	28 29.198	28.486633
	Alnilam	148 19.141	148.319017	11 37.800	11.630000
	Sirius	130 13.243	130.220717	-1 49.642	-1.827367
	Sirius	133 13.037	133.217283	0 0.001	0.000017
	Alcyone	184 41.023	184.683717	34 7.551	34.125850
	Aldebaran	170 3.792	170.063200	29 0.005	29.000083
	Alnilam	151 48.112	151.801867	12 51.115	12.851917
3500	Alcyone	179 59.994	179.999900	35 50.745	35.845750
	Aldebaran	165 25.656	165.427600	30 9.027	30.150450
	Alnilam	147 54.695	147.911583	13 14.101	13.235017
	Sirius	129 59.465	129.991083	-0 33.197	-0.553283
	Sirius	130 53.173	130.886217	0 0.004	0.000067
	Alcyone	181 25.345	181.422417	35 50.203	35.836717
	Aldebaran	166 44.181	166.736350	30 19.519	30.325317
	Alnilam	148 57.412	148.956867	13 36.936	13.615600
3350	Alcyone	180 0.002	180.000333	36 40.007	36.666783
	Aldebaran	165 16.396	165.273267	30 59.039	30.983983
	Alnilam	147 42.746	147.712433	14 1.580	14.026333
	Sirius	129 53.337	129.888950	0 3.723	0.062500
	Sirius	129 47.347	129.789117	-0 0.001	-0.000017
	Alcyone	179 50.401	179.840017	36 40.003	36.666717
	Aldebaran	165 7.591	165.126517	30 57.801	30.963350
	Alnilam	147 35.734	147.595567	13 58.986	13.983100

continued next page

Table D.1 (continued):

Star positions when Alcyone approaches culmination (az. 180°) and when Sirius approaches the eastern horizon (alt. 0°)

Year	Star	Azimuth		Altitude	
3200	Alcyone	180 0.003	180.000050	37 29.641	37.494017
	Aldebaran	165 6.941	165.115683	31 49.041	31.817350
	Alnilam	147 30.970	147.516167	14 48.555	14.809250
	Sirius	129 47.726	129.795433	0 39.756	0.662600
	Sirius	128 44.152	128.735867	-0 0.001	-0.000017
	Alcyone	178 17.235	178.287250	37 28.874	37.481233
	Aldebaran	163 33.016	163.550267	31 35.175	31.586250
	Alnilam	146 16.399	146.273317	14 20.509	14.341817
3000	Alcyone	179 59.999	179.999983	38 36.295	38.604917
	Aldebaran	164 53.993	164.899883	32 55.648	32.927467
	Alnilam	147 15.446	147.257433	15 50.436	15.840600
	Sirius	129 40.931	129.682183	1 26.545	1.442417
	Sirius	127 23.475	127.391250	0 0.000	0.000000
	Alcyone	176 15.205	176.253417	38 32.679	38.544650
	Aldebaran	161 29.503	161.491717	32 23.660	32.394333
	Alnilam	144 33.748	144.562467	14 48.420	14.807000

Table D.2

Star Azimuths and Altitudes, 4000 to 3000 BC

Difference in star azimuths (in decimal degrees) between the moment Alcyone culminated (azimuth α ≈ 180º 00’ 00”) and the moment Sirius was at the east horizon (altitude h ≈ 0º 00’ 00”) as viewed from Winklebury Hill.

	Date					
Star	**4000**	**3800**	**3500**	**3350**	**3200**	**3000**
Alcyone	6.940150	4.683047	1.422517	-0.161983	-1.713083	-3.746566
Aldebaran	6.449050	4.335583	1.308750	-0.146750	-1.565416	-3.408166
Alnilam	5.200118	3.482850	1.045284	-0.116866	-1.322250	-2.694966
Sirius	4.488417	2.996566	0.895134	-0.099833	-1.059566	-2.290933

Differences in star altitudes (in decimal degrees)between the moment Alcyone culminated (azimuth α = 180º 00’ 00”) and the moment Sirius was at the east horizon (altitude h = 0º 00’ 00”) as viewed from Winklebury Hill.

	Date					
	4000	**3800**	**3500**	**3350**	**3200**	**3000**
Alcyone	-0.222967	-0.100067	-0.009033	0.000066	-0.012784	-0.060267
Aldebaran	0.693650	0.513450	0.174867	-0.020633	-0.231100	-0.533134
Alnilam	1.774317	1.221917	0.380583	-0.044233	-0.467433	-1.033600
Sirius	2.708833	1.827384	0.553350	-0.062517	-0.662617	-1.442417

Table D.3

Star Azimuth and Altitude 3800 to 3100 BC

Alcyone at South Meridian (azimuth 180° 00’)

	Azimuth	Altitude	Azimuth				Azimuth	Altitude
Year (BC)	Sirius	Sirius	Alnitak	Alnilam	Mintaka	Aldebaran	Alcyone	Alcyone
3800 BC	130 13’	-1 50’	147 08’	148 19’	149 26’	165 44’	180 00’	34 14’
3500 BC	129 59’	-0 33’	146 44‘	147 55’	149 02’	165 26’	180 00’	35 51’
3350 BC	129 53’	0 04’	146 32’	147 43’	148 50’	165 16’	180 00’	36 40’
3200 BC	129 48’	0 40’	146 20’	147 31’	148 38’	165 07’	180 00’	37 30’
3100 BC	129 44’	1 03’	146 12’	147 23’	148 30’	165 01’	180 00’	38 03’

Range: **Sirius** **azimuth:** 130 13’ – 129 44’ **altitude:** -1 50’ to 1 03’ **declination:** -25 53’ to -22 50’
Belt Stars “ 149 26’ – 146 12’
Alnilam “ 148 19’ – 147 23’
Aldebaran “ 165 44’ – 165 01’
Alcyone “ 180 00’ – 180 00’ **altitude:** 34 14’ to 38 03’

Sirius Altitude 0° 00’ at East Horizon

	Az.	Alt.	Dec.	Azimuth				Azimuth	Altitude
Year (BC)	Sirius			Alnitak	Alnilam	Mintaka	Aldebaran	Alcyone	Alcyone
3800	133 13’	0 00’	-25.53	150 35’	151 48’	152 57’	170 04’	184 41’	34 08’
3500	130 53’	0 00’	-24 20’	147 46’	148 57’	150 05’	166 44’	181 25’	35 50’
3350	129 47’	0 00’	-23 45’	146 25’	147 36’	148 42’	165 08’	179 50’	36 40’
3200	128 44’	0 00’	-23 12’	146 06’	146 16’	147 22’	163 33’	178 17’	37 29’
3100 BC	128 04’	0 00’	-22 50’	144 15’	145 25’	146 30’	162 31’	177 16’	38 01’

Range: **Sirius** **azimuth:** 133 13’ – 128 04’ **altitude:** 0 00’ **declination:** -25 53’ to -22 50’
Belt Stars “ 152 57’ – 144 15’
Alnilam “ 151 48’ – 145 25’
Aldebaran “ 170 04’ – 162 31’
Alcyone “ 184 41’ – 177 16’ **altitude:** 34 08’ to 38 01’

Sirius Altitude 1° 00’ at East Horizon

	Az.	Alt.	Dec.	Azimuth				Azimuth	Altitude
Year (BC)	Sirius			Alnitak	Alnilam	Mintaka	Aldebaran	Alcyone	Alcyone
3800	134 57’	1 00’	-25 32’	152 35’	153 49’	154 59’	172 33’	187 20’	33 59’
3500	132 33’	1 00’	-24 20’	149 41’	150 54’	152 03’	169 10’	184 02’	35 46’
3350	131 25’	1 00’	-23 45’	148 19’	149 31’	150 39’	167 32’	182 27’	36 38’
3200	130 21’	1 00’	-23 12’	146 58’	148 10’	149 17’	165 56’	180 53’	37 29’
3100	129 39’	1 00’	-22 50’	146 06’	147 17’	148 24	164 53’	179 52’	38 03’

Range: Sirius **azimuth:** 135 57’ – 129 39’ **altitude:** 1 00’ **declination:** -25 53’ to -22 50’
Belt Stars “ 154 59’ – 146 06’
Alnilam “ 153 49’ – 147 17’
Aldebaran “ 172 33’ – 164 53’
Alcyone “ 187 20’ – 179 52’ **altitude:** 33 59’ to 38 03’

Table D.4

Star Coordinates c. 3350 BC viewed from Winklebury Hill

Star	Right Ascension	Declination	Azimuth at 0° altitude
Alcyone	23 h 3.529 m	-2° 20.742’	93° 43.68’
Aldebaran	23 h 54.266 m	-7° 00.235’	101° 10.16’
Mintaka	1 h 11.051 m	-18° 42.484’	120° 37.97’
Alnilam	1 h 16.610 m	-19° 08.729’	121° 23.99’
Alnitak	1 h 22.251 m	-19° 23.918’	121° 50.74’
Sirius	2 h 51.625 m	-23° 45.391’	129° 47.35’

Notes:
Winklebury Hill: Elevation 260 m, Latitude 50° 5’9 14.84” N, Longitude 2° 4’ 17.91” W

Highest elevations along horizon between azimuths 124° and 185° viewed from Winklebury Hill:

- St Boniface Down, Isle of Wight, rises to 241 m, highest point on the island
- Swyre Head, highest point of the Purbeck Hills and the Isle of Purbeck, Dorset, 208 m

Appendix E

Geologic and Paleoenvironmental Context

> "As geology is essentially a historical science, the working method of the geologist resembles that of the historian. This makes the personality of the geologist of essential importance in the way he analyzes the past."
> – Reinout Willem van Bemmelen

> "Don't look for new landscapes, use new eyes to see what is already there."
> – Gerald Causse

E.1 Introduction

The study area – Cranborne Chase (the Chase) and a portion of the South Hampshire Lowlands to the southeast – hosts a unique geological and cultural landscape within the Hampshire Basin catchment, with extensive archaeological evidence supporting a large Neolithic population in southern central England from approximately 3600- to 3440 BC (Woodbridge *et al*., 2013). The Chalk downland includes outcrops of Upper Chalk extending across the majority of the Chase, and Middle and Lower Chalk exposed in upper reaches of a few valleys and front of the Chalk and Fovant escarpments. The catchment includes folded Late Cretaceous and Paleogene deposits with only minor impacts to an overall southeasterly dip of the bedrock, while sets of west-east and northwest-southeast trending faults impacted the thickness of basement rock beneath the Chalk, and affected the extent and shape of the basin (Allen and Crane 2019). The network of rivers and dry valleys of the Chase is highly developed, with deep valleys cutting back into upper reaches of the dip slope. (Allen *et al*. 1997). Climatic changes developed during the early centuries of the 4th millennium and might have effected hydrologic changes and sedimentation on the Chalk of Wiltshire and Hampshire (Field 2008). Winterbournes may have formed along upper reaches of valleys, and the upper valley of the River Allen in the downs of the study area likely held water at that time (Field 2008). However, mid-Holocene cultural development of the landscape was effected by geological and paleoenvironmental evolution that occurred across the region over many millions of years.

Southern England has experienced a complex history of deposition and erosion since the Late Cretaceous, as variations in patterns of sedimentary processes were likely associated with structural development of the region (Hadlow 2014). The west portion of Wessex Basin includes conspicuous geomorphological features including the Fovant and Chalke escarpments with steep fore-slope scarps and gently-inclined dip slopes, extensive chalk plateaus such as Salisbury Plain extending from the Chilterns in the north to Cranborne Chase in the south, the dissected South Hampshire Lowlands underlain by Paleogene sediments between the chalkland and the English Channel, and the hogback ridge of the Purbeck-Isle of Wight Monocline that serves to define the south perimeter of Hampshire Basin to elevations of up to 300 m (Lake 1975; Allen and Crane 2019, Table 4.4). The Chalk has been affected by Alpine tectonics across Hampshire Basin and the South Downs, resulting in more structural complexity than in other areas in England (Allen *et al*. 1997).

The topography of Cranborne Chase is characteristic of chalk downland, with steep escarpments and long gently sloping dip slopes containing ephemeral streams and dry valleys. Soliflucted sediments including Clay-with-flints are found over much of the higher ground in chalklands, with Head deposits and alluvium commonly found on valley sides and bottoms valleys. The hydrogeology of the chalklands is complex, with many factors affecting the development of aquifer properties (Allen *et al*. 1997). The tectonic structure and lithology in Hampshire Basin influences the geomorphology and groundwater flow in the Chalk (Mortimore 2011). Small (1980:56-57) suggests that many topographic features of chalklands may be explained by lithological control. A summary of Chalk downland geomorphology is provided by Hadlow 2014 (Figure 2.12). Karst features and periglacial forms and patterns have been identified at Cranborne Chase and across Britain using air photography and field investigations (Green 2010; Fookes *et al*. 2015, Table 3.5.1; Hammer *et al*. 2020), and grassland across the downs of the subject area at the beginning of the 4th millennium BC supported development of one of the most well-known and documented Early- to Middle-Neolithic cultural landscapes in Britain. It was a landscape intimately related to geology and paleoenvironmental conditions experienced by the Neolithic population.

E.2 Regional Geology

E.2.a Geologic Structure and Stratigraphy

The study area occupies a chalk[1] plateau and adjoining lowland in extreme southern Wiltshire, northeast Dorset, and extreme eastern Hampshire (Figure E.2.1). It lies in the northwest corner of Hampshire Basin, an elliptical, asymmetrical, west–east trending syncline located beneath portions of Dorset, Hampshire, the Isle of Wight, and Sussex, along strike with the London Basin to the northeast (Aldiss 2012). The axis of Hampshire Basin is aligned with the Solent, a 32 km strait located between Keyhaven, Hampshire, and Gosport, Hampshire, north of the Isle of Wight. The basin extends from central Dorset in the west, to Beachy Head, in East Sussex, a distance of about 160 km along the coast of England. It is the landward portion of the Hampshire-Dieppe Basin that extends across the English Channel to central France. The orientation of the Hampshire-Dieppe Basin is parallel with linear structures of the pre-Mesozoic basement, including fault structures associated with the more extensive Wessex Basin, as describe below (Jones 1999b, Figure 1; Aldiss 2012).

The southern limit of Hampshire Basin is the Purbeck-Isle of Wight Monocline, including a near-vertical fold in Chalk Group limestone and a prominent ridge (the Purbeck Hills) subparallel to the coast of Dorset, outcropping at the Isle of Purbeck south of Studland (Figure E.2.2; Figure E.2.3). The fold and associated ridge form a linear complex known as the 'Purbeck disturbance' (Hamblin, 1992; Newell *et al*. 2018, Figure 5). The monocline extends eastward beneath the English Channel to The Needles before continuing across the Isle of Wight. It then continues southeast across the English Channel to western France as the Wight-Bray monocline. The northern extent of Hampshire Basin follows the west-east trend of downlands from Cranborne Chase, across the southern limit of Salisbury Plain, to the South Downs south of the Weald. Thus, the width (north-northeast to south-southwest) of the basin, from Salisbury, Wiltshire to the Purbeck monocline south of Studland, Dorset is about 50 km. For the purpose of this study, references to Poole Basin concern the portion of Hampshire Basin extending across the South Hampshire Lowlands underlain by Paleogene sediments west of the River Avon, including the southeastern portion of the study area.

The generalized stratigraphic section at Hampshire Basin includes rocks within three age ranges: younger sedimentary rocks (Paleogene to Permian), older sedimentary rocks (Carboniferous) and basement rocks (Devonian and older) (Newell *et al*. 2018, Table 3). The Late Cretaceous Chalk overlies various Jurassic sediments that do not crop out in the study area. The oldest exposed bedrock in the study area consists of Late Cretaceous Upper Greensand Formation at Bowerchalk (BGS 2018).

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[1] Herein the term 'Chalk' or 'the Chalk' is used to refer to the Chalk Group of limestone formations of England, while 'chalk' refers to chalk material – 'very fine-grained (less than 10 µm), white limestone containing some marl bands and flint' (Hancock, 1975; Allen *et al*. 1997).

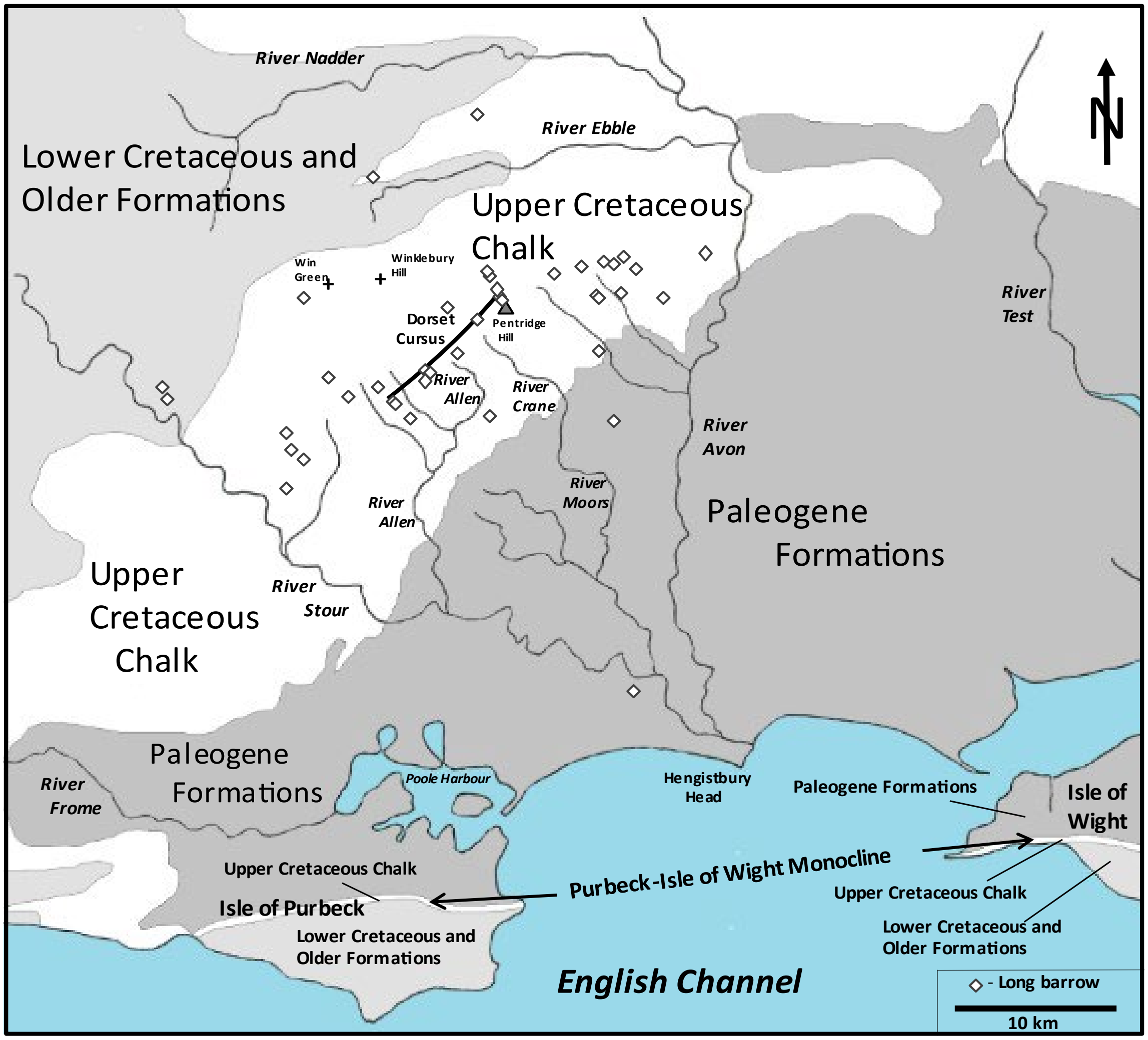


Figure E.2.1: Map showing locations of outcrops of Paleogene formations, Upper Cretaceous chalk, and Lower Cretaceous and older formations in study area and surrounding region.

The Paleogene-age Hampshire Basin is a sub-basin of the larger Wessex Basin that extends across an onshore area exceeding 20000 km^2 in southern England and a similarly-sized area under the English Channel (Kent 1949; Chadwick 1986, Fig. 1). Wessex Basin is founded upon Cambrian to Carboniferous age basement sediments (Smith 1985) deformed by thrust during the Variscan (Hercynian) Orogeny (Late Carboniferous) (Chadwick 1986) (Figure E.2.4). Deformation structures include thrust faults, NW-SE trending strike-slip - transform faults, and NE-SW trending strike-slip faults defining boundaries of lateral accretion and loss. Reactivation of Variscan thrusts and large-scale strike-slip faults influenced extension directions, locations of basin bounding faults, and tectonic inversion from the Devonian to today (Coward 1990). Reactivation of E-W basement structures dominated Wessex Basin fault-controlled subsidence from Permian to early Cretaceous times, and produced minor normal movement and strike-slip motion along NW-SE fractures. The observed geometry of Wessex Basin is consistent with NW-SE oriented shear and anisotropic extension creating depocenters offset and bounded by NW-SE oriented wrench (transfer) faults (Bally 1982).

Figure E.2.2: Photo of top of Purbeck Monocline south of Studland, looking east toward the Isle of Wight and the ridge of the Isle of Wight Monocline on the horizon. (Photo by P. Burley)

a)

b)

Figure E.2.3: View of the Chalk cliffs south of Studland, at the east end of the Isle of Purbeck. a) cliffs located just south of the Purbeck Monocline; b) Old Harry Rocks, three remnant chalk formations located at Handfast Point south of Studland. (Photos by P. Burley)

Locations of the thrust faults and transfer faults in the upper and middle crust governed regional morphologies of Wessex Basin's constituent structures (Chadwick 1986). Those structures include sub-basins produced by normal reactivation of the basement thrusts and wrench faults that compartmentalized the basement and initiated development of four centers of deposition (Sellwood *et al*. 1985; Whittaker, 1985; Lake and Karner 1987; Jones 1999b). Gross morphology of the sedimentary basins is governed by the geometry of pre-existing crustal weaknesses, with the stress field influencing directions of movement along major basin margin faults and affecting orientations of intra-basin faults (Chadwick 1986, Figure 23). This compartmentalization of Wessex Basin defines morphotectonic regions, each with a specific structural expression of uplift, warping, sedimentation, and erosion (Small 1980:56-57; Jones 1999b). Morphotectonic zones (Jones 1999a) within Wessex Basin experienced variable structural and geomorphological histories resulting in different rates of erosion ranging from low to normal rates of denudation, to morphostasis (Hadlow 2014). Structural development during extension (basin formation) and compression (inversion) of Wessex Basin began during the Cenomanian and continues today (Lake and Karner 1987). The Paleogene Alpine orogenic sequence included regional uplift and development of inversion anticlines across Wessex Basin (Hawkes *et al*. 1998). As a result, each sub-basin exhibits two major structural trends produced by simple sinistral pull-apart structures opened along NW-SE-oriented faults: a primary W-E direction intersected and offset by a secondary NW-SE orientation (Lake and Karner 1987). Each of four episodes of crustal extension in the Wessex Basin were followed by more regional subsidence indicated by stratigraphical onlap (Chadwick 1986). The four Hercynian sub-basins are identified based on regional structural trends, basin fill, and tectonic evolution as follows (Lake and Karner 1987, Figure 2):

- Channel Basin, a Mesozoic northern-dipping half graben, primarily located in the English Channel;
- Winterborne-Kingston Trough, a narrow W-NW -trending symmetric graben located immediately south of the study area and primarily filled by Late Paleozoic-Mesozoic deposits;
- Pewsey Basin, a Late Paleozoic-Mesozoic northern-dipping half graben, the northern extent of which defines the northern limit of Wessex Basin north of the study area; and,
- Weald Basin, a Mesozoic northern dipping half graben located east of the study area, with increased symmetry to the east.

The Late Cretaceous Wessex-Channel Basin is defined by three extensional structural elements. They include the west-east- trending Pewsey, Wardour-Portsdown, and Abbotsbury-Ridgeway-Purbeck-Wight fault zones forming three distinct structural and topographic expressions of Paleogene inversion (Farrant *et al*. 2012). The west portion of Hampshire Basin, including the study area, is located along the northwestward trend of the Bray Fault Zone linked to the Purbeck-Isle of Wight monoclinal structures south of the study area, in addition to faults situated in the Bristol Channel to the north of the Wessex Basin (Mortimore & Pomerol, 1997; Evans and Hopson 2000). The Purbeck-Wight fault zones are the most important structural elements affecting the Isle of Wight area (Farrant *et al*. 2012), their topographic expression readily apparent from more than 60 km to the northwest, along the crest of the Chalke Escarpment, in the northwest portion of Cranborne Chase.

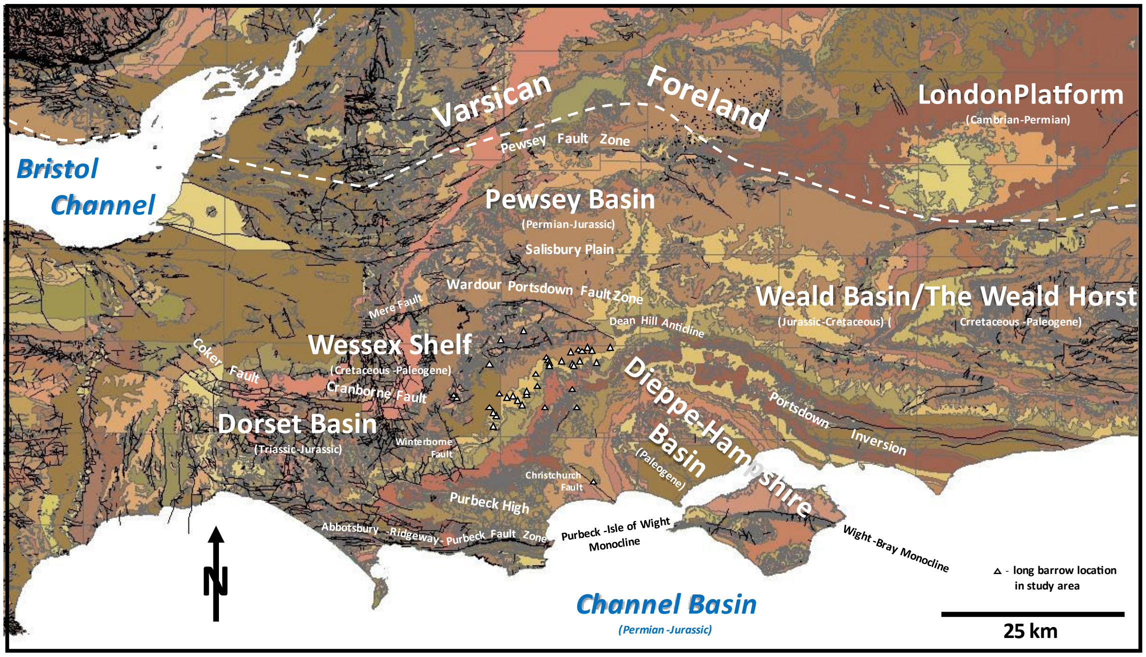


Figure E.2.4: Map showing locations of subbasins of the Wessex Basin in central southern Britain. Locations of the Variscan front (dashed), Variscan foreland and major faults in the region, and long barrows (triangles) in the study area between Wessex Shelf and Dieppe-Hampshire Basin are indicated. Base map illustrating bedrock geology of the region provided by BGS (2018).

The Weald, located in the northeast portion of Wessex Basin and east of the study area, is a complex horst structure distinct from the North Downs (to the north), the South Downs (to the south), and the Dorset Downs and South Hampshire Lowlands to the west, including the study area. The Weald is set apart from the basement of the Hampshire-Dieppe Basin as a result of late Neogene - Quaternary uplift by the Wardour-Portsmouth inversion and movements farther east (Jones 1999b, Fig. 7). In similar fashion, well-developed inversion axes in the Pewsey Basin isolate Salisbury Plain from the Dorset Downs and Cranborne Chase to the south, and the Marlborough Downs to the north (Small 1980:56-57; Jones 1999b).

Westaway *et al*. (2006) used the fluvial system of the Solent River and marine terraces north of the Purbeck-Wight fault zones in Hampshire Basin to reconstruct uplift history of central southern England, including the study area. Results provided a high degree of consistency between uplift histories inferred for river terraces and marine terraces, with most of the region uplifted about 70 m since the late Early Pleistocene, and about 150 m since the Middle Pliocene. Uplift rates increase to the west, with about 80 m of uplift since the late Early Pleistocene along the River Frome at the western end of the Hampshire Basin. Westaway *et al*. (2006) interprets the variation in uplift to be a consequence of regional-scale variation in crustal properties.

The Isle of Wight Monocline is a composite high-angle structure derived from a down-to-the-north reverse fault cutting the northern limb of two east-west trending, southerly dipping and overlapping syndepositional normal faults expressed in the overlying Upper Chalk by two *en échelon*, curvilinear folds - the Sandown and Brighstone anticlines (Evans *et al*. 2011) (Figure E.2.5; Figure E.2.6). The composite monocline delimits the eastern end of a major structural and topographic line of inversion (the Portland-Wight Fault Zone) trending west-east from Lyme Bay in southwest Dorset, eastward to the Isle of Purbeck, beneath Poole Bay, onto the Isle of Wight, and continuing east beneath the English Channel (Evans *et al*. 2011).

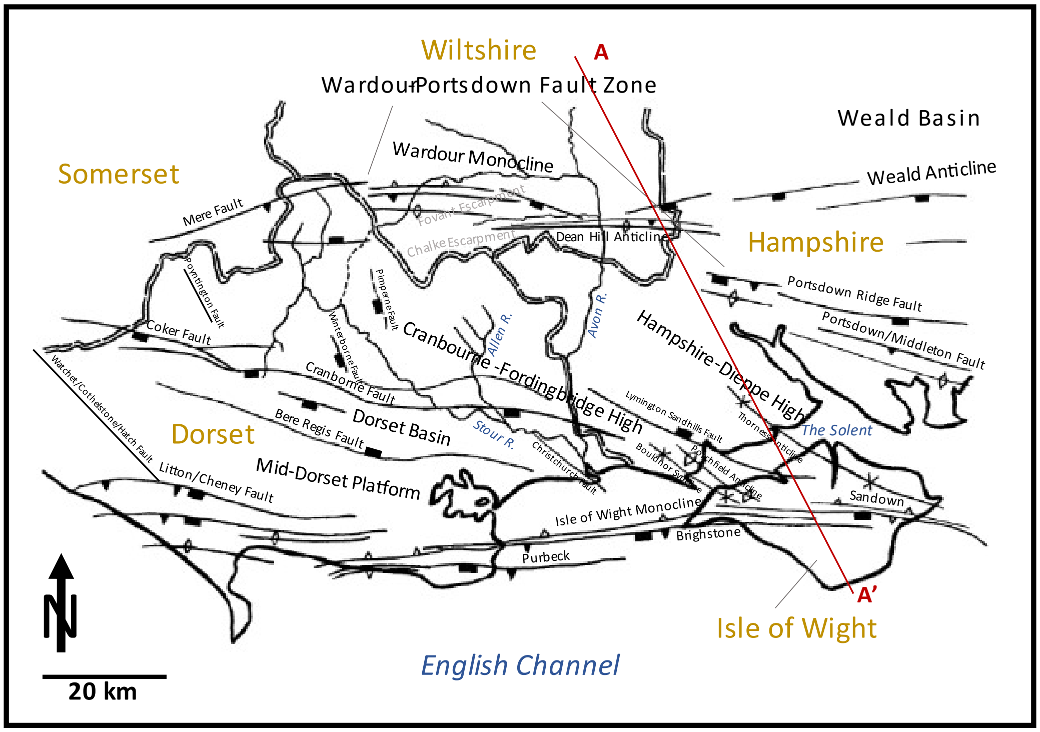


Figure E.2.5: Map illustrating major structural features of the study area and surrounding region. The study area is located in the central portion of the map. seismic reflection data do not indicate that the Cheverton Fault is a northern extension of the Cranbourne-Fordingbridge/Hampshire-Dieppe High.

The curved axis of the Bouldnor syncline, located north of the Sandown and Brighstone anticlines, extends west-northwest from the Isle of Wight, across the Solent, and continues at least 32 km across the Hampshire mainland (Evans *et al*. 2011). Similarly, the Porchfield Anticline trends northwestward, beginning at the Bouldnor syncline in the northwest portion of the Isle of Wight (Evans *et al*. 2001, Figure 2; Chadwick and Evans 2005, Figure 4). The Porchfield Anticline overlies a northwest-southeast-trending down-to-the-north syndepositional fault concealed by the Chalk and Paleogene strata (Farrant 2012). It is subparallel with the Bouldnor syncline north of the Solent, and correlated with an anticline near Lymington on the Hampshire mainland (Evans *et al.* 2011).

A West-East trending seismic line on the Isle of Wight indicates a west-northwest-trending fault complex breaking through the Chalk along the alignment of the Cheverton Fault, subparallel to the southwest edge of the Cranbourne–Fordingbridge High that extends northwest across the Solent and farther west beneath Cranborne Chase (Mortimore 2011). The southern edge of the Hampshire-Dieppe High, including the Cranborne-Fordingbridge High and the area immediately south of Cranborne Chase, is defined by the Purbeck-Wight-Bray fault zones (Hamblin *et al*., 1992; Farrant *et al*. 2012). In addition, numerous small faults are located along which valleys have formed on the Isle of Wight (Mortimore 2011). Mortimore (2011) proposes that the Cranborne-Fordingbridge High extends southeast across the Solent to the Isle of Wight, and the northwest end of the structure might follow the line of the northwesterly-trending Cheverton Fault.

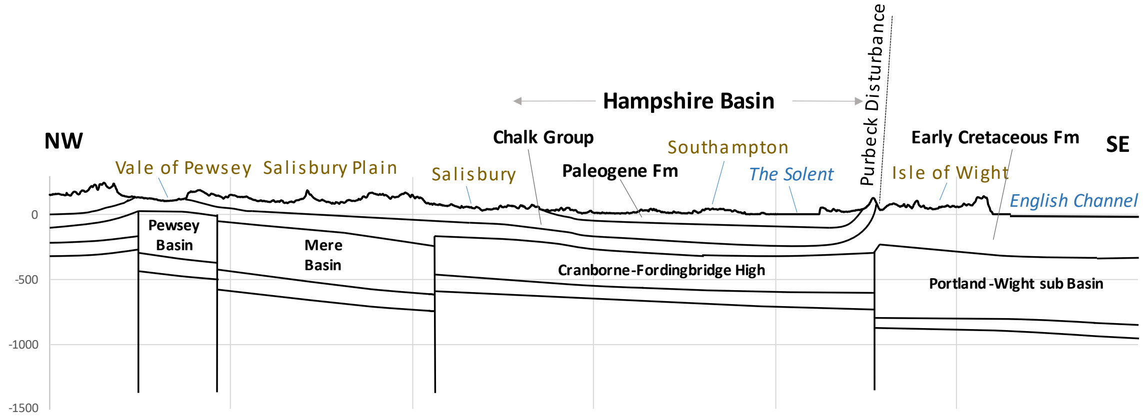


Figure E.2.6: Geologic cross section A- A' illustrating general stratigraphic and structural features between the Vale of Pewsey and the English Channel, including the study area. Refer to Figure E.2.5 for location of the cross section.

Two additional fault systems are noteworthy with regard to the structure of the Chalk in the study area. The Cranborne Fault extends northwest from north of Bournemouth toward Cranborne Chase, and was likely the source of local tectonic movements generating trough and mound structures evident in seismic lines across the Upper Chalk in that area (Newell 2000, Figure 2; Newell 2017). The northwest-southeast -trending Christchurch Fault underlies the River Stour valley, along the south side of the study area (Newell 2000; Evans and Hopson 2001). Tertiary movement along the Christchurch Fault is evident by displacement of Cretaceous and Paleogene formations (Bristow *et al*. 1991; Nowell 2001).

Most Wessex Basin sediments are of Permian to Paleogene age, deposited during post-Carboniferous subsidence of the NW European continental shelf, with total thickness of the sediments exceeding 3000 m in some areas (e.g. Ziegler 1981; Chadwick 1986). The Upper Chalk underlying a cover of Paleogene sediments in Hampshire Basin regionally dips to the south-east (Allen and Crane 2019). Pleistocene erosion removed about 350 m of the Chalk (Hadlow 2014). Post-extension sediments deposited between Aptian and Maastrichtian times, exceed 500 m, in addition to up to 600 m of Paleogene strata, with no net rise of global sea level (Chadwick 1986). The rate of post-extension subsidence decreases near-exponentially over time (Chadwick 1986).

Late Cretaceous structural control and stratigraphic complexity of the Chalk in the study area was influenced by a line of periclines extending across the Wessex Shelf in east-central Dorset, in a wide area of condensation situated between Cranborne Chase and the Purbeck-Isle of Wight anticlines (Mortimore, 1983; Bristow *et al*. 1998). Those complexities are related to the underlying basement structures, expressed in the Chalk by outcrops of near-vertical chalk along the Purbeck-Isle of Wight Monocline and folding at the north rim of the Hampshire Basin syncline by the Portsdown and Dean Hill anticlines located south and southeast of Salisbury (Hopson 2010, Figure 5; Allen and Crane 2019) (Figure E.2.5).

Thrusts that reactivated extensionally during the Jurassic-Cretaceous experienced compression during the early stages of the Paleogene Alpine Orogeny to form the Hampshire-Dieppe Basin. Reversal of movement along former extensional normal faults resulted in northerly-verging, unfaulted monoclinal folding in the Chalk and overlying Paleogene sediments (Evans *et al*. 2011). Pre-Albian faults north of Bournemouth likely reactivated and led to local syn-sedimentary faulting, slumping and erosion of the Chalk across Wessex Basin (Evans & Hopson 2000; Nowell 2001). The NW-SE trending line of periclines affected contemporaneous sedimentation in the Dorset area by the Upper Albian and Cenomanian (Drummond 1970). In addition, a series of *en echelon* west-east -oriented thrusts run beneath east Dorset and the Isle of

Wight, producing the structural grain of the region (Gale 2005). Continued deformation through the early Miocene produced the structural pattern approximating its present form (Jones 1999b).

There is little apparent evidence of synsedimentary structure and major faulting of the Chalk in Hampshire Basin. However, results of paleostress and lineament analyses indicate NW-SE dextral shear has continued since the Cenomanian as a control on basin evolution in southern England, with similarly-oriented strike-slip evident in facies changes in the Paleogene basins (Plint 1982; Lake & Karner, 1987; Mortimore & Pornerol, 1997). Basin uplift continued throughout the Palaeogene and Quaternary (Evans *et al*. 2011). Folding and sub-Paleogene erosion led to lateral variations and differential preservation in the succession of the Chalk (Mortimore 2011). Hampshire Basin contains chalk younger or equivalent in age with limestones encountered in the London Basin to the north, with the youngest chalks preserved in the portion of the Hampshire-Dieppe Basin located across the Solent Syncline, between the Isle of Wight anticline to the south and Portsdown Anticline to the north (Mortimore and Pomerol 1997). The core of Hampshire Basin includes a maximum of 435 m of Chalk beneath primarily arenaceous, Upper Paleocene to Lower Oligocene sediments surrounded by chalklands (Allen and Gibbard 1993, Figure 2) (Figure E.2.6). The Chalk forms the North Dorset Downs (including the downland of Cranborne Chase), Wiltshire Downs to the north, and South Dorset Downs that are bounded to the south by the Purbeck Hills (Allen and Gibbard 1993) (Figure E.2.1). At outcrop the thickness of White Chalk is typically less than 250 m (Sellwood *et al*. 1986). Paleogene formations and underlying Chalk of the region were folded, uplifted and extensively eroded during the Neogene (Allen and Crane 2019, Figure 2.9). The Chalk in Hampshire Basin dips gently toward the south from Salisbury Plain, north of Cranborne Chase, to the nearly vertical Purbeck-Isle of Wight monocline located along the coast of Dorset and across the central area of the Isle of Wight (Figure E.2.6). In the study area, the dip of the Chalk Group also has a gentle easterly gradient, from chalk escarpments along the northwest edge of Cranborne Chase to the Solent (Figure E.2.7, Figure E.2.8). The Chalk underlies Paleogene sediments in the South Hampshire Lowlands that occupy the central portion of the basin. Pulses of Paleogene sediment accumulation in Hampshire Basin were contemporaneous with periods of erosion on uplifted areas to the west and east (Jones 1999). Flanks of the basin were buried by sediments covering what is generally interpreted as a sub-Tertiary unconformity with the underlying Chalk.

The Proto-Solent catchment north and west of Poole Harbour developed during the Paleogene, transporting sediments eastward from Devon during the Eocene Period. The Solent Basin, within which the Solent waterway is situated, extends west-east from Weymouth, Dorset to Bognor, West Sussex, along the south coast of Britain, and as far north as Basingstoke (Field 2008). The basin includes watersheds of the rivers Frome, Stour, Avon, Hamble, Itchen and Test. The post-glacial Holocene transgression, c. 10,000 cal yr BP, resulted in the English Channel breaking

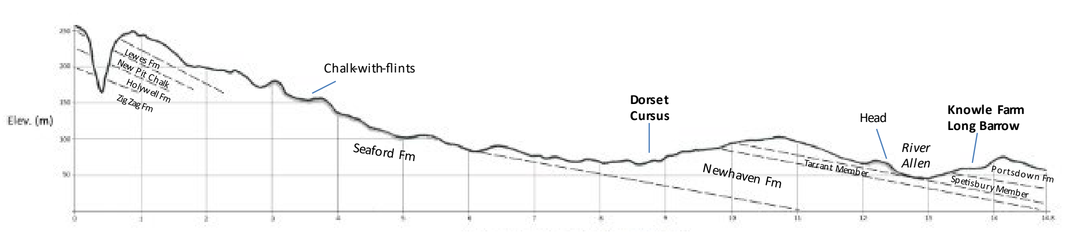


Figure E.2.7: Geologic cross section illustrating outcropping formations of the Chalk across the central portion of Cranborne Chase, from the Chalke Escarpment at Winklebury Hill to Knowle Hill Farm and Paleocene sediments of the South Hampshire Lowlands (based on Jones, D. 1999a, Figure 2F and Figure 10). The Chalk dips at about 4 degrees toward the southeast.

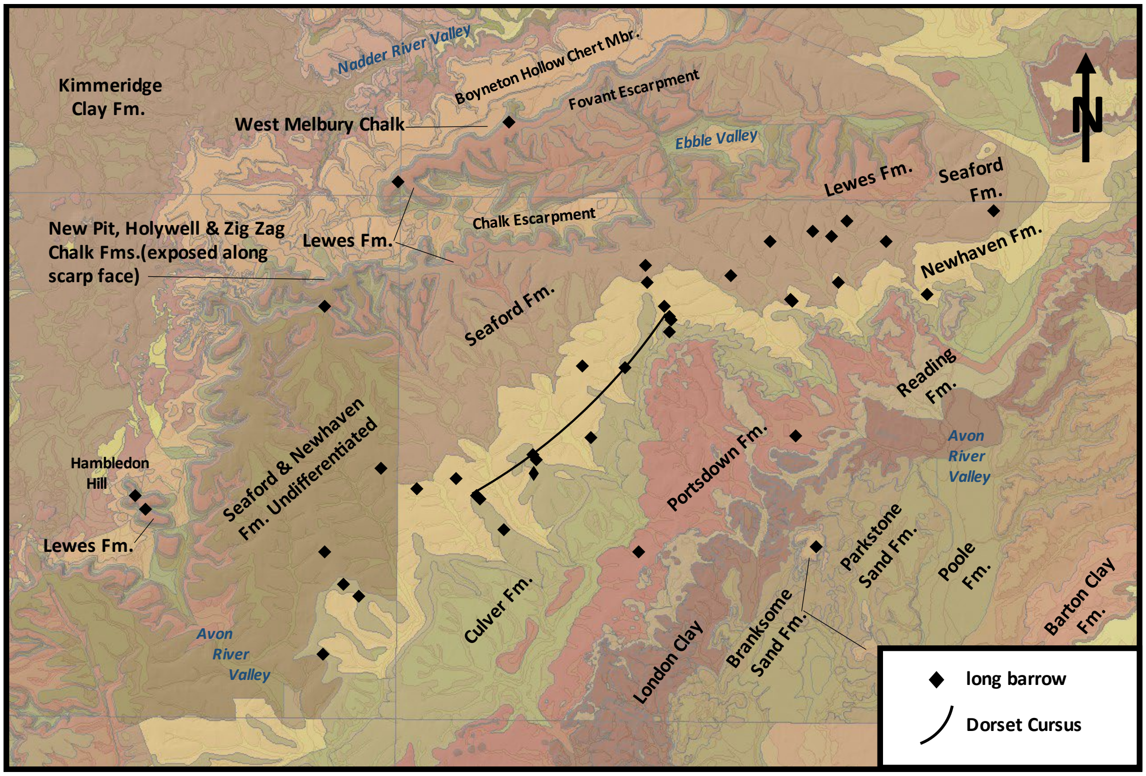


Figure E.2.8: Geologic map of Cranborne Chase and adjoining SHL to the southeast, showing outcrops of the Chalk formations and Paleocene sediments in the central portion of the study area. The Chalk dips at about 4 percent toward the southeast from the Fovant and Chalke Escarpments to the center of Hampshire Basin. Locations of long barrows in the study area and the Dorset Cursus are indicated.

through the monoclinal Chalk ridge that had joined the Isle of Purbeck to the Isle of Wight, forming the western Solent Channel immediately south of Poole Basin (Gale 2005).

While the Upper Chalk may be envisioned as "an extensive sheet" (Evans and Hopson 2000; Allen and Crane 2019) simply draped over older and structurally more complex sedimentary and basement rocks, with structural characteristics derived from regional basin morphologies, general geographic features of the Chalk conceal smaller-scale structural and stratigraphic complexities that are important to understanding topographic, geomorphological and hydrogeological features of the chalklands of Hampshire Basin and surrounding regions. Tectonic compaction, diagenesis, pressure solution, and solution in later stages of development in the Upper Chalk altered properties of the limestone to various degrees depending on location, while the Paleogene Alpine orogeny produced a dominant west-east structural trend in the Chalk across southern England (Fookes *et al*. 2005). The Chalk was impacted by two primary tectonic events:

1) Late Cretaceous and early Paleogene tectonic inversions uplifted the Chalk that led to widespread erosion and formation of hardgrounds, channels and glauconitic and phosphatic cements; and

2) Early Oligocene to early Miocene (Alpine) folding and faulting producing compressional movement that deformed the Chalk and formed monoclinal and periclinal folds during reactivation of pre-Permian basement faults (Allen 1997).

Localized tectonic events and fault reactivation affected Chalk sedimentation in Hampshire Basin, with compressional events possibly leading to gentle folds and onlap onto inversion structures (Evans and Hopson 2000). Also, two phases of intra-Chalk folding have been identified by Gale (1980; Geological Conservation Review, undated). Such structural and stratigraphic information supports the hypothesis by Nowell (2001) that the Upper Chalk is not simply a blanket deposit overlying previous tectonic structures, but that Chalk deposition was likely impacted by reactivation of local structures to a greater degree that previously understood.

Examples of local heterogeneities in the Upper Chalk beneath the South Hampshire Lowlands of the study area include inter- and intra-formational mounded and trough-shaped structures, erosion/truncation and onlap surfaces, infill sequences, large rotated blocks, and rapid lateral thickness changes within the Upper Chalk Formation (Evans and Hopson 2000). Channeling is indicated at all levels of the Upper Chalk (Evans and Hopson 2000). In addition, Evans and Hopson (2000) interprets troughs and mounded structures inferred from the seismic data as slumped channel infill resulting from movement of low-angle listric faults, with possible hardgrounds forming décollement horizons near the base of the channels. Evans and Hopson (2000) suggests disturbances below seismic resolution can be expected, with potential for minor syndepositional movements on the underlying fault reflected in formation of minor faulting and jointing in newly lithified limestone, altering its properties and leading to zones of weakened chalk.

Local, heterogeneous, lateral and vertical spacing of fractures provide additional complexities to faults, joints and fractures in the Chalk. Discontinuities in the limestone, ranging from tectonic joints and faults to microscopic grain boundaries and microfractures, are important controls on mass hydrogeological and mechanical behavior of the Chalk (Fookes *et al.* 2015). Three general types of fracture occur in the Chalk - faults, bedding plane fractures and joints (Bloomfield, 1996). Joints in unweathered Chalk are generally oriented in three mutually sub-perpendicular planes, producing approximate cubical or rectangular blocks between the three sets of joints: one parallel to bedding planes in horizontal or gently dipping stratum, and two sets orthogonal and perpendicular to bedding (Allen and Crane 2019; Williams 1987).

A primary fabric of fractures and faults developed in the study area during development of the Upper Chalk formations, with each formation exhibiting a characteristic style of fracturing (Mortimore 2011). Reactivation of basement faults led to development of faults in the Chalk and controlling orientations of NW-SE and NE-SW joint sets and fault orientations developed during the early Paleogene stress regime (Allen *et al.* 1997). However, lack of lithological contrast in the white, fine-grained formations of the Upper Chalk makes identification of faults in the Chalk difficult, and folds and faults might be more common than currently recognized (Allen *et al.* 1997). While faults with 10-30 m displacements have been identified south and west of Cranborne Chase (Mortimore and Pomerol 1997), the blanket of Chalk at outcrop masks the underlying tectonic framework, with very few mappable faults apparent at surface in the study area (Allen and Crane 2019).

The chalklands are conspicuous topographic belts between the Paleogene basins and uplifted regions where Chalk and strata above and below have been removed by weathering and erosion. Hampshire Basin was affected by periods of deepening at the end of the Miocene, soon after the Chalk emerged during the Late Cretaceous, and experienced pulsed growth of the basin's margins including the Purbeck-Isle of Wight Monocline (Jones 1999a). Differential uplift of between 250 and 400 m in southern England, in tandem with further warping and episodic erosion continued during the Pleistocene, increasing the relative topographic relief of Hampshire Basin and surrounding chalklands (Jones 1999a; Preece *et al.* 1990). As a result, the downs of southern England exhibit morphological variations including Paleogene rocks and spatially variable sediments that have been altered by weathering and erosion (Jones 1999a). Fissure patterns in the downs are related to geomorphological conditions and underlying geological structure in the Chalk, including open stress-relief fissures, cambering, and other processes along crests of anticlines and sides of Chalk valleys and impacting water transmissibility through the limestone (Lake 1975). As a result, significantly different structural frameworks exhibited in the Channel Basin to the south and Weald Basin east-northeast of Hampshire Basin (Jones 1999b) resulted in landscape geomorphologies different that those encountered in the study area.

Slopes and fluvial systems continue to reorganize in response to climate change and mediated by alterations in vegetation cover (Small 1961). Changes in rainfall patterns and inputs effect immediate response by the hydrologic system such as slope failures and flood sedimentation (Small 1961). The magnitude of response to climate change in catchments at Cranborne Chase and other downs located across southeast Britain might be controlled by local discharge, sediment availability, channel gradient and valley floor morphology (Coulthard *et al*. 2005). The geomorphic response varies with distance from the basin divide, with upstream reaches responding to a lesser degree than farther downstream, likely related to stream powers, sediment availability, and increasing sediment throughput in the lower reaches of river basins (Coulthard *et al*. 2005).

Numerous major and minor topographic features of the Chalklands can be explained by lithological control (Jones 1999a). Hogback ridges are encountered where the dip of the Chalk approaches vertical, while cuestas developed where the dip slope is shallow, typically less than 2 degrees, that can be related to the presence of secondary anticlines and reductions in dip (Jones 1999a). The former is exemplified by the Purbeck-Isle of Wight monocline, and the latter by the Chalke Escarpment extending along the northwest side of Cranborne Chase. Pleistocene pediment-like surfaces formed on the Chalk beneath unconsolidated sediment in lowlands of southern England, with gradients typically ranging from about 5° to 9° (French 2018). The concept of etchplanation, generally developed by Büdel (1982), is a process of landscape development in which a topographic surface of low relief, formed above deep regolith overlying a 'basal weathering surface', is denuded as a result of chemical attack and development of two levels of lowering ('double surfaces of planation'). In other words, in the case of the Chalkland at Cranborne Chase, the limestone surface lowers in tandem with leveling and removal of the overlying Paleogene deposits, resulting in an *etchplain*, a very resistant landform with the ground surface being a pediment (Jones 1999a). The process has been applied to the 'Summit Surface' of the Chalk in the east portion of Hampshire Basin, including Cranborne Chase, the South Dorset downs, and South Hampshire Lowlands, with evidence of a marine-worn surface of limestone overlain by Chalk-derived sediments, Paleogene deposits and Quaternary soils (Jones 1999a) (Figure E.2.9).

E.2.b Chalk and Sediments of the Study Area

Outcrops of Cretaceous Upper Chalk extend across the majority of the Chase, while Middle and Lower Chalk are exposed in upper reaches of a few valleys and front of the Chalk and Fovant escarpments. Hopson (2005) provides a formal description of the Chalk Group stratigraphy adopted by the British Geological Survey (BGS). The White Chalk of the Upper Chalk Group includes seven formations: Holywell Nodular Chalk, New Pit Chalk, Lewes nodular Chalk, Seaford Chalk, Newhaven Chalk, Culver Chalk and Portsdown Chalk (Bristow *et al*. 1998). Litho- and biostratigraphical correlation for the Chalk Group in the basins of Southern England are described by Hopson (2005) and Fookes *et al*. (2015, 94).

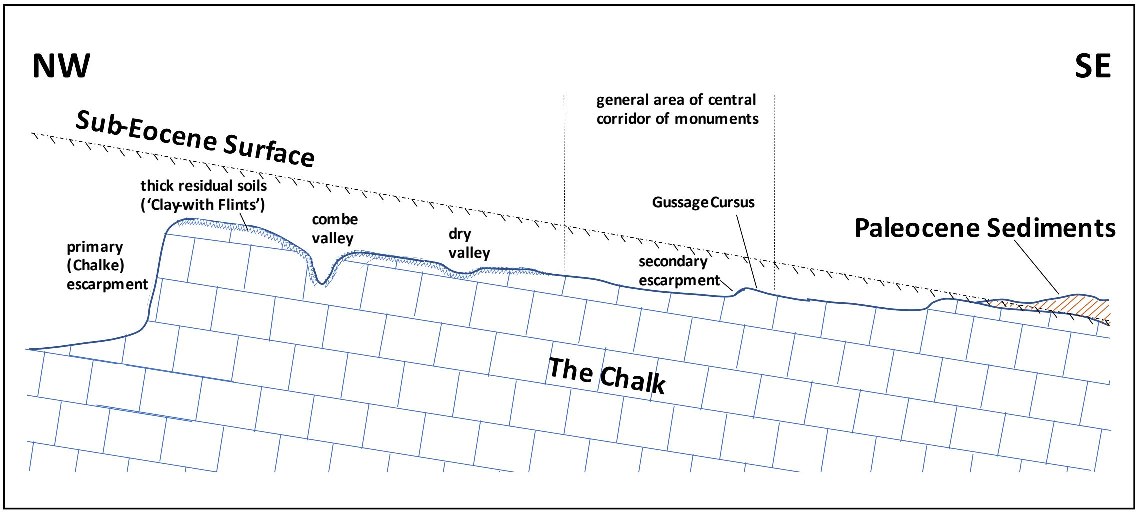


Figure E.2.9: Profile of the chalkland of Cranborne Chase between the Chalke Escarpment and Paleocene sediments of the South Hampshire Lowlands (based on Jones, D. 1999a, Figure 2F and Figure 10). Most long barrows located on the downs are situated on the dipslope southeast of combe valleys and southeast of Clay-with-flints- covered slopes. The Dorset Cursus is situated above the secondary escarpment as it crosses interfluves of Newhaven and Culver chalks.

The Chalk at Cranborne Chase forms an extensive dip slope toward the southeast and is overlain by Paleocene formations on the South Hampshire Lowlands between the Chase and Solent. Marine transgression-regression cycles from the late Paleocene to middle Eocene resulted in deposition of lithologically variable facies consisting of gravels, sands and clays developed in marine, estuarine and fluvial environments (Hadlow 2014). The fluviatile and brackish-marine Paleocene and Eocene formations extending across the central portion of Hampshire Basin include a succession of more than 650 m of sediment consisting of poorly consolidated sands, silts, and clays with few strata of limestone, lignite and flinty gravels, the thickest sequence of sediments located in the north portion of the Isle of Wight, and thinning toward the west-northwest portion of the basin (Allen and Crane 2019, Figure 2.1). Sedimentation continued in Hampshire Basin during the Oligocene, and subaerial erosion during the Eocene formed a broad, low relief and duricrusted land surface (etchplain) as a result of hot, arid climatic conditions across the Chase and most of the chalkland of southern England (Jones 1999a).

E.2.c Periglaciation

Southern England and portions of central England were located beyond the limits of the ice during each of the three glaciations since the the late Middle Pleistocene (c. 0.43 Ma) (Lee *et al*. 2011; French 2018). The Devensian (Weichselian) Glacial ended abruptly during an increase in temperature at the Younger Dryas–Preboral transition c. 9,700 BC (Friedrich *et al*. 1999; Rasmussen *et al*. 2006; French 2018), with landforms carved into the Chalk and overlying sediments under permafrost conditions (Te Punga 1957:410; French 2018). Most periglacial erosion and deposition across Britain occurred during the last glacial maximum, the Dimlington Stadial, dated to between 26,000 and 13,000 yr. cal. BP (Rose 1985; Catt 1987). Permafrost would have covered the ground surface, with partial thaw of near surface sediments and chalk layers occurring on an intermittent basis (Lake 1975).

While lowland catchments of southern Britain between the Bristol Channel and areas south of the River Thames were not affected directly by glaciation, the chalklands of southern England were impacted significantly by periglaciation (Macklin 1999). Thompson *et al*. (2015a) notes enhanced periglacial erosion by solifluction (down-slope movement of saturated ground, including freeze-thaw processes) and extensive fluvial processes during periods of significantly lower base levels during extreme glacial episodes. Examples of periglacial activity and near-surface disturbance features and deposits include (Fookes *et al*. 2015):

- cryoturbation and other forms of frost action such as ice wedges and pingos in the active layer of the Chalk;

- soliflucted sediment flows and other forms of down-slope mass movement of debris downslope associated with the active layer; and

- alluvial deposits and metastable, wind-blown loess (referred to as 'brickearth' in Britain), and cover sands that can be laterally extensive. Catt (1978) proposed up to 2 m of loess covered southern Britain, but evidence for such deposition is lacking (Wilkinson 2009).

Further evidence of periglacial conditions in southern Britain are found in the Chalk's geology, stratigraphy, geotechnical conditions, and geomorphology of the region (French 2018):

- The geological evidence includes brecciated chalk bedrock, sedimentary deposits disturbed to depths of 30-40 m, and cambering and bulging of frost-shattered valley bottoms and side slopes that, in sum, indicate former perennially-frozen (permafrost) ground conditions or a prolonged period of freeze-thaw enhancing weathering and erosion.

- Stratigraphic evidence includes disturbed soil and sediment horizons, and cracks in the Chalk by thermal contraction and wedge structures.

- Geomorphic evidence ranges from valley incisions to enlarged drainage networks exhibiting asymmetrical valleys, and relict ground surfaces with indications of former frost mounding and other ground-ice-related features.

The drainage pattern that exists across southern England was likely initiated on a flexure land surface subsequent to recession of the Paleogene sea (Jones 1999a; Hadlow 2014). In a study of parallel river networks, Jung *et al*. (2011) concluded that preexisting slopes are related to the natural dendritic or parallel network. Specifically, preexisting slopes with gradients less than about 3% exhibit channel networks consistent with a dendritic pattern, and where the preexisting slope exceeds about 3% channel networks are congruous with a parallel pattern. In addition, the form of the network changes gradually as the preexisting slope increases, and the transition between network patterns is dependent on the roughness of the initial topography and boundary conditions (Jung *et al*. 2011).

Rivers and brooks flowing down dip across the Chase form a trellis network of drainage, common to much of the British chalklands (Jung *et al*. 2015), within a scarp-land topography of river piracy, and obsequent streams (Fookes *et al*. 2015). The trellis networks include channels that are small and short, with lattice-like channels merging almost at right angles (Jung *et al*. 2015). Those streams, and the dry valleys that are remnants of drainage systems developed across Paleogene sediments when fluvial systems formerly extended across the dip slope of Chalk, are positioned and oriented such that their course might be defined by "subtle structural features superimposed on the Chalk by flexures and faults in underlying Mesozoic rocks" (Birch and Griffiths 1996).

Fookes *et al*. (2015, Figure 26.12) provides a conceptual block model of the Chalk landscape in Britain. Upon weathering and erosion of Chalk exposed to periglacial conditions, the Chalklands typically formed distinctive rolling landscapes, 'the Downs', exhibiting trellis-like drainage patterns occupied by dry valleys and combes (steep-sided, bowl-shaped hollows alongside dry valleys) (Fookes *et al.* 2015). Engineered slopes in sub-horizontally bedded chalk rarely exhibit significant instability, and Chalk slopes up to 45^{o} composed of blocky rubble infrequently suffer spalling (Fookes *et al*. 2015). However, a 53^{o} slope angle is the steepest form that can be maintained in unweathered chalk without degradation occurring under conditions of weathering and erosion. (Phipps and McGinnity 2001). Slump failure in chalky, clay-rich deposits results by rotational or sub-planar movements, and could be followed by flow (Fookes *et al*. 2015).

Surface and subsurface features indicative of former periglacial processes in southern Britain include involutions, solifluction, valley bulging, cambering, frost mounds, and ice-wedge casts and polygons (Fookes *et al*. 2015, 79). Innumerable cycles for freeze-thaw led to development of a weathered mantle (referred to as the active zone) of broken, rubbly chalk typically 1 to 2.5 m thick (Williams 1987). Periglacial features on the chalklands include patterned ground in the form of polygons and stripes (produced by irregularities in soil thickness), avalanche chutes, steep gullies along scarp faces, and serrated undulations in valleys located on dip slopes, in addition to cambering and valley bulging (Allen *et al*. 1997).

Periglacial-related frost shatter in chalk of southern England is extensive, typically extending 10 m or more beneath the ground surface (Waltham 2002). Frost weathering in chalk, like other rock, results from a volume increase as water freezes, a purely physical process. The duration, intensity and number of temperature cycles above and below 0^{o} C are important parameters of frost weathering and shattering (Barsch 1993). High porosity in tandem with a significant amount of saturation results in softening chalk, making it frost susceptible and capable of producing a slurry when the chalk is disturbed, as in the case of engineering and construction activities (Hadlow 2014). Irregular cryoturbated ground, patterned ground with stone polygons, and sediment-filled ice wedges are products of ice heave and collapse, each forming disturbed and vertical boundaries in the active layer of soil (Waltham 2002).

The chalk mantle formed by periglacial frost action and developed toward the end of the Devensian, and has been little modified since the end of periglacial conditions (Williams 1987). The generally shallow depth of the mantle indicates it formed during seasonal freeze-thaw, likely above the zone of permafrost, although the mantle could have formed under other circumstances unrelated to permafrost conditions (Williams 1987). The chalk mantle is most well-developed across level ground and gentle slopes, with a vertical transition between mantle and unweathered bedrock that is often sharp, but can be gradual such that it is difficult to define the base of the mantle (Williams 1987). Combined thicknesses of the mantle and overlying sedimentary cover in southern England is commonly about 1 to 2.5 m, with mechanical weathering deep into the Chalk occurring only under floors of larger dry valleys (Williams 1987). However, increased fracturing as a result of weathering has been observed in the upper 5 to 6 m of the Chalk, and periglacial conditions resulted in fracturing to depth of 20 or 30 m (Higginbottom and Fookes, 1970; Williams, 1987) (Allen *et al*. 1997).

Aeolian and fluvial geomorphological processes were enhanced during periglacial summer snowmelt and ponding prior to flowing in streams, potentially leading to flooding (Fookes *et al.* 2015, 79). Late Pleistocene ponding under periglacial conditions at Cranborne Chase has been identified where naleds and karst features are located in the upper Allen River, about 1 km up-gradient from the spring currently serving as the source of the river (French *et al*. 2007).

Maritime periglacial conditions of southern England are expressed in the slow mass-movement of regolith forming a complex of sheet-like, terrace-like and lobate morphologies, including numerous relict sheets and lobes related to Late Devensian climatic conditions (Ballantyne 1987). Dominant controls affecting distribution of active, local scale, periglacial features include gradient, aspect, altitude and vegetation cover conditions (Ballantyne 1987). Bedrock structure and stratigraphy influenced valley shape, width, and orientation, including orientation of dry valleys affected by the jointed limestone aquifer that also determined location and discharge of springs (Paul 2014).

At Cranborne Chase and adjoining South Hampshire Lowlands, unconsolidated sediments and the Chalk were impacted similarly by temperate interglacial periods separated by periglacial climatic conditions, with the ground perennially frozen to depth and the surface dominated by snow or ice cover (Hadlow 2014). Most chalks in the British Isles are almost saturated below the zone of evaporation, about 0.5 to 1 m below the surface (Lake 1975). Road Research Laboratory (1953) and Lewis and Croney (1965) demonstrate that particle size of the chalks approximates the optimum necessary for ice segregation in pore spaces and, therefore, pore water can remain fluid at sub-zero temperatures as the freezing temperature is depressed by high capillary forces, while surface water freezes in cracks and fissures nearer the surface (Lake 1975).

The Chalk and Plateau Drift (derived from weathering and erosion of the Chalk and overlying Paleogene sediments) were impermeable as a result of permafrost, renewing surface erosion that incised surficial deposits and the Chalk (Catt and Hodgson 1976). Plateau drift in southeast England is generally derived from Reading Beds that underwent disturbance, weathering, and burial by loess (Catt and Hodgson 1976). The Chalk surface weathered, as well, and there is extensive evidence of cryoturbation or flow of sediment in solution hollows in the Chalk, with only a minor portion of surficial Paleogene sediments located *in situ* and not impacted by Quaternary alteration (Catt and Hodgson 1976). Significantly, drift-covered interfluves from the sub-Paleogene surface likely remained rather stable once interconnecting systems of valleys were established, while exposed Chalk in valleys was more susceptible to periglacial weathering and erosion, the clayey surficial cover helping protect the landscape and limiting shattering and erosion of Chalk by solifluction compared to areas of unprotected Chalk (Catt and Hodgson 1976). Repeated freeze-thaw of the active layer would have increased fractures in the top few meters beneath the outcrop, forming a mantle of weathered, easily erodible chalk (Higginbottom and Fookes, 1970; Gibbard, 1985; Williams, 1987; Allen *et al*. 1997).

Catt and Hodgson (1976) concludes that remnants of the dissected sub-Paleogene surface protected by Clay-with-flints *senso stricto* (described below) produced discontinuous escarpments on the dip slope, such as the gentle slope extending southeast from the Chalke Escarpment at Cranborne Chase (Figure E.2.7, Figure E.2.8). The majority of the Chalk dip slope, including drift-covered interfluves noted above, was modified by subaerial processes, dissected by streams and dissolution beneath the sub-Tertiary surface, but did not lose all of its cover of Paleogene sediments. Primary irregularities in such dip slopes might be products of mid-Paleocene folding and processes of differential dissolution of the Chalk (Catt and Hodgson 1976).

Erosion in numerous valleys across low-relief landscapes, including dry valleys dissecting chalk uplands of southern England, occurred during periods of permafrost or deep seasonal frost (French 2018). The Chalk underneath major valleys was likely much wetter and more susceptible to frost action than other areas of the landscape. Permafrost could occur without significant impact to drier chalk, primarily limiting physical weathering to the active zone of freeze-thaw and/or other mechanical processes (Williams 1987).

Controls on bedrock channel morphology include tectonics and base-level changes, substrate properties, river sediment supply, discharge, and climate (Turowski 2012). As noted above, the Chalk is porous and has high hydraulic conductivity, with joints and brecciation of the near-surface bedrock promoting incision. While development of many valley systems can be attributed to normal groundwater discharge, impermeable substrates resulting from prevailing permafrost resulted in expansion of drainage networks (French 2018). Deeply-incised valleys in chalk escarpments, produced by rapid erosion of the frost-shattered bedrock during latter stages of Devensian glaciation, are products of former periglacial conditions. Upland valleys located where groundwater discharged from hillslopes would have experienced intense frost shattering of the Chalk (French 2018).

Heads of combes near the ridge crest of the Chalke Escarpment extend to the southeast, with the most extensive and deepest series of steep-sided, V-shaped valleys incising the Chalk from just west of Win Green to Winklebury Hill. Those combes continue to the southeast for about 3 to 4 km. The heads of shallower combes east of Winklebury Hill are located farther from the ridge crest. In some areas the combes are asymmetrical in cross-section, indicative of former periglacial conditions, when the drainage system was incised rapidly during lower sea levels and erosion of the fractured mantle of Chalk led to mass wasting across the downs. Thick deposits of periglacially weathered and soliflucted combe deposits are commonly encountered on Chalk scarps and along valley slopes in chalkland (Harris 1987).

Solifluction is slow, down-slope movement of viscous, saturated soil containing other unsorted and unsaturated surficial sediments (BGS 2020j). Gelifluction is the process of slow flow of waterlogged sediments, but as a product of thawing of seasonally frozen deposits (BGS 2020j). In other words, it is solifluction driven by freeze-thaw action. Solifluction is widespread where a thawing layer of saturated soil with excess pore pressure in the upper layer is underlain by a frozen, impermeable subsurface. That condition leads to downslope movement of soliflucted material, the rate of movement conditioned by the slope gradient, soil texture, water content and depth of thawed soil, and extent of local vegetation. Almost all Chalk slopes in southeast England include soils derived from gelifluctec sediments (Catt 1987).

Solifluction and meltwater processes dominated mass movement of frost shattered material during periglacial conditions, while soil creep, hill wash and fluvial processes were major influences on denudation during temperate interglacial intervals (French, 1996; Hadlow 2014). Frost-derived debris such as brecciated and weathered chalk moved downslope by creep, slope wash or solifluction. Surface runoff during rain events would produce incision within the fluvial landscape with fine-grained aeolian sediments deposited from above (French 2018). Chalk scree, gravels and slope wash developed along valley slopes and bottoms, possibly attaining thicknesses of up to 20 ft in some areas (Lake 1975).

Springs located on the dip slope of the Chalk are almost always on valley bottoms where the ground surface intersects the water table. There are two main categories of springs on the downlands (Woodland 1946):

- overflow from the main water table to the ground surface; and
- at certain horizons determined by lithology (Allen *et al.* 1997).

The springs dry up if the water table falls below the overflow elevation during the summer and autumn. As the water table rises to overflow elevations during winter those springs become active again. Seasonal streams produced by such springs are called 'bournes', or 'winterbournes' (Allen *et al*. 1997). A spring line occurs at the foot of scarp slopes and the Chalk overlays less permeable strata such as the Gault Clay underlying the White Chalk, or marls seams, or where the dip slope of Chalk is overlain by less permeable deposits and overflow seepage occurs (Fookes *et al*. 2015).

Differences in insolation and freeze-thaw effects affected differential mass wasting during stream downcutting and migration (French 2018). The wetted perimeter of rivers located where brecciated Chalk was exposed on valley floors and lower banks was smoother than along gravel-lined streams, producing relatively high flow velocities even in channels with low gradients. Weathered and eroded Chalk was transported downstream as each channel migrated across its floodplain, thermally eroding broad low-gradient erosion surfaces.

Combes are bowl-shaped hollows on the flanks of dry valleys. Some combes developed in scarp slopes formed by frost action and erosion of snow-filled hollows on hillsides during the

Pleistocene. Other combes formed by springs developing near the base of scarps during periglacial conditions. Combe rock is Chalk eroded from combes to form broad fans of reworked debris accumulating at the base of escarpments.

Relict Pleistocene soliflucted deposits, known as 'Head' are evident across southern England and across Britain (Catt 1987; Waltham 2002). Head consists generally of soliflucted chalk and flints that moved downslope during periglacial conditions and is now located at valley bottoms, the foot of scarped slopes, and along dip slopes of the Chalk. Head did not form on slopes already depleted of interglacial soil mantles (Catt 1987). The primary means of mass movement forming Head deposits during the Devensian was likely saturated mudflow, in areas that were wetter and slightly warmer than glaciated regions (Catt 1987). Head typically has higher compressibility and lower bearing capacity than the parent sediment or soil, can reactivate and flow downhill, and is vulnerable to landslides if it retains relict shear planes (Fookes *et al*. 2015).

Solifluction is commonly related to surface wash and flows of water saturated sediments along lower portions of valley side slopes, and in tandem with erosional processes forms low-angle ground surfaces transitioning between higher slopes and fluvial terraces (Barsch 1993). Therefore, solifluction features are shallow, as saturation or near-saturation conditions in the freeze-thaw zone encourages down-slope movement, and regolith characteristics including lithology influence the range of periglacial phenomena at local scales (Ballantyne 1987).

Soliflucted sediments derived from chalk are encountered across much of southern England, particularly along valley side-slopes, valley bottoms, combes, and beyond the mouths of dry valleys as fan deposits (Lake 1975). The soliflucted sediments at or near valley bottoms may transition laterally into alluvium, colluvium, or other deposits (Lake 1975). Deposits derived from soliflucted material may exhibit:

- poor sorting and poor stratification of chalk or material derived from other lithology;,
- very soft chalk matrix where deposited below the water table;
- a hard layer overlying a very weak layer;
- variable engineering properties and behavior, particularly with regard to application in earthworks;
- chalk susceptible to flow and/or translatory slides; and
- an ill-defined extent of the sediments (Lake 1975).

Head is unsorted, soliflucted debris typically consisting of very gravelly, silty, sandy clay to clayey sandy gravel, with coarse-gravel- sized, nodular flint (Allen and Crane 2019). It results from over-saturated sediment with water from melting snow or ice, rain, or lines of springs or seepage (Dines *et al*. 1940). Slopes steeper than 5° formed on chalk beyond the limit of Devensian glaciation commonly include a veneer of sheared and unstable Head (Waltham 2002). It is notably well sheared, with basal, intermediate and circular slip surfaces (Waltham 2002). It develops easily on chalk slopes and other soft sedimentary rock and clayey sediments. That process suggests gelifluction and solifluction are the primary means of formation processes, although local conditions can encourage other processes of periglacial mass movement to be associated with the deposits (Catt 1987).

Combe rock is a form of Head derived from chalk. Periglacially weathered and soliflucted chalk with angular limestone clasts set in a silty matrix is sedimentologically similar to other nonargillaceous Head sediments (Harris 1987). Head is typically encountered on lower areas of scarps and valley slopes, in chalkland as well as over other bedrock types. Thick combe deposits situated on floors of dry chalkland valleys are mostly composed of frost-shattered bedrock transported down slopes by rolling, frost creep, mass sliding across upper surfaces of melting ice lenses or the surface underlying permafrost (Harris 1987).

All areas of dip-slope interfluves of southeast England are protected by a thin, weathered cover of periglacially disturbed Paleogene deposits (Thompson *et al*. 2015a, Figure - Major structures of southern England). Clay-with-flints Formation, widespread across the English chalk, is a mixture of soliflucted residual soils and Paleogene clastics (Waltham 2002). It is composed of unbedded and heterogeneous clays and sandy clays with abundant flint pebbles and nodules derived from dissolution, decalcification, and cryoturbation of bedrock strata of the Chalk Group and original Paleogene formations (Allen and Crane 2019; BGS 2020k). Deposits mapped as Clay-with-flints in sub-aerial portions of the Hampshire-Dieppe Basin consist of a wide range of laterally and vertically variable mixtures heterogeneous sediments including clay, sand, gravel, and flint and other clasts (Gallois 2009). The thickness of Clay-with-flints typically ranges from 2- to 10 m (BGS 2020l). Residual Deposits such as Clay-with-flints Formation can result in local development of karst features such as pipes and hollows infilled with the residual deposits (BGS 2020l). Clay-with-flints occurs in scattered patches on high ground of the Chalk, as well as in some sinkholes and solution pipes, and has been encountered to depths exceeding 10 m (Fookes *et al*. 2015). Slightly acidic meteoric water percolating through Clay-with-flints dissolves underlying chalk, resulting in formation of solution depressions since the Middle Pleistocene, into which Clay-with-flints sediment is deposited by low-energy colluvial processes (Wilkinson 2009).

Clay-with-flints is most extensive at higher elevations and interfluves underlain by Seaford Chalk (Thompson *et al*. 2015a). The upper part of Seaford Chalk and some Newhaven Chalk would have dissolved at locations where Clay-with-flints overlies Lewes Nodular Chalk and/or Seaford Chalk, (Gallois 2009). Soliflucted Clay-with-flints deposited on a hillslope is classified as Head (BGS 2020k). Head sediments are most widespread on north- and east-facing hillslopes, generally grading laterally into areas exhibiting a thin flinty veneer or to valley bottoms (Thompson *et al*. 2015a).

Other than areas of alluvial, marine and lacustrine deposition during the Holocene, most soils of eastern and southern England, south of the Devensian glacial limit, were impacted by periglacial deposition, erosion or disturbance. The Devensian cold stage promoted significant rejuvenation of British soils by removing earlier, strongly weathered soil mantle materials and replacing it with loess and other deposits produced by physical weathering and transportation (Catt 1987). Soil characteristics inherited from periglacial frost action affected the depth of Holocene pedogenic processes (Catt 1987). Upper portions of paleo-argillic horizons on level interfluves and terrace remnants provide the best evidence for *in situ* frost disturbance, as those areas consisted on stable land surfaces during the Late Devensian. Evidence for interglacial soil development in Britain is limited to level or slightly sloping plateaus, interfluves, and remnants of upper terraces south of the Devensian glacial limit (Catt 1987). Soils developed along foot-slopes and floors of dry valleys are associated with combe deposits. Some combe deposits are cemented by secondary calcium carbonate to produce rather hard combe rock (Lake 1975). Some low-angle northeast-facing slopes with gradients of 5° in asymmetrical chalk valleys of southern England are underlain by up to 3 m of combe rock (French 1973; Harris 1987).

Terraces above Ordnance Datum in south Hampshire, including the southwest portion of the study area, indicate they were deposited by rivers controlled by high base levels during relatively cold climatic conditions (Keen 1980). Gravels and brickearths of south Hampshire were deposited under periglacial fluvial conditions during a transition between interglacial and glacial regimes, with gravels on low terraces formed during higher stream discharges at the end of the late-Ipswichian, early Devensian interglacial (Keen 1980). Perceived accelerated geomorphic change in upland catchments across Britain during the Holocene have been attributed to human activity or catchment sensitization as a result of land-use change (Foulds and Macklin 2006). However, chronologies and paleoenvironmental reconstructions allowing clear identification of cause are few (Foulds and Macklin 2006).

E.2.d Karst

Subsurface investigation of karst in southern England has included geophysical logging, borehole imaging, packer testing, dilution testing, pumping tests, and observing, measuring and classifying numerous features located in Hampshire Basin and other regions of Britain underlain by the Chalk. BGS has been compiling a national GIS database of karst features since the mid-20th century (Cooper *et al*., 2001; Farrant and Cooper, 2008). The information includes karstic (dissolution) features such as sinkholes (dolines), caves, stream sinks, springs, and instances of damage to infrastructure (Cooper *et al*. 2011; BGS 2021). The dissolution process is a result of precipitation obtaining carbon dioxide derived from the atmosphere or soil overlaying the limestone, forming carbonic acid ($H_2O + CO_2 = H_2CO3$). Insoluble calcium carbonate ($CaCO_3$) in limestone is altered to soluble calcium bicarbonate ($Ca(HCO_3)_2$, that is then removed by solution in surface water or ground water ($H_2CO_3{+}CaCO_3{=}Ca(HCO_3)_2$. Formation of karst features in chalk of southern England is influenced by local geological conditions and the pattern and frequency of joints in the limestone (Lake 1975). Genesis of karst landforms can be related to factors such as terrain setting, cover deposit thickness, cover deposit, lithology, chalk lithology, and depth to the water table. (Edmonds 2008).

Unglaciated areas of Britain are underlain by limestone karst features that were exposed to periglacial conditions, with some areas of karst features located between stratigraphic units underlain by thin sedimentary deposits (Cooper *et al*. 2011). Examples include buried sinkholes (also referred to as 'swallow holes') encountered in glaciated and fluvial areas (Waltham *et al*., 2005; Gutiérrez *et al*., 2008; Cooper *et al*. 2011). The degree to which shallow karstification has developed in a region or particular location is a function of the contact between meteoric and shallow groundwater in contact with the Chalk, and the extent of periglacial phenomena such as frost heave and effects of low ambient temperatures. In addition, tectonics can govern the morphology of drainage basins and the predominance of karst and/or fluvial features of the landscape (Kakavas *et al*. 2015).

There are numerous geomorphological characteristics of karst terrains in the Chalk of southern England (e.g. West and Dumbleton, 1972; Sperling *et al*., 1977; Edmonds, 1983; Goudie, 1990). Surficial karst features of the Chalk include dolines (solution depressions not necessarily with water flowing into them), solution pipes (large sub-vertical pipes commonly backfilled with coarse-grained sediment) and swallow holes (the location where a stream flows underground). Dolines and swallow holes are located on areas of recharge areas such as interfluves, and discharge areas including valleys. The regional density of such features in the Chalk is generally less than in other limestones, although the frequency locally can be similar. The highest density of karst features in the Chalk is in Dorset where more than 150 features per km^2 are documented at Puddletown Heath, about 15 km southwest of Cranborne Chase (Sperling *et al*. 1977). An undulating ground surface occurs in some areas where the Chalk is overlain by a sedimentary cover, giving the general appearance similar to grikes (fissures widened by carbonation) and clints (flat-topped residual blocks separating the grikes) that are more commonly noted on ground surfaces overlaying more competent limestones (Allen *et al*. 1997).

Since karstification is a product of water infiltration and dissolution (generally via chemical mechanisms in the presence of water and carbonic acid), there is a direct relationship between fluvial activity and karst. Chalklands dominated by fluviokarst landscapes have extensive networks of dry valleys. Groundwater flow in the Chalk is dominated by *fractures* typically solutionally enlarged to form karstic fissures or small conduits (Lake 1975). The highest rates of hydraulic conductivity in the Chalk are located within the zone of water table fluctuation, where fractures enhance the groundwater movement by dissolution (Allen *et al*. 1997). Solution of chalk enlarges cracks, joints and other fissures, increasing transmissivity of the Chalk in river valleys and dry valleys (Lake 1975). Higher transmissivity is typically encountered in valleys, and lower beneath interfluves (Allen *et al*. 1997). Rapid groundwater flow in chalklands is related to proximity of the Chalk to Paleogene cover (Allen *et al*. 1997). Areas of dolines and stream sinks are often close to overlying strata such as Paleogene formations of the Hampshire Basin (Maurice *et al*. 2010). Large sinkholes in areas of sand-covered Chalk in Dorset generally appear inactive, while active subsidence at smaller sinkholes appear to have limited distribution (Sperling *et al*. 1977; Fookes *et al*. 2015).

Various and numerous expressions of karst are noted on the Chalk outcrop of southern England, while data from the saturated zone demonstrates significant and widespread solution-enhanced fractures that can channel a rapid flow of groundwater (Allen *et al*. 1997). Groundwater flow in karst is often rapid as a result of networks of fractures, enlarged factures (conduits), and caves (conduits large enough to be explored physically by humans). Solution caves too small for human exploration are likely very common in the Chalk (Fookes *et al*. 2015).

The Chalk is major aquifer in southern England with potential for significant spatial variability in aquifer properties (Evans and Hopson 2000). Allen *et al*. (1997) provides limited information regarding aquifer properties of Cranborne Chase, as there is no record of groundwater investigation or research into the aquifer properties in the area. The lack of local hydrogeological analysis makes it difficult to determine the effective Chalk aquifer thickness at Cranborne Chase. In general, the combination of low hydraulic gradients and large variations in Chalk topography can create an unsaturated zone more than 100 m thick in interfluve areas (Lee *et al*. 2006). Saturated chalk aquifers are characteristically associated with higher permeability in valleys, lower permeability beneath interfluves and local effects imparted by the presence of major fractures (Hadlow 2014). Hadlow (2014, Table 2.7) summarizes factors responsible for high permeability along valleys. Geological structure can add complexities and variations in local water tables (Hadlow 2014). Factors likely contributing to higher frequency of open fractures in valleys include lines of structural weakness with a higher frequency of fractures associated with valley alignments (Price *et al*., 1993).

The unsaturated zone in unconfined British Chalk aquifers is an important part of the hydrological cycle, significantly affecting timing and magnitude of recharge (Ireson *et al*. 2009). Recharge in the Chalk is predominantly via the matrix, with a strongly attenuated response at depth and rapid recharge pathways through fractures in the unsaturated zone. This has important implications for groundwater flooding, as simulations provide evidence that recharge fluxes continue throughout the year, regardless of drought conditions (Ireson *et al*. 2009). In addition, the Chalk is a mildly karstified fractured limestone with high matrix porosity (Maurice *et al*. 2010). Rapid groundwater flow ('karst'-like behavior) is widespread throughout the Chalk, including beneath interfluves and in valleys (Allen *et al*. 1997). The relatively high hydraulic conductivity of the Chalk restricts the amount of surface runoff, limiting local concentration of surface water and the formation of solution cavities as a product of dissolution (Lake 1975). However, where clay or other relatively impermeable cover material overlays the Chalk, including deposits of severely-weathered sediments derived from the limestone itself, dissolution of the Chalk can result in development of karst features at the boundary of the capping materials (ibid).

Aquifer properties in the Chalk are products of numerous factors. A topographic pattern of transmissivity develops by:

- concentrating groundwater flux in valleys;
- structure of the Chalk;
- removal of overburden; and
- periglacial erosion of unfrozen ground (Allen *et al*. 1997).

Additional effects that can result in significant hydraulic conductivity including karstic behavior are imprinted upon the general trend. They include:

- lithology of the Chalk, particularly the presence of marls, flints or hardgrounds;
- structure of the Chalk, with regard to potentially significant fracturing and presence of fault gouge, or channel structures;
- cover materials such as Paleogene sediments or Clay-with-flints leading to developing solution features and groundwater conduits;
- current or former presence of major surface water features; and
- periglacial activity (Allen *et al*. 1997).

Ground subsidence dimensions and geological setting often provide clues about the cause and nature of karst features (Edmonds 2008). Factors accounting for high degrees of karst features associated with cover deposits might include (Edmunds *et al*. 1992):

- acidic soils related to Paleogene sediments and Clay-with-flints overlying the Chalk;
- while soils derived from the Chalk are generally permeable, other cover deposits and associated soils can be more clayey and cohesive (such as London Clay, Reading beds and Clay-with-flints), concentrating runoff to specific locations; and
- recharge percolating through the cover remains undersaturated with respect to calcite before it encounters the surface of the Chalk, and the acidic recharge is channeled to discrete locations.

Solution of the Chalk is active at the contact between the Chalk and overlying sediments (Sperling *et al*. 1977). Paleogene rocks and sediments overlaying the Chalk support catchment and drainage of meteoric and surface waters onto the Chalk surface. Chalk overlain by superficial deposits commonly include fluctuations in the surface consisting of troughs and ridges - solution features often exhibiting relief of 1 to 2 ½ m or more – some of which include cavities formed by dissolution of chalk and bridging of the overlying sediments (Lake 1975).

Small-scale surface karst such as dolines and stream sinks are common in southern England, particularly at the boundary between the Chalk and Paleogene sediments (Sperling *et al.* 1977, Table IV; Banks *et al.* 1995; Maurice *et al.* 2010). Geomorphological karstic features such as dolines in south Dorset (Sperling *et al*., 1977) underlay Paleogene deposits. Dolines are located in areas of moderately thick surface sediments underlain by the Chalk, indicating the karst features are formed by 'intense and localized solutional activity promoted by highly acidic conditions' (Sperling *et al*. 1977).

The distribution of swallets (karst features in which an active stream flows into a sinkhole) on the Chalk and Reading Beds near Burnham Beeches, west of London, were mapped by Hare (1947: 327) (Sperling *et al*. 1977). Dolines in southeast Dorset similar to those in the London Basin have been observed and described for the last 200 years (ibid. 1977). Sperling *et al*. (1977) documents dolines concentrated in heathland areas between Dorchester and Bere Regis, between the valleys of the Rivers Frome and Piddle, 12 km south of Cranborne Chase. Distribution of the Dorset features is constrained by the location of Eocene sediments (Reading Beds and Bagshot Beds with occasional outliers of London Clay) overlying the Upper Chalk bedrock. In addition, Pleistocene and Holocene deposits including Clay-with-flints, Plateau Gravels, and Valley Gravels are located in the area of study (Sperling *et al*. 1977).

Karst 'pipes' generally refers to sinkholes that approximate a cylindrical shape and are infilled with collapsed debris (Lake 1975). Pipes in the Chalk of southeast England are commonly situated near boundaries with, or beneath, Paleocene deposits, where meteoric water and shallow groundwater concentrate to form solution cavities in the Chalk in the vicinity of basal sediments such as clays of the Woolwich and Reading Beds, London Clay, and sandy Thanet beds (Lake 1975).

Results of field investigation and mapping of karst features in the South Dorset Downs and Cranborne Chase indicate the highest density of karst features are located along the contact between Paleogene deposits and underlying Chalk (Sperling *et al*. 1977; Hammer *et al*. 2020, Figure 1). Buried sinkholes encountered in the vicinity of the contact are usually small, wide, and shallow in shape, with deep, narrow pipes located at some areas (Fookes *et al*. 2015), while some features appear to be laterally extensive (Hammer *et al*. 2020) (Figure E.2.10, Figure E.2.11).

Hammer *et al*. (2020) used remote sensing imagery in Google Earth to map karst features of Cranborne Chase by visual identification of vegetation color differences and cross-checked with a DEM hillshade derivative. Locations of mapped karst features were compared to results provided by Sperling *et al*. (1977) for an area of extensive doline development in the South Dorset Downs. The comparison indicated significant correlation with regard to proximity of features to the contact between the Chalk and overlying Paleogene deposits. Hammer *et al*. (2020) mapped more than 1,700 karst features on Cranborne Chase (Figure E.2.12). Of those features there was a significant correlation between their density and proximity to specified chalk formations (Figure E.2.13). More than 75 percent of the features are located in the Portsdown Chalk Formation, and about 13 percent are mapped in the Culver Chalk Formation. Minor karst feature assemblages were mapped in Newhaven Chalk and Paleogene deposits including Reading formation, London Clay and Poole Formations. Most visible karst features were identified on steeper hillslopes and in valleys (Hammer *et al*. 2020). A database of mapped locations of those karst features was prepared with intent to provide geographic assistance to further archaeological investigations and paleoenvironmental reconstruction of south central England.

Karst features developed in the Chalk can be excellent paleoenvironmental archives (Hammer, *et al*. 2020). For example, Fir Tree Field Shaft doline yielded an extensive collection of animal and cultural remains during the Late Mesolithic and Early Neolithic (Allen & Green, 1998). Other typical data archives commonly used for paleoenvironmental reconstruction of the Neolithic period, such as lakes or peat fens, do not exist in Cranborne Chase because of the well-drained karst landscape. Karst features recently mapped by Hammer *et al*. (2020) were identified as potential a)

Imagery of karst in area underlain by Reading Formation south of Puddletown, Dorset, study area of Sperling *et al.* (1977). Aerial photograph courtesy Google Earth.

b)

Imagery of karst features in Portsdown Formation at Cranbone Chase near Edmondsham, Dorset. Aerial photograph courtesy Google Earth.

c)

Imagery of karst features in Seaford Formation east of Winklebury Hill, near the crest of the Chalke Escarpment on Trow Down at Cranbone Chase. Aerial photograph courtesy Google Earth.

Figure E.2.10: Aerial photographs of karst features located in East Dorset. Land surfaces shown in images photos b) and c) are located in the study area.

Figure E.2.11: Photo of possible karst sinkhole at Edmondsham, Dorset (SU 063 122). The site is underlain by Quaternary river terrace sand and gravel that overly Paleocene Reading Formation, in turn underlain by Portsdown Chalk Formation. Hammer *et al*. (2020) identified karst features at numerous locations in the Edmondsham area. Inset: a) location of site indicated by red arrow on map of karst features on Cranborne Chase (Hammer *et al*. 2020, Fig. 1); b) photo of surficial Quaternary river terrace sand and gravel in the vicinity of the sinkhole. (Photos by P. Burley)

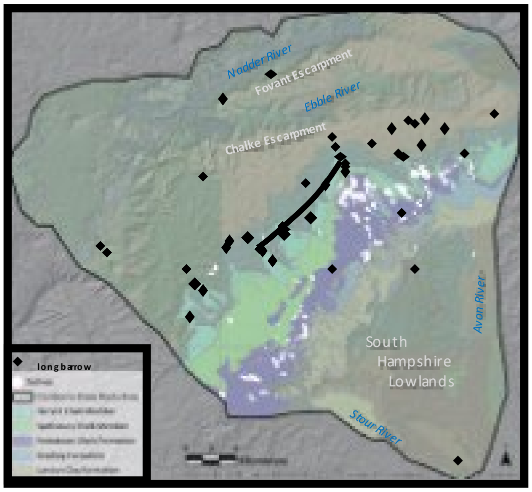


Figure E.2.12: Map of Cranborne Chase showing karst feature density on the Portsdown Chalk Formation and surrounding formations in the southeast portion of Cranborne Chase. Areas of mapped karst features shown in white. Dorset Cursus and long barrows indicated. Base map from Hammer *et al*. 2020.

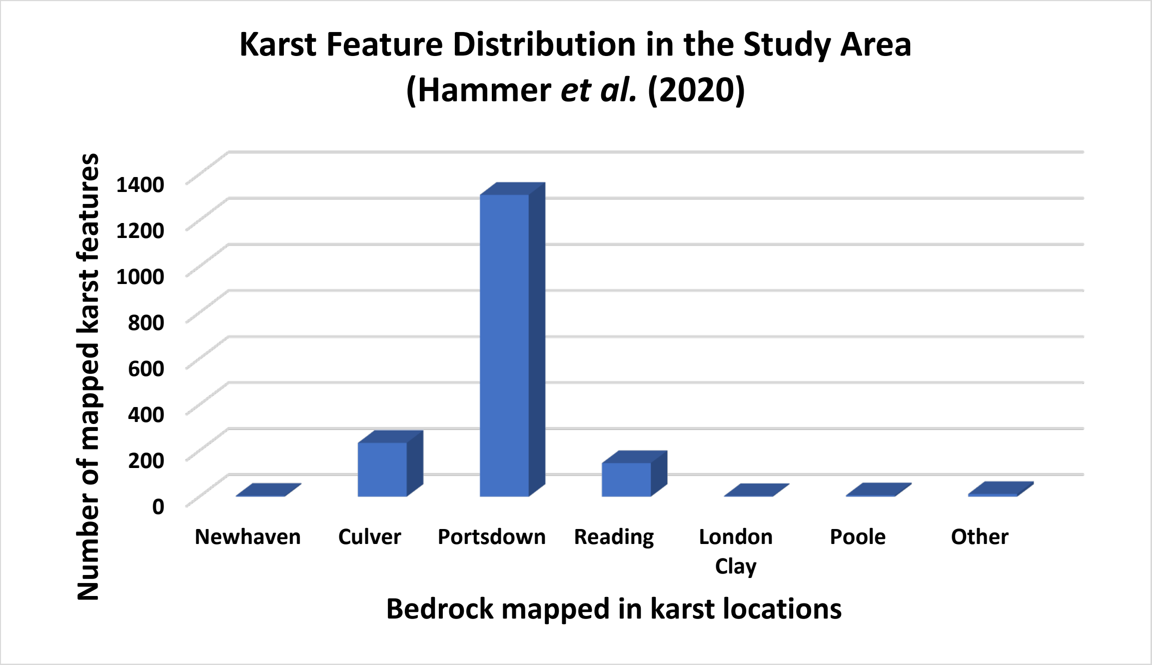


Figure E.2.13: Distribution of karst features underlain by listed bedrock formations in the study area. Data from Hammer *et al*. (2020).

locations for archaeological investigation related to Mesolithic and Neolithic occupancy of the study area. To date, Mesolithic and Neolithic use of karst features at Cranborne Chase appears to be limited to temporary occupancy of a doline in the upper Allen River Valley (Green and Allen 1997).

E.2.e Escarpments

D.2.e.i The Primary (Chalke) Escarpment

Recent means for delineating boundaries between Chalk formations on unexposed, often vegetated ground, have included recognizing characteristic landforms associated with each formation (Bristow *et al*. 1997, 2020; Aldiss *et al*. 2012). Feature mapping of the White Chalk Subgroup for the purpose of identifying lateral continuity of formations and members across southern England is described by Bristow *et al*. (1997, 2020). An empirical approach has been applied to mapping the Chalk, identifying landforms associated with the particular changes in the composition that characterize each formation. Variations in topographic features of the formations are associated with changes in lithofacies and lithostratigraphy, structural attitude of bedrock, local erosional and weathering history, and deposition of superficial sediments (Aldiss *et al*. 2012). Topographic features observed in large areas underlain by each formation correspond consistently with changes in lithology at specific stratigraphic horizons within each formation, or at formation boundaries (ibid. 2012). Those characteristic landforms provide the means to identify geological boundaries.

The crest of the primary escarpment bounding Chalklands is generally formed by the Lewes Nodular Chalk or Seaford Chalk, with much of the broad dip slope behind the cuesta underlain by Seaford Chalk (Aldiss *et al*. 2012). Less pronounced escarpments form at contacts between younger Chalk formations (Figure E.2.14). A secondary escarpment is formed at contacts between the Seaford and Newhaven formations, or between the Newhaven and Culver chalks. A third escarpment is evident in the Culver Chalk, and a 4th in the Portsdown Chalk (Bristow et al., 1997; Aldiss et al. 2012). Characteristics of each of those escarpments encountered in the study area are described below.

The Chalke Escarpment and dip slope of the Chalk across the Chase represent remnants of a sub-Paleogene erosion surface modified by late Tertiary and Quaternary geomorphological processes (Fookes et al. 2015). The primary escarpment of the Chalk forms an irregular north-east trending ridge and is primarily formed by a narrow outcrop of Late Cretaceous Chalk formations of the White Chalk Group resting on a platform of Upper Greensand and blue clays of the Gault Formation (Allen and Crane 2019). The Holywell Nodular Chalk, often observed above a positive topographic feature in the middle portion of the Main (primary) Chalk escarpment (e.g. Fovant and Chalke Escarpments), underlies a rather gentle slope and can form a subsidiary escarpment (Aldiss et al. 2012). The contact between the Holywell Chalk and overlying New Pit Chalk outcropping along primary escarpments typically exhibits a sharp negative break in slope, and the New Pit often forms the steepest ground surface in the upper part of the cuesta (Aldiss et al. 2012). A lithological change at the top of the New Pit Chalk, or a positive break of slope just above it, indicates a lithological change between the steep slope of the New Pit and the convex slope of the overlying Lewes Nodular Chalk, that commonly forms the crest of the primary escarpment. That change in landform is consistent with the change in lithology between the formations. The Chalk Rock, a hard nodular chalk, is situated near the base of the Lewes Nodular Chalk, often readily indicated by fragments of chalkstone (brash) in soil, with inclusions of glauconitic or phosphatic mineralization, or glauconite grains (Aldiss et al. 2012).

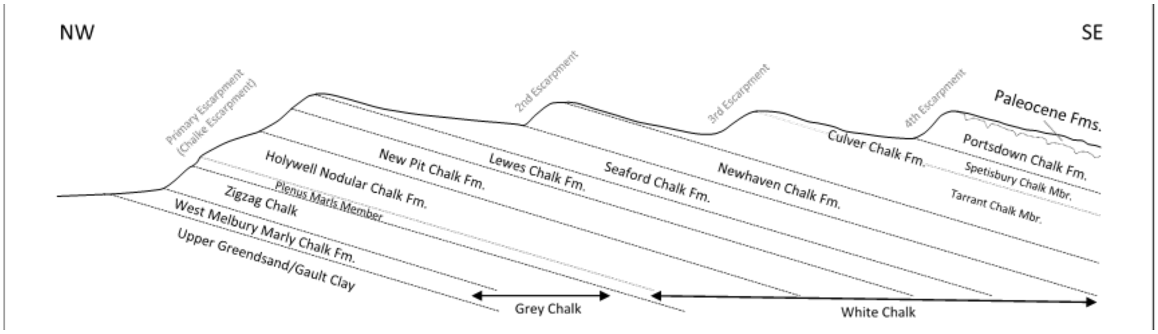


Figure E.2.14: Schematic cross section of chalk formations underlying the study area. Outcropping chalk formations of the White Chalk Group on Cranborne Chase range from the New Pit Chalk in bottoms of combes situated southeast of the Chalke Escarpment (primary escarpment) to Portsdown Chalk that underlies Paleocene and Eocene formations encountered in the South Hampshire Lowlands. Secondary, tertiary and quaternary escarpments are associated with inter-formational boundaries between Seaford, Newhaven, Culver and Portsdown chalks. The Dorset Cursus overlies Newhaven and Tarrant Chalks southeast of the secondary escarpment as it crosses interfluves in the central portion of the Chase.

Primary escarpment summit elevations in southern England commonly exceed 180 m, rising to 277 m at Win Green at the crest of the Chalke Escarpment, located along the north and northwest perimeter of Cranborne Chase. The elevation of the crestline of the Chalke Escarpment falls from the northwest edge of the study area toward the north perimeter of the Chase, evidence of the intensity of Quaternary denudation (Jones 1999a). Descending southeast from the crest of the escarpment is a long, gentle dip slope in Lewes Nodular Chalk to Newhaven Chalk formations that underlies much of the catchment including the Hampshire lowlands overlain by Paleogene sedimentary formations. The base of Seaford Chalk is located at the contact with the uppermost nodular and gritty Lewes Chalk. The contact can exhibit a very slight negative break in slope in association with the change in brash as the steep, convex slope of Lewes Chalk changes to the flatter convex slope of Seaford Chalk rising to the crest of the escarpment (Aldiss *et al.* 2012). Seaford Chalk commonly develops extensive dip slopes extending down-dip from the crest of the main escarpment. The slope is far from smooth, however, as two smaller, heavily dissected escarpments are formed by the Tarrant and Spetisbury Members of the Culver Formation that overlies the Newhaven Chalk (Bristow *et al*., 1997, Figure 4). The contact between the Chalk and overlying Paleogene deposits dips northwest-southeast, with the general orientation of strike (southwest-northeast) evident by the orientation of contacts between succeeding Chalk and Paleogene formations (BGS 2018). The base of the Paleogene deposits consists of clay-rich sediments of Reading and London Clay formations, overlain by typically sandy deposits of the Bracklesham Group (Allen and Crane 2019).

E.2.e.ii Second Escarpment

Newhaven Chalk typically presents a steeper ground surface than the underlying Seaford Chalk, the contact of the two formations represented by a negative break of slope and the face of the secondary escarpment (Jones 1999a, Figure 10; Aldiss *et al*. 2012). The landform at the base of the Newhaven Chalk can be subdued and difficult to recognize in some areas (Hadlow 2014). In Wiltshire and Dorset the negative break of slope is observed about 10 m above the base of Newhaven Chalk, with additional negative breaks of slope located near the base of formation, presenting the appearance of a concave slope (Aldiss *et al*. 2012). The secondary Chalk escarpment is capped by Culver Chalk underlying a portion of the down-dip slope (Aldiss *et al*. 2012). The base of Culver Chalk is typically just below a strong persistent positive break in slope coinciding with brash containing abundant large flint nodules.

E.2.e.iii Third Escarpment

In areas of Dorset and Hampshire, including Cranborne Chase, Culver Chalk is divided into the lower Tarrant Chalk Member and upper Spetisbury Chalk Member, the base of the Spetisbury Chalk indicated by a positive break in slope at the top of a subsidiary escarpment within the Culver Chalk (Bristow *et al*. 1997; Aldiss *et al*. 2012). Landforms marking the bases of the Tarrant and Spetisbury chalks can be mapped across their outcrop (Gale and Hancock 1999).

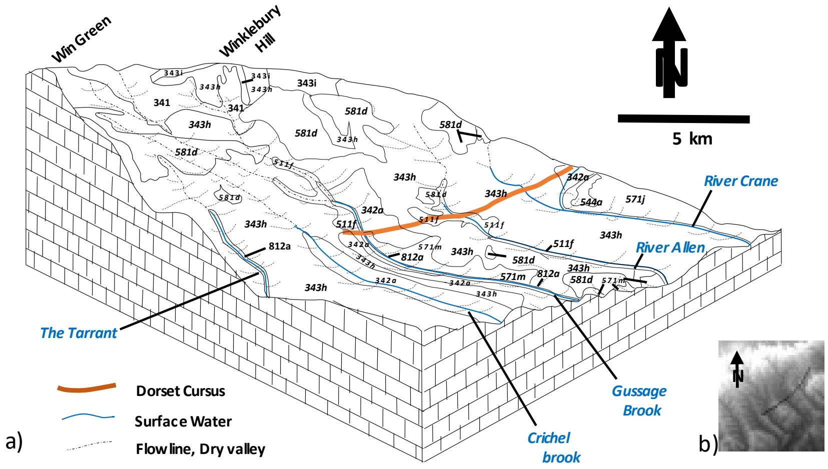
E.2.e.iv Fourth Escarpment

The base of Portsdown Chalk in Dorset and Hampshire is mapped at a negative break in slope at the base of a fourth escarpment, formed between the top of the Spetisbury Chalk and the Portsdown Chalk, the youngest formation of the Chalk Group in southern England (Bristow *et al*., 1997; Aldiss *et al*. 2012). The negative feature break at the contact between formations represents the change from flint-rich Spetisbury Chalk that forms the long up-dip slope, to the base of flint-free Portsdown Chalk (Bristow *et al*. 2020). The base of the slope formed by Portsdown Chalk is typically covered by Paleogene formations.

E.2.f Soils

Soils Site Reports prepared for this study by the National Soil Resources Institute (NSRI), Cranfield University, document the majority of soil associations located across Cranborne Chase consistng of rendzinas. Rendzina soils mapped across the Chase consist of rendzinas of the Andover 1 (0343h) and Andover 2 (0343i) soil associations (NSRI 2017a, 2017b, 2017c, 2017d; NSRI 2018a, 2017 b, 2017c, 2017d, 2017e, 2017f, 2017g, 2017h) (Figure E.2.15). Thompson (2004) describes rendzinas as "calcareous soils over chalk limestone or, extremely calcareous unconsolidated material . . . Rendzina-like alluvial soils are formed in little altered calcareous alluvium, lake marl or tufa. . ." Avery (1980a; 1980b) provides a classification, distribution, and general characteristics of rendzina soils. They are described as lithomorphic soils containing chalk (or limestone) bedrock, or extremely calcareous unconsolidated material underlying topsoil (Avery 1980b). Lithomorphic soils are associated with "older surfaces where horizon development has been constrained by the nature of the substratum, as on chalk, . . typified by freely draining soils (Avery 1980b)." Those soils resulted from formation of an organic or organic-enriched mineral surface horizon at or within 30 cm depth of bedrock or soft unconsolidated material (Avery 1980b; Thompson 2004).

The rendzina soil associations generally consist of shallow, well drained, calcareous silty soils over chalk on slopes and crests of hills, and deep calcareous and non-calcareous fine silty soils in valley bottoms of chalklands. The soils are variably flinty and can include clayey soils (Cranfield University 2018a). The Andover soil association occurs on the Chalke Escarpment in Cranborne Chase, on the upper part of the west-facing scarp slope and on the gently sloping dip slope (Figure E.2.15). The dip slope is dissected by steep-sided dry valleys floored mainly with rendzinas of the Combe series or Upton soils on the upper slopes (Cranfield University 2018a). Humose Icknield soils are located along steep slopes or scarps, typically under semi-natural grassland, scrub, or woodland. Extensive areas of deeper Combe and Charity soils are situated along valley bottoms where calcareous chalky drift and non-calcareous flinty silty deposits are located (Cranfield University 2018a).



<u>Soil associations noted on block diagram</u>:
341 – Icknield: Shallow, mostly humose, well-drained loamy calcareous soils over relatively high permeability chalk on steep slopes and hilltops
342a – Upton 1: Shallow well drained calcareous silty soils over chalk; mainly on Moderately steep, sometimes very steep slopes
343h – Andover 1: Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk on slopes and crests
343i – Andover 2: Shallow, well-drained, calcareous silty, loamy soils over relatively high permeability chalk
511f – Coombe 1: Well drained calcareous fine silty soils deep in valley bottoms
544a – Frilford: Deep well drained sandy and coarse loamy soils
571j – Frilsham: Well drained mainly fine loamy soils over chalk, some calcareous; hallow calcareous fine loamy and fine silty soils in places
571m – Charity 2: Well drained flinty fine silty soils in valley bottoms
581d –Carstens: Well-drained fine silty over clayey, clayey and fine silty soils, often very flinty
812a – Frome: Shallow calcareous and non-calcareous loamy soils over flint gravel affected by groundwater

Reference: National Soil Resources Institute. 2021c, 2021d, 2021e, 2021g, 2021h

Figure E.2.15: a) Block diagram showing locations of soil associations overlying the Chalk in the west-central portion of the study area. The Dorset Cursus, locations of surface waterbodies and dry valleys, and high points along the crest of the Chalke Escarpment are indicated. B) Inset: location of block diagram in the Chase.

E.2.g Sea Level Changes

Hosfield *et al*. (2007:27) notes that the shape of the present coastline of southern Britain developed by c. 7000 to 6000 BP, with mean sea level in the order of 4 to 6 m lower than at present. While a precise configuration of the coastline of Dorset and Hampshire at the Mesolithic-Early Neolithic transition remains unclear, a significant increase in sea-level of about 3 m occurred not long before the beginning of the 4th millennium, and Warren Hill on Hengistbury Head, flanking the River Avon, would have signified the route through the estuary in that area (Field 2008). It should be noted that while global sea level rise is generally associated with glacial melt since the late Pleistocene, variable rates of sea level changes along the coast of Britain are also related to isostatic rebound as the island recovers from Devensian glaciation. For example, regional-scale differences in sea level along the east coast of England may be explained by an isostatic effect of glacial rebound, including contributions by both glacial ice and water (Shennan *et al*. 2000).

E.2.h Rivers and Terraces

Fluvial activity along ancient and modern lowland river valleys of Hampshire (such as the former River Solent and tributaries including the Avon and Stour rivers, and smaller transversely-aligned rivers that cross the coastal plain) deposited extensive sand and gravel bodies. Major rivers of Hampshire Basin are flanked by river terrace deposits that generally parallel and fall gently down alignments of current river channels (Keen 1980). The deposits typically consist of angular gravels with some rounded flints and sand, totaling less than 5 m in thickness (Allen and Crane 2019). The Solent River was the major stream along the west-east axis of Hampshire Basin, flowing east across southeast Dorset and south Hampshire (Allen and Gibbard 1993). Terraces bordering the Solent waterway are evidence that the former Solent River flowed from west to east prior to breaching of the Purbeck-Isle of Wight Monocline and marine flooding of the river's channel between Poole Harbor and the east end of the existing Solent Channel east of the Isle of Wight (Allen and Crane 2019). Tributary rivers flow from the north and south sides of the syncline towards its axis (Allen and Gibbard 1993, Fig. 1). The Solent flowed west-east along the axis of Hampshire Basin, now represented by the location of the Solent seaway from Pool to Portsmouth and southeast from there to the English Channel, where it drained into the Channel River east of the Isle of Wight (Bates and Briant 2009).

The Frome and Solent rivers flowing west to east between the Stour River and the Purbeck Disturbance, drained much of the Hampshire Basin (Keen 1980). Tributaries of those rivers flow from the north and south, from Cranborne Chase and the South Dorset Downs. Upon flooding of lower reaches of the Solent valley during Holocene eustatic sea level rise, easterly flow from upper reaches of the Solent watershed was accomplished by the Frome and Piddle rivers that continue draining into Poole Harbour (Allen and Crane 2019). The Stour flows into the Avon near Hengistbury Head, and the combined flow then enters the English Channel.

The Chalk of the study area, dipping gently toward the southeast, is incised by catchments of the Stour and Avon. The largest catchment area in the Wessex Basin, including Hampshire Basin, is the River Avon, its flow dominated by groundwater discharge from the Chalk (Allen and Crane 2019). The Avon River flows south from upper reaches in Pewsey Basin, passing through Salisbury, Wiltshire, and continues south before discharging to the English Channel at Hengistbury Head. The River Stour flows southeast along the south perimeter of the study area, and discharges to the Avon about 2 km upstream of the mouth of the Avon. The geology of the Stour–Allen catchment includes Paleogene Branksome Sand Formation, with a regional structural dip toward the southeast (ibid.). Upper reaches of the Stour incise Jurassic limestones and mudstones. Middle reaches are underlain by the Chalk while lower reaches include sequences of Paleogene sediments of the Hampshire Basin Lowlands. The Stour River receives significant flows from south-flowing tributaries including the River Allen and Crane River, with discharges dominated by the Chalk aquifer of Cranborne Chase (ibid.). Hydrogeologic study of the River Allen catchment indicates that the regional flow is influenced by vertical hydraulic conductivity of confining beds in the Chalk, and that springs are the primary focus of discharge from unconfined units of the karstic Chalk (ibid.).

E.3 Landscape Reconstruction

E.3.a British Paleoenvironment

Late-glacial dryland assemblages in Britain were dominated by open country species although shade intolerant species were replaced by woodland species during the early Holocene (Rousseau *et al*. 1998). The composition and structure of European primeval forests has been inferred from palaeoecological data and studies of old growth stands that have experienced minimal human impact (Mitchell 2005). A succession of closed-canopy natural forest biomes were generally assumed to have migrated northward after amelioration of Devensian glacial conditions, occupying much of Britain by the Mesolithic (Tansley 1939a; Kirby 2004). Paleoecological data reveals significant spatial variability in vegetation cover in northern England during the mid-Holocene (Chiverrell *et al*. 2008). Changes in solar activity appear to have significantly impacted Holocene climate oscillations across the North Atlantic (Magny 2004), with shifts toward a drier climate during the late Mesolithic likely mediated by changes in pedological conditions and biomass-storage (Cayless and Tipping 2002). Aside of anthropological impacts to vegetation patterns across Europe, Gachet *et al*. (2003) demonstrate an extension of deciduous forest to the north and east was an effect of milder winters during the last 6000 years. Closed forest assemblages reverted to grassland communities with minor evidence of scrub once forest clearance began during the Neolithic (Rousseau *et al*. 1998). Thereafter, evidence of widespread agriculture in northwest Europe concurrent with a drier continental climate could explain increasing agricultural land use in Britain, possibly including formerly marginal environments (Bonsall *et al*. 2002).

Analysis of globally distributed paleoclimate records provide evidence of significantly rapid climate change during the British early- to Middle-Neolithic, 6000 to 5000 cal yr B.P. (Mayewski *et al*. 2004). Use of local pollen data for recognizing vegetation change in upland hillslopes and valleys has been important for interpreting evidence of geomorphic change (Chiverrell *et al*., 2008). However, there is a paucity of pollen data from southern England, and there is a significant lack of data regarding vegetation on the chalklands (French *et al*. 2005:120). Stafford (1995) argues for a holistic analysis of paleo-landscapes linking geomorphological evolution with the history of ecosystem structure as it affected prehistoric land use.

Woodbridge *et al*. (2014) concludes that mid-Holocene regional-scale landscape change in Britain was a product of Neolithic forest clearance and variations in climate. A comparison of pollen-based land-cover and archaeological ^{14}C date-inferred population change indicates that after an initial demographic shift and opening of the landscape during the Late Mesolithic (~7600 cal. BP) conditions stabilized until 6400 cal. BP (Woodbridge *et al*. 2014). An Early Neolithic population increase took place in tandem with an initial, rapid and widespread cultural transformation of the landscape, reaching a peak between 5700 and 5400 cal. BP, followed by reduced landscape impacts including woodland reestablishment during the mid- to late Neolithic. Transformation of British landscapes as a result of Neolithic and Bronze Age deforestation and agricultural clearance is inferred from paleoenvironmental pollen records in tandem with archaeological investigations (Woodbridge *et al*. 2014). Tilia (linden, basswood) were all but was removed from areas with calcareous and loamy soils during Neolithic land clearance activities in southern Britain between 5000 and 3000 cal. BP (Late Neolithic to Late Bronze Age) (Grant *et al*. 2011). However, Cayless and Tipping (2002) concludes that Neolithic effects to woodland were limited, and differences between hunter-gatherer and farmer/hunter-gatherer behaviors in terms local vegetation appear to have been insignificant.

Development of a natural wooded landscape in Britain might have been a product of large herbivores grazing across open areas that eventually experienced phases of scrub and woodland (Kirby 2004). Cayless and Tipping (2002) conclude that Mesolithic vegetation modification including openings in the woodland canopy in southern Scotland was effected by wild animal grazing or climate change. Mitchell (2005) concludes that large herbivores did not maintain an open landscape across prehistoric Europe, although it is possible that they could have influenced the forest species composition. In contrast, Vera (2000) argues that grazing by large herbivores maintaining a more open landscape in Europe, preventing formation of closed canopy deciduous forest. Grazing inhibited regeneration of woodland species, and the degree to which the landscape was opened to parkland or grassland depended on spatial and temporal conditions, such as the length of time closed woodland or open phases occurred and the pattern (clumped or scattered) of patches of vegetation at any given phase (Kirby 2004).

Fyfe *et al*. (2013) presents a compilation and analysis of 73 pollen stratigraphies from the British Isles, to assess the pattern of landscape/woodland openness (i.e. the cover of low herb and bushy vegetation) through the Holocene. The study found higher estimates of landscape/woodland openness, particularly during the first half of the Holocene, than has been previously recognized based on pollen percentage data. However, the degree of openness might be associated with a bias toward data largely developed from wetland and upland areas (Fyfe *et al*. (2013). None of the referenced pollen stratigraphies are associated with the downs or lowlands of the present study area.

Trends in fire history in the general fire history of northwestern and western Europe are attributed to climate forcing during the early and mid-Holocene and anthropogenic land-use in the late Holocene (Cui *et al*. (2015). Innes *et al*. (2013) propose that Late Mesolithic vegetation disturbances were designed to maximize resource benefits of successional vegetation communities resulting from constructing a regeneration niche within the ecology of the natural forest. Repeated fire disturbance of upland woodland on the North York Moors, likely resulting from Mesolithic ecological practice, is indicated by pollen, micro-charcoal and non-pollen palynomorph (NPP) data from the mid Holocene *Ulmus* decline (Early Neolithic c. 5550 cal B.P.) and the preceding millennium (late Mesolithic) (Innes *et al*. 2010). Increased fire frequency correlates with an *Ulmus* decline between about 5650 and 5600 cal BP that Cayless and Tipping (2002) relates to climate change. Edwards and Hirons (1984) finds that arable agriculture on a minor scale occurred in Britain, possibly effected by the indigenous Mesolithic population who had acquired the needed techniques and materials of cereal cultivation, or by a pioneering phase of Neolithic colonization, or a combination of the two, prior to major Neolithic clearance in elm decline times.

Until recently, chalk grasslands of eastern and southern England were presumed to be products of post-Neolithic land clearance (Tansley 1939a). Local, open grassland appears to have been a continuous feature in some areas of the northern British chalklands since the end of the Younger Dryas (Bush 1993). An early post-glacial flora of the Yorkshire Wolds contained a species-rich grassland element with Mesolithic people causing forest disturbance as early as c. 8900 BP, predating development of oak, beech (*Fugus*) and lime (*Tilia*) forests that, until recently, were thought to comprise the natural vegetation of lowland England (Bush 1988). Results of palaeoecological analyses using pollen, and plant and animal macrofossils in the chalkland of the Yorkshire Wolds provides evidence of grassland between the early Holocene and Boreal period (Bush and Flenley 1987).

Vegetation communities and other species within ecosystems exhibit complex interaction involving a breadth of environmental variables, often including soil type, structure and pH, available nutrients, ground surface aspect, elevation, available soil moisture, and other parameters including human behaviors (BGS 2017). Bedrock has a fundamental influence on pedogenesis, as do plant and animal species commonly associated with certain soils and rock types. Chalk downland habitats typically include thin rendzina soils over Chalk in southern England. With thin, well-drained soil conditions and removal of Pleistocene soils by solifluction on steep slopes of the chalklands, and climatic amelioration during the Holocene, Piggott and Walters (1954) concluded that areas in southern Britain likely remained generally free of trees while other regions experienced a northward advance of the forest line. At the same time, evidence of calcicolous (lime-loving) species distributed discontinuously indicates chalk grasslands might have been present across some areas of the downs throughout the Holocene (Piggott and Walters 1954). Bush (1989) notes that locations peripheral to the Chalk were likely lined by trees trapping pollen carried by winds off the chalklands.

Older grasslands are more resilient than those in earlier stages of succession (Grime *et al.* 2000; Carey 2013). Unimproved calcareous grassland is rather resistant to climate change (Natural England 2014). Eriksson and Jakobsson (1998) concludes that colonization processes have a significant influence on the composition and pattern of grassland species, although individual mechanisms influencing abundance and geographical distribution of species can be identified. Bunting *et al*. (2004) argues that the relevant source area of pollen is primarily related to patterning of different vegetation elements within the landscape. Calcareous grassland species likely propagate vegetatively and might have extremely small dispersal distances (Fagan *et al*. 2008).

The most species-rich community per unit area in Britain is chalk grassland (Tansley 1939a). However, Bennie *et al*. (2006) argues that species composition of fragmented, semi-natural grasslands can alter naturally as a result of random local extinction and/or colonization events, successional change and/or as a response to physical conditions. Calcareous grasslands are characterized by species-rich grass and herb communities thriving on shallow, lime-rich soils (Forest Research 2014). The soils are commonly freely draining and parched during summer, and the environment favors plants having a smaller-scale stature and tolerate alkaline, low nutrient, dry soil conditions (BGS 2017). Calcicolous plants are linked with poor mineral soils over strongly calcareous rocks including the Chalk and other limestones (BGS 2017). For example, juniper (*Juniperus communis L.*) can occur in grazed and ungrazed grassland but is restricted to calcareous soils in southern England (Ward 1973).

E.3.b Paleoenvironment of the Study Area

Topography is an important factor in the distribution of chalk grassland species in northeast Dorset, including the downs of Cranborne Chase, the main axis of plant distribution coincident with a southwest to northeast trend indicated by local climatic conditions (Perring 1959). The xerosere on chalk soil is a very stable grassland community under continued grazing (Tansley 1939b; Hope-Simpson 1941). Rendzinas and other dry calcareous soils high in free calcium carbonate typically have an alkaline pH and very low concentrations of major plant nutrients (nitrogen and phosphorus) and other trace elements. The rate at which plants uptake water from well-drained chalk soil is remarkably steady although plants can suffer from drought under dry weather conditions (Locket 1946). Bennie *et al*. (2006) finds evidence of vegetation change in British chalk grasslands as a product of invasion by common competitive species, extinction of infrequently occurring species at the local scale, and a combination of local extinction and decreased frequency of stress-tolerant calcareous grassland species, leading to a decrease in grassland species diversity and a succession toward mesotrophic vegetation communities.

Pollen analyses indicates beech (*Fagus sylvatica*) was present during the Boreal period (c. 9000–8000 BP) with Scots pine (*Pinus sylvestris*) dominating the New Forest valley bog system of the South Hampshire Lowlands during the Holocene, although evidence of persistent open habitat plants is indicated, as well (Seagriff 1960). Beech, open heath and grassland were present during the early Holocene at Wareham, at the west end of Poole Harbour (Seagriff 1959). *Pinus sylvestris* continued to be a major component of woodland cover during the early Neolithic c. 6050 cal. BP, competing with deciduous trees on freely-draining sands and water-saturated soils (Groves *et al*. 2012). Based on examination of about 50 globally-distributed paleoclimate records, Mayewski *et al.* (2004) identifies a period of significant rapid climate change c. 6000–5000 cal yr B.P., noting North Atlantic ice-rafting events and strengthened westerlies over the North Atlantic, while gradually increasing land-use effects particularly evident since 4500 BP.

During a paleoenvironmental and archaeological study in the upper Allen river valley area of Cranborne Chase, French *et al*. (2005:115, Figure 7) encounters no significant evidence of an accumulation of eroded soil in the upper Allen valley system. Palynological analysis of the basal peat and underlying chalky silt sampled from two relict paleochannel systems in the upper Allen river chalkland valley indicates an open and herbaceous plant-dominated landscape that became partially wooded during the late Devensian and early Holocene (ibid:116). Those results contrast with a sediment sample obtained from a peat-infilled channel in the South Hampshire Lowlands at Allenbourne, Wimborne Minster, about 9 km south and downstream of the upper Allen river valley study area, where a pollen sequence from the late Mesolithic and Neolithic vegetation record (c. 6000 to 3000 B.C.) indicates a vegetation community dominated by deciduous woodland with hazel understory and alder/willow carr woodland on the floodplain, and a distinct elm decline contemporary with the first evidence of arable activity (ibid:119-120). French *et al*. (2005:120) concludes that while early Holocene woodland included successive development of a temperate deciduous and mixed forest including juniper, birch, pine, hazel, and oak/elm (particularly in the South Hampshire Lowlands portion of the study area), the chalkland habitat in the upper Allen River valley "remained a substantially open environment, allowing continuity of many herbs well into the middle part of the early Holocene (Boreal or Mesolithic period), without evidence of significant soil erosion."

French *et al*. (2007) presents further results and conclusions based on the paleoenvironmental and archaeological fieldwork, including a geoarchaeological survey, aerial mapping, and soil/molluscan/palynological analytical work in tandem with targeted archaeological exploration in the upper Allen River valley area. The investigation focused on sampling and analysis of buried soils with particular interest in site-specific pre-monument land use, and a search for evidence related to prehistoric land-use and time-depth information in terms of landscape and land-use change. The project applied soil stratigraphic (including buried soil, and colluvium and alluvial sediments) and micromorphological methods with pollen and molluscan analyses to record landscape changes dating to the Neolithic and Bronze Age.

Certain results for the paleoenvironmental and archaeological investigation are pertinent to interests of this study. The following results and conclusions from French *et al*. (2007) are noteworthy with regard to Late Mesolithic through Middle-Neolithic paleoenvironmental conditions along and in the vicinity of the upper Allen River valley, including downs in the central portion of Chase to Wimborne Minster, in the South Hampshire Lowlands, situated near the south perimeter of the study area.

- Mesolithic activity on the chalk downs dates to the latter half of the fifth millennium BC including the majority of the infilling recorded in Fir Tree Field shaft, a doline located between Gussage Down and an area exhibiting numerous karst or periglacial features (naleds) along the Allenbourne; radiocarbon dates (4470-4240 cal. BC) from archaeological study of infill at Fir Tree Field shaft encompass the Mesolithic/Neolithic transition. Human activity on the downs of southern Britain, including Cranborne Chase, was significant enough to produce a substantially open landscape during the Mesolithic, the relatively open/parkland mosaic likely managed as a resource by Mesolithic hunters through use of fire and grazing. The resulting open area inhibited development of a fully closed woodland canopy. This assumes long-term exploitation of upper elevations of the grassland downs and downland slopes in the later Mesolithic and Early Neolithic.

- The earliest dates for the Neolithic on the Chase correspond to former locations of significant Late Mesolithic activity. The parkland landscape is most evident in the uppermost part of the Allen valley between Gussage Cow Down to Wyke and Bottlebrush Downs, potentially predisposing that area to later development of long barrows and the Dorset Cursus, and other cultural features including henges, hengiforms, round barrows, pit groups and artefact scatters, with similar conditions developed around the Knowlton complex of henges and tumuli about 5 km southeast of the cursus.

- Lower elevations of the downs might have been locations of long-established routes of people and game moving between the coast and Salisbury Plain and the Stonehenge area, in addition to areas of the Chase where Clay-with-flints on the higher parts of the downland contained flint resources (Barrett *et al*. 1991a).

- The two dates noted above from Fir Tree Field shaft provide the earliest evidence for Neolithic occupation in the upper Allen valley and correspond well with the date (4040-3810 cal BC) obtained from antler retrieved from the old land surface beneath Thickthorn long barrow.

- Samarasundera (2007) uses dynamic spatial models to test how the downs of the upper Allen Valley of Cranborne Chase changed between c. 9500 to 3500 BP. He concludes that grazing by livestock might have caused and maintained forest recession during the early Neolithic.

- All three long barrows (Thickthorn, Gussage Cow Down long barrows 78 & 294) included in the paleoenvironmental study were built in pre-existing well-established dry chalk grassland. Shady conditions indicated by mollusk shells retrieved beneath Gussage 294 long barrow might have consisted of light cover of shrubs in grassy parkland.

- The pre-existing relative openness of the downs during the Mesolithic appears to have been exploited during the Middle- Neolithic by construction of the Dorset Cursus. The established and grazed grassland sward was established and maintained in the Neolithic period.

- Portions of the cursus banks survive to a thickness of 25-30 cm where protected by other earthen monuments or field boundaries. No earthen bank survives where it was unprotected and plowed since the mid- 20th century, and only linear soil marks are visible.

- Four sections of the lateral ditches of the cursus were examined on Bottlebrush Down: two from the northwest ditch and two from the southeast ditch. Similarities in both ditch fills and ecological interpretation allows French *et al.* (2007) to be confident that the cursus was constructed in an area with a long-established well-developed open grass downland between Gussage Down and Bottlebrush Down. Apart from mollusk shells from *Vitrea contracta* (considered to have lived in a generally grassland environment) there were no shade-loving species in the assemblage obtained from the ditches; mollusk assemblages are dominated by open-country species (especially *Vallonia excentrica*), with catholic species; no evidence of ancient mature woodland fauna with significant diversity in the base of the ditches; *Ena montana* was reported from the Chalkpit Field section and might indicate proximity to some shade. If those results represent the soil contemporary with the construction of the cursus, then they represent well-established, lightly grazed, dense, generally dry grassland.

- Both the northern and southern banks of the cursus on Bottlebrush Down were affected by the deliberate back-filling of the ditch with bank material as well as pre-Roman ploughing. Enough deciduous species are indicated in the ditch fills to have enabled accumulation of leaf litter with long grasses. All of the northwest-side ditch shows very open conditions throughout its infill history; this contrasts with all other sections that were excavated for study, where temporal vegetation development might have been concurrent as the landscape evolved after initial construction of the cursus. After some portions of the ditches were backfilled with chalk rubble, and possible slighting of the banks, other ditch locations such as at Chalkpit Field might have been emptied of their primary fill; infilling of the north ditch might have been almost complete, while that in the south only partial.

- Molluscan, paleosol and pollen evidence indicates the landscape continued to be opened up during the late Neolithic (although there are indications of re-development of at least some woodland as the landscape evolved after initial construction of the cursus).

- Limited evidence of colluviation based on soil transects across Wyke and Bottlebrush Down, in the upper Allen valley, suggests livestock grazing may have been the dominant economic activity during the Neolithic rather than extensive arable agriculture.

- There is no evidence of late Mesolithic, Neolithic, Bronze Age or later development of thick brown forest soils, with shallow, well-developed rendzinas encountered at all locations and all periods.

- Paleoenvironmental evidence indicates a gradual transition from grassland in the northern, upper Allen valley, to a more complex vegetation mosaic in the vicinity of Down Farm and then to predominantly woodland in the southern part, where the chalk downs transition to lowlands with Paleogene sedimentary cover. The collective picture presented by the molluscan, paleosol and pollen evidence also indicates the Neolithic witnessed the opening up of the landscape such that open grassland dominated by the early Bronze Age.

In summary, soil information derived from the long barrows and cursus, in tandem with additional analysis across the downs and valley of the Allen River, provides sufficient data for French *et al.* (2007) to develop a hypothesis of the nature of the pre-cursus landscape, the nearby woodland composition, vegetation regeneration in the monument, and the wider landscape. Data derived from ancient soil and molluscan evidence is indicative of long and well-established grassland at each of the Neolithic and Bronze Age sites investigated by French *et al.* (2007). Evidence from pre-monument soils encountered beneath Neolithic long barrows on Gussage Down and the cursus on Wyke and Bottlebrush Downs, demonstrates that the earthen monuments were constructed in areas where thin rendzina soils characteristic of short-turfed grassland were well-established. The predominant soil type and grassland vegetation was exploited during the main period of long barrow and cursus building during the Early and Middle Neolithic.

The grassland environment during that period occurred from the top of the chalk downs, along the hillsides to the edge of the Allen River flood plain. In contrast, pollen data from a relict channel near the Knowlton henge complex southeast of the Dorset Cursus supports the French *et al*. (2007) conclusion regarding this openness, with the grassland in the upper downs transitioning to variable mosaic of vegetation and then woodland farther to the southeast. Significantly, French *et al*. (2007) concludes that the downland hills and slopes experienced less long-term forest cover than previously understood, with those areas managed likely as grassland in association with earthen monuments (including long barrows and the cursus) situated on the downs. Discovery of earlier and later Holocene paleochannel systems indicates there was greater throughput of water thorough the upper Allen valley. Upland areas were cleared of woods earlier to a greater extent than along the valley bottom and flood-plains that were fringed by woodland and marshes of varying density and species composition.

Recent archaeological investigations of human-landscape interactions have combined archaeological, geoarchaeological, and paleoenvironmental analyses (such as palynological, paleosol, and erosion sequence analyses) to provide increasing spatial and dating resolution at Cranborne Chase. French *et al*. (2012) propose that livestock grazing and feeding impacts might have caused and maintained forest recession during the Early- to Middle-Neolithic, pre-adapting downland such as the extensive grassland-dominated landscape encountered in the nearby Durrington Walls-Stonehenge Avon River valley and other areas of chalkland. French *et al*. (2012) describes results of an investigation of sediment sequences, palaeosols, pollen and molluscan data obtained from palaeo-channels, and palaeosols and molluscan data from buried soils and ditches located with reference to Neolithic sites across the Stonehenge landscape. Early post-glacial vegetational succession appears to have been slow, with occasional woodland development and opening of the landscape on upper elevations of the downs, extensive rendzina soils supporting calcareous grassland on downland slopes, and sedges and alder-hazel carr woodland occupying peripheral areas of the Avon River floodplain during the Late Mesolithic and Early Neolithic. French *et al*. (2012) concludes that the landscape appears to have been stable and managed during the Neolithic, and suggests that landscape transformations evident by a sedentary agricultural subsistence lifestyle in the Wessex region – including downlands of Cranborne Chase and other areas of chalklands - might be a product of the area already consisting of open countryside.

Further, studies of landscapes at Cranborne Chase, Stonehenge, Dorchester and the Isle of Wight indicate partly open grassland to partly wooded environments landscapes existed over large areas of downland, with a significant amount openness developed and managed during the Mesolithic (French *et al*. 2012; Table 8; Hudson *et al*. 2022). The predominant, stable grassland postulated for the Stonehenge area and Cranborne Chase in the vicinity of the Dorset Cursus, Wyke Down and Bottlebrush Downs "was a culturally desired, determined and managed landscape", and those landscapes were "almost always partly open and underwent significant inroads into woodland cover during earlier Neolithic and Mesolithic times" (French *et al.* 2012). Increasing numbers of people were occupying south-central England and managing a more animal-based economy during the early Neolithic (Collard *et al*. 2010), postulated to have resulted in maintenance of the calcareous grasslands (French *et al*. 2012).

Appendix F

British Neolithic Context

F.1 Migration, Population and Cultural Change

> "Objects of material culture are suited to long-range communication. Carried by trade over great stretches of space, now as always, artifacts can inspire cultural connections between people at a distance."
>
> – Henry Glassie (2000)

Ancient DNA genome-wide analysis by Fernandes *et al*. (2018) indicates an overall population turnover with Early Neolithic migrating farmers from Anatolia and the Near East replacing significantly autochthonous Mesolithic hunter-gatherers in central and southern Europe. The dispersal of Neolithic people, technology and ideas along the Mediterranean coasts and river ways across Europe likely involved a complex process of irregular rates of movement of farmers and cultural diffusion (Bar-Yosef 2017, Figure. 19.6). Linearbandkeramik (LBK) culture might be associated with the first farmers who rapidly migrated into central Europe from the Hungarian Plain about 7500 years ago, or was spread as a result of adoption of agriculture by indigenous hunter-gatherers, or a combination of both colonization and indigenous adoption (Midgley 1992; Bentley *et al*. 2002). In any case, farming was established on the North European Plain and along the Channel in northern France between 5400 and 4900 cal BC.

Massive burial monuments located in the west Mediterranean are indicative of indigenous peoples, farmers, semi-farmers and pastoralists who shaped long-term development of distinctive regional Neolithic cultures and influenced the cultures of northern, western, and central Europe (Malone 2015:188). Archaeological analysis of the Gurgy 'Les Noisats' group of Early to Middle Neolithic tumuli in the southern part of the Paris Basin indicates the ritual district developed as a result of genetic contributions of descendants of Danubian and Mediterranean farmers (Rivollat *et al*. 2015). The elaboration and complexities of cultural materials and behaviors might be related to mixing of genetic and cultural diversity resulting from Neolithic farmers migrating into lands occupied by Mesolithic hunter-gatherers (Thomas 2015: 1073).

Evidence from material culture indicates multiple points of origin of the Neolithic lifeway in Britain (Tresset 2015:121). Brace *et al*. (2018) finds a genetic affinity between British and Iberian Neolithic related to ancestry from Anatolian farmers who travelled along the Mediterranean route. Brace *et al*. (2019) notes genetic affinities between Neolithic individuals from Britain and modern individuals from France that are shared with Neolithic populations in Iberia who migrated via the Atlantic seaboard or southern France to northern France before limited mixing with Neolithic populations (including low levels of admixture between Mesolithic hunter-gatherers of Western, Southern and Central Europe) and traveling across the English Channel to Britain. Chronological modelling based on early Neolithic radiocarbon data derived from bones of individuals having Aegean Neolithic farmer ancestry indicates continental farmers arrived in Britain by 3975–3722 cal BC (95% confidence interval) (Brace *et al*. 2019). In summary, genetically heterogeneous populations of northern France, Belgium and the Netherlands, sharing variable proportions of ancestry related to Neolithic groups in Iberia via Atlantic and southern France, are the probable continental sources for the British Neolithic (Brace *et al*. 2018; Tresset 2015:121).

Evidence of agricultural activity appears in Britain during the first century of the 4th millennium (Bonsall *et al*. 2002). Collard *et al*. (2010, Figure 2) finds evidence of sparse populations in all regions of Britain prior to a rapid increase in population density with the appearance of cereals in southwest England between 3950 and 3700 cal BC, proposed to be associated with migration by farmers from Basse-Normandy and/or the Channel Islands. Paleoenvironmental and archaeological ^{14}C data indicate a rapid transition from hunting/gathering to agricultural subsistence strategies after the Mesolithic (Whitehouse *et al*. 2014). However, there are indications of subsequent decreasing cultivation practices within 300 years (Thomas 2015:1074). Increasing numbers of people were occupying south-central England during the early 4th millennium, managing an increasingly animal-based economy well into the Middle Neolithic (Collard *et al*. 2010). Nonetheless, the case for the Neolithic transition in Britain resulting from a large immigration of farmers from continental Europe is supported by an abrupt shift in diet between the late Mesolithic and early Neolithic, evidence of similarities in material culture from multiple points of origin, similarities between parts of northern France and parts of Britain during the early Neolithic, and a comparable range of fauna at Early Neolithic sites in southern England and Middle Neolithic sites in northern France (Collard *et al*. 2010; Tresset 2015:121). Whittle, Healey and Bayliss (2011:1) concludes that geographic expansion of Neolithic behaviors and materials in Britain was a gradual process in the 41st century, beginning in southeast England and likely reaching across Britain and Ireland by about 3800 cal BC (Prendergast 2020).

The annual decision to cultivate depends on the stability of climatic conditions, with the culmination of appropriate methods and behaviors under suitable conditions leading toward intensified food security, preferably supplemented by sufficient foresight to anticipate impacts of less suitable conditions if and when they occur (Bar-Yosef 2017). Boom-and-bust patterns in regional population densities occurred with the introduction of agriculture across Europe and Britain (Timpson *et al.* 2014). Population fluctuations in western France indicate a population boom with the appearance of farming in the mid- 5th millennium BC, a peak at about 6000 BC, and then a decline corresponding with Early Neolithic population expansion in England and Wales (Collard *et al*. 2010; Whittle *et al*. 2011; Timpson *et al*. 2014). After a peak in use of cereals in Britain by about 3700 cal BC there was a significant decline circa 3650–3600 cal BC with further decline at about 3500 cal BC (Whittle *et al*. 2011:724–6). Population density continued decreasing until about 3400 cal BC (Collard *et al*. 2010). The decrease in cultivation in Britain has been attributed to a ‘boom and bust’ in horticultural activities subsequent to 600 to 700 years of demographic, social and economic changes of the Early Neolithic (Stevens and Fuller 2012; Whitehouse *et al*. 2013). Agriculture appears to have provided a nominal contribution to the economy by about 3300 BC (Thomas 2015:1074), suggesting increasing importance of hunting, gathering, and further cultural shifts, as well. Downey *et al*. (2016) explores the possibility that early warning signals including interactions between fast human demographic cycles and slower ecosystem recovery cycles could explain an observed pattern of demographic collapse in Neolithic Europe, including Britain. The economic change was followed during the later Neolithic by a decline in population density and changing cultural patterns (Collard *et al*. 2010).

The time frame for the mid- 4th millennium decline in cereal production also corresponds to a period of increased monument building in southern Britain – including construction of causewayed enclosures and cursus monuments – appreciably between 3700 and 3200 BC (Whittle *et al*. 2011:724–6; Thomas 2015:1075; Loveday 2016). Long barrows as funerary monuments continued to be constructed while development of additional large-scale earthen structures proceeded with construction of causewayed enclosures (Whittle *et al*. 2011; Thomas 2015:1075). Cursus construction in southern Britain began during a period of deteriorating climate and provisional abandonment of agricultural practices (Loveday 2016; Fari 2016). There is evidence of an increasing reliance on livestock at locations including causewayed enclosures at Hambledon Hill immediately south of Cranborne Chase, and Windmill Hill in Wiltshire (Rowley-Conwy and Legge 2015; Whittle *et al*. 2011). Glassie (2000) notes that architectural change is evidence of spatial and temporal cultural changes. Lifeways in Britain and other regions along the Atlantic façade during the 4th millennium entailed variable degrees of Mesolithic and Neolithic social, economic, technological and cultural behavior, with an increasing network of interregional transportation and communication, and deepening interest in siting the dead with reference to spatial and temporal features of the surrounding environment (Thomas 2015:1078-1086).

F.2. Earthen Monumental Architecture of the Early to Middle Neolithic

> "Each traditional structure evolved from the special relationship people had evolved with their environments . . . reflections of the special features and available resources of the landscape of which they were part."
>
> – Gregory Cajete (2000)

F.2.1 Long Barrows

Online databases developed by Historic England (Historic Environment Records available at heritagegateway.org.uk) and the University of London's Institute of Historical Research (British History Online) provide updated inventories and summary accounts of Neolithic monuments, historical archaeological investigations and documentation of more recent findings in England and the whole of Britain. In 2006 the National Monuments Record (now the Historic England Archive) identified 538 definite and probable long barrows in England (Field 2006:22). Use of aerial photography has extended the known distribution of long barrows across the British Isles (Field 2006: 22, Figure 48; Field 2008: Figure 4:7).

Midgley (1985:1) defines earthen (non-megalithic) long barrows as long, anthropologic earthen monuments typically used for inhumations, potentially supplemented by external structures (e.g. rows of posts or small stones). Ahlers (2018:61) defines earthen (unchambered) long barrows as large earthen mounds (commonly exhibiting a rectangular, sub-rectangular or trapezoidal shape) generally without megalithic features and flanked by ditches from which the mounded material derived. The rectangular-shaped barrows may include a causewayed ditch extending around one or both ends of the mound, both types encountered on Cranborne Chase (Ashbee 1970). Field (2006: 21) suggests that construction materials used in the creation of British long barrows "simply reflect what was available in the immediate area. However, rather than simply dumped mounds of chalk, long barrows have been found to consist of a series of bays defined by fencing (hurdles) filled with combe rock, marl or chalk, while others contained brickearth or stacks of turf to form cells (Field 2006:95, Figure 46 and Figure 47).

Long barrows are the earliest type of tomb encountered in the British Isles and much of northwest Europe, preceded only by monumental Passy-type tombs in Normandy and the Paris Basin (Wanderlich *et al*. 2019) (Figure F.2.1). Midgely (1984, 1985) details the origin and function of long barrows in northern Europe and the British Isles, noting that they represent many features within a far-reaching tradition of large-scale funerary earthen monuments associated with many regions of Europe during the Neolithic period. She notes an extensive body of theoretical concepts developed during numerous attempts to interpret the origins and use of the tumuli. Midgley (1984) points to prolonged contact between Late Mesolithic (5th millennium and early 4th millennium) hunting and fishing communities of the North European Plain and settlements occupied by *Linearbandkeramik* (LBK) groups who introduced a farming economy in Central Europe.

Wanderlich *et al*. (2019, Figure 1) provides a summary of chronological and social contexts related to construction of prehistoric monuments across Europe. British monumental burials in the form of long barrows and stone chambered tombs were built by societies who were a mixture of immigrants and indigenous people at the beginning of the Neolithic (Ray and Thomas 2018:88). The earliest type of monument in southern England is the long cairn soon followed by earthen long barrows (Whittle *et al*. 2011:728, Figure 14.45 and Figure 14.48). British long barrows are frequently dated to the first quarter of the 4th millennium BC (Field 2006:13). ^{14}C analyses show that the first long barrows built in England were present by about 3800 cal BC, with most dated mounds appearing not long before 3500 BC, before widespread development of causewayed

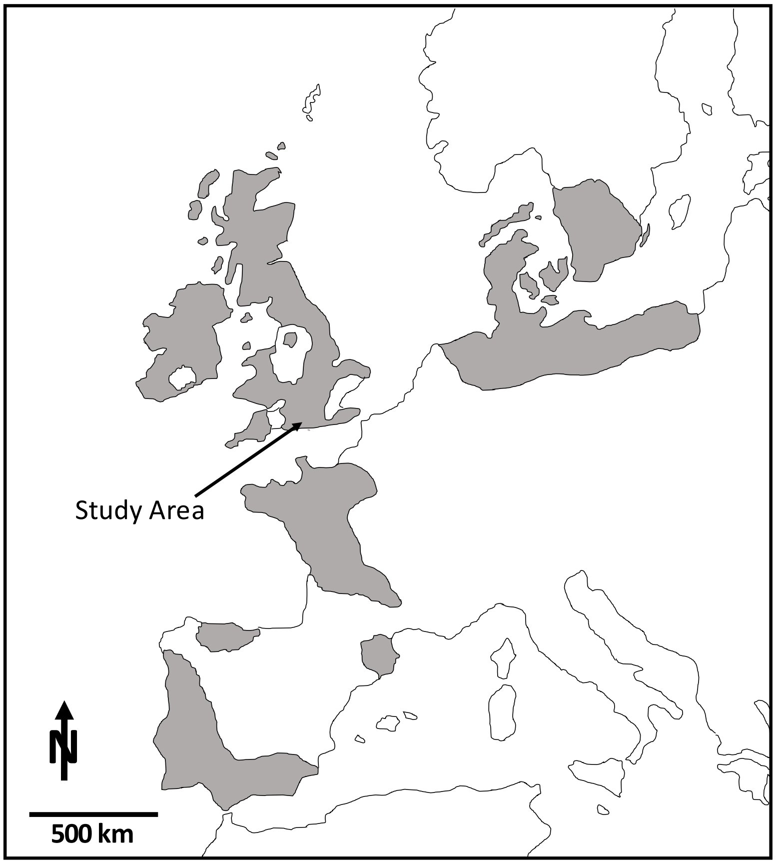


Figure F.2.1: Map of distribution of European long barrows and related Early Neolithic massive earthen and megalithic tombs. Based on map in Lynch (1997: 6).

enclosures (Field 2006: 20). Wysocki *et al*. (2007) provides preliminary Bayesian assessments of dates for both megalithic and earthen monuments south of a line drawn westwards from the Wash (at the northwest corner of East Anglia on the East coast of England), and determined that all dates indicate construction no earlier than about 3750 cal. BC. Whittle *et al*. (2008) concludes that most British long barrows date to the thirty-eighth century cal BC or later and most monumental earthen enclosures were constructed during the thirty-seventh century cal BC or later. However, radiocarbon dates are available from only about 44 sites in the British dataset (Ahlers 2018:105). Construction of causewayed enclosures began around 3700 BC (Whittle *et al*. 2008) and played no role in the Mesolithic–Neolithic transition in Britain (Thorpe 2015:223) (Table 1.1). Long barrow Hambledon Hill South, located at the Hambledon Hill causewayed enclosure immediately west of Cranborne Chase, likely dates to the early- to mid- thirty-seventh century cal BC (Wysocki *et al*. 2007). Wysocki *et al*. (2007) suggests that the pattern of dates could indicate monumental commemoration of the dead did not begin until after the Mesolithic–Neolithic transition, developing around 3900 cal. BC, after the Neolithic began, although possibly earlier in some regions. Construction and use of earthen long barrows in Britain continued until the end of the 34th century, at the approximate time when most cursus monuments were constructed in southern England (3600 – 3300 BC) (Loveday 2006: 165; Rassmann 2011).

Childe (1940) considered the concept of long barrow tumulus design to have come from southern France. As previously noted, Neolithic individuals in Britain and France shared ancestry with populations migrating from Iberia via the Atlantic seaboard and travelling across the English

Channel (Brace *et al*. 2019). Long mounds built in southern Britain are closely paralleled by earlier or contemporary structures of similar construction in Brittany, Normandy and Denmark (Scarre 2002d: 99; Whittle 2007), with the relationship between European mainland and British megalithic monuments understood as a matter of translation rather than transmission (Ray and Thomas 2018:89). At the same time, as noted above, evidence suggests a possible modulating role of regional climate on Neolithic innovation in terms of the subsistence economy and monumental earthen architecture, both of which spread from the European continent to Britain.

Four significant archaeological excavations of long barrows on the Chase and South Hampshire Lowlands during the late 19th century and early 20th century include those of Verwood 1 (Pistle Down) excavated in 1828 (Warne 1866; Field 2006:44), Wor Barrow (Pitt-Rivers 1898), Thickthorn 136a long barrow (Drew and Piggott 1936), and Holdenhurst long barrow (Crawford 1930).

The oval-shaped long barrow at Pistle Down, Dorset, was excavated in 1828 and found to have been constructed from sand, earth and turf (Historic England 2021b). It yielded no indication of burial (Warne 1866; Field 2006:44). The mound is located on a plateau of Paleogene sediments in the South Hampshire Lowlands and overlooks the River Crane (BGS 2018; Historic England 2021b).

The first modern archaeological study of earthen long barrows included excavation of Wor Barrow on Cranborne Chase during 1893 and 1894 by Pitt-Rivers (1898:62). The mound was surrounded by a ditch except for a causeway at the northwestern end and three additional causeways at the southeastern end. Contrary to current methods of archaeological investigation, the mound was completely excavated. The inner chamber was found to have been constructed of wood (Pitt-River 1898, preface 20). The barrow was oriented northwest-southeast and overlooked a dry valley and the valley of the Crane River farther southeast. Early Neolithic burials were encountered in the ditch and six primary burials beneath a circular mound of turf. The site received further investigation by Barrett *et al*. (1991a).

The first earthen long barrow excavation between WWI and WWII was at Thickthorn Down by Drew and Piggott (1936), with complete removal of the barrow in quadrants, excavation of the surrounding ditch, and then restoration of the chalk mound. Thickthorn 136a long barrow was located on the crest of Thickthorn Down and oriented northwest-southeast about 0.25 km southeast of the south terminal of the Dorset Cursus. The barrow was constructed of chalk placed in a series of bays possibly formed by rows of hurdles. No primary human burial was encountered beneath the mound or within the surrounding quarry ditch. However, fill material in the ditch "included sherds of Early Neolithic pottery, 2 carved chalk phalli, and a quantity of animal bone, with particular concentrations occurring in the ditch terminals at the southeast end" (Historic England 2012). Re-examination of mollusk shell obtained from beneath the barrow confirmed that the long mound was constructed in open, dry, grassland (Historic England 2012).

Holdenhurst long barrow was constructed of turf and earth on a gravel terrace near the River Stour about 5 km upstream from the river's confluence with the Avon in Hampshire Basin (Field 2008). Crawford (1930) describes results of the archaeological excavation of the barrow, with evidence of burial within the tumulus including a circular burial platform constructed in the east portion of the mound. The mound was completely excavated. The monument was the only long barrow known to be located in an area occupied by Paleocene sediments and gravel terraces of the River Stour (Field 2008). At the time of excavation the northwest-southeast- oriented mound was located in a ploughed field on the southern bank of the river, between the 10 and 15 m contours and below Haddon Hill, about 1 km from the stream channel (Field 2008). Crawford (1930) concluded that the long barrow was likely situated in the vicinity of a prehistoric seaport that might have served the Avon and Stour river valleys. The mound's orientation toward the south-southeast could not have aligned with a solar sunrise (Field 2008).

Aside of Holdenhurst long barrow, there is little evidence of 4th millennium earthen monuments on the Coastal Plain (Field 2008). However, archaeological evidence indicates significant contact between builders of the monuments and "an established framework of fisherman and navigators" (Kinnes 1992). Field (2008) notes the importance of the sea in that area for communications and cross-channel contact during the Neolithic, and suggests that regularly spaced groups of long barrows in the Solent Basin represent a division of land that was important within economic, social and cosmological spheres of the region during the Neolithic. Alinei and Benozzo (2008) argues that the astronomical function of prehistoric architectures is bound with navigation and techniques of orientation. Both Phillips (2003) and Alinei and Benozzo (2008) conclude that the sea is a vital component for understanding the megalithic phenomenon.

Results of those four excavations of long barrows at the Chase and South Hampshire Lowlands in tandem with many archaeological studies of other long mounds in Britain provide evidence that inhumation burial was not a feature of some – and perhaps most – British Early- to Middle- Neolithic long barrows (Field 2006:96). However, as with Wor barrow, remains of wooden inner chambers have been encountered at some mounds. Near Salisbury, a few kilometers northeast of the Chase, Fussell's Lodge long barrow (excavated by Paul Ashbee (1966) in 1957) consisted of a wedge-shaped mound containing a wooden burial chamber covered by a flint cairn, with the burials located at the east end of a trapezoidal mortuary enclosure (Field 2006:52).

The broader geographic and cultural context of long barrows and other archaeological features encountered in the catchment of the ancient Solent River of central southern England, including Cranborne Chase, is addressed by Field (2008). Long barrows on the Chase, such as those at Thickthorn Down, Pimperne, Gussage Hill and Wor Barrow, are oriented nearby low ridgelines and interfluves where rivers including the Allen and Tarrant flow southward, while others such as Chettle 2 long barrow are oriented along the contours of the underlying slope (ibid., 69-70). Field (ibid., 104) concludes that long barrows on Cranborne Chase "invariably focus on present or former springs." In addition, numerous long mounds are located nearby rivers or streams, emphasizing the importance of river basins (Field ibid., 105). Tilley (1994) and Field (2006:109) also suggest a potential linkage between barrow locations and the sea, noting the location of Holdenhurst long barrow 3 km from the present coastline, near the mouths of the Stour and Avon rivers. Field (206:103-105) suggests regardless of whether barrows are located proximal to hilltops and ridgelines, or near rivers or other surface waters, the siting of barrows appears to have been related to water bodies.

Kinnes (1992) provides the following additional information regarding long barrows at Cranborne Chase:

- the average nearest neighbor distance between long barrows is 3.2 km (range 5 to 11 km);
- long mound locations are generally along the contour, overlooking valleys, with the mound typically oriented subparallel to northwest-southeast oriented interfluves and hills, an unusually high percentage of those features oriented with a bearing 135^{o} (Kinnes 1992, Figure 2.2.8, Table 2.2.3);
- long barrows 30 m or less in length include 4 mounds at peripheral locations of the area of tumuli group, the other 5 barrows located in two linear patterns in the central portion of that area;
- the longest mounds are located in two clusters toward the north and south ends of the area;
- locations of several long barrows appear to be associated with the Dorset Cursus, including Pentridge 4 long barrow situated in the west bank of the cursus;

- while there are a few stone-chambered long mounds in south Dorset, there are no such tumuli at Cranborne Chase;

- the geological format of long mounds is reminiscent of a natural chamber, such as caves that are common features of limestone massifs and can include both Neolithic domestic and mortuary residues; and

- the Middle Neolithic causewayed enclosure at Hambledon Hill (Mercer 1980), yielding evidence of burial of as many as 350 individuals, has some funerary relationship with the long barrows of the Chase.

Environmental and cultural parameters identified by Kinnes (1992) for long mounds situated at Cranborne Chase include:

- development across chalk upland characterized by a scarp at the west fringe of the Chase and an eastern dip of bedrock dissected by series of valleys;

- indication of spatial patterning of mounds based on length and basin topography (Kinnes 1992, Figure 2.2.7) although limited evidence from archaeological excavations prevents detailed evaluation of the apparent pattern;

- mound orientation at the majority of sites (77%) is between NE and SE;

- precise measurement of long axis orientation of each barrow is difficult to obtain without excavation or good preservation of the mound, however, the general pattern remains; and

- distribution of barrow orientations generally appears symmetric across the Chase albeit with indications of local preference, particularly toward the southeast SE (a feature also noted for sites in Lincolnshire), likely related to topographic conditions, siting tumuli along interfluves.

Ahlers (2018:203-204) speculates that barrow sites might have been chosen based on cultural significance of place or cosmological associations, while the general east-west trend of mound orientations “probably relates to common cosmological principles of early Neolithic societies” (Ahlers 2018:246). Orienting long barrows toward the east might have been intended to link the east direction with sunrise, birth, fertility (Darvill 1997). Field (2006:69) notes predominance of the larger end of each long barrow at the east end of each mound and proposes this undoubtedly had a cosmological implications. Kinnes (1992) reiterates the possibility expressed by Burl (1981) that the mounds appear to emphasize orientations associated with solar and lunar cycles and in accordance with an agricultural calendar. However, no evidence of measured orientations are provided.

Numerous phenomenological studies and GIS-based analyses have been conducted in recent decades to identify monument viewshed characteristics, long barrow visibility, and intervisibility, and to understand the significance of monument location as an aspect of the Neolithic cultural landscape (e.g. Tilley 1994; Wheatley 1995; Scarre 2002b; Llobera 2003; Cummings & Whittle 2003; Gillings 2009; Maguire 2015; Ahlers 2018). Brughmans and Brandes (2017) use observed visibility network density in a statistical simulation model during a study of intervisibility of Neolithic long barrows in Cranborne Chase based on the visibility network of 33 tumuli included in the study by Tilley (1994). Tilley (1994) studies the intervisibility of the long barrows using a phenomenological approach and a network representation in which nodes represent long barrows and edges represent their intervisibility based on results of on-the-ground site observations or inferences based on mapped topography. Tilley (1994:157) argues "there is little evidence to suggest that barrows which are prominently sited and intervisible today might not also have been during the period of their initial construction and use," and concludes that certain barrows were sited with an intent to reference other apparent tumuli. The statistical simulation model applied by Brughmans and Brandes (2017) provides a statistical method to represent what they view as important structural features of the landscape, and to analyze and enable replication of results related to potential evolution of the visibility network formulated by Tilley's phenomenological approach.

Beyond use as tumuli, Field (2006:117) identifies numerous postulated purposes for long barrows:

- nomadic or semi-nomadic populations returning periodically to places of ancestral importance marked by barrows, causewayed enclosures and flint mines;
- monuments constructed by regional groups to denote the presence of good pasture;
- mounds marking grazing rights of transhumant groups
- barrows marking the holding of a sedentary, extended family group
- monuments indicating significant features in the landscape
- mounds suggesting the importance of water frontage and valley; and
- monuments defining drainage patterns as territories, such as the Wylye Valley located between Salisbury Plain and Cranborne Chase.

F.2.b Causewayed Enclosures

Causewayed enclosures were constructed of singular or multiple circuits of ditch and bank works often containing various numbers of artifacts, tools, food residues and bones (Oswald *et al.* 2001:9–34; Whittle *et al.* 2011:5). Although more than 70 causewayed enclosures are known in Britain, the purpose and use of the monumental earthen structures are not well understood. In a detailed study of Neolithic enclosures in southern Britain and Ireland, Whittle *et al.* (2011:5) notes multiple interpretations of the structures, including enclosed settlements, fortifications with defensive elements, animal herding, sites for material exchange, important sites for consumption and deposition, and monuments having ritual significance associated with processing (excarnation), mortuary rites and burial of the dead – potentially in tandem with other Early to Middle-Neolithic structures including long barrows and cursuses.

Isobel Smith observes that causewayed enclosures were generally constructed across contours of hillsides rather than on top of hills, with most enclosures oriented toward a certain direction and therefore they relate to features of the surrounding area (Smith 1971:92; Whittle *et al.* 2011:11). Clark *et al.* (2019:210) finds that recent accounts of causewayed enclosures acknowledging ritual, ceremony, symbolism and ideology are all associated with Neolithic behaviors expressed by the British Neolithic archaeological record, and that by unifying domestic and ritual behaviors of the growing population of insular hunter-gathers and migrants within the Neolithic lifeway it is possible to develop a more holistic reconstruction of semi-sedentary culture in the early Neolithic. Jiménez-Jáimez (2018) discusses an interpretation of British Neolithic enclosure sites as small-scale seasonal gathering places for kinship-based mobile communities that contradicts interpretation of Iberian models for similar structures.

Use of Hambledon Hill causewayed enclosure for interment of hundreds of individuals raises the possibility that the structure is related in some ritual or ceremonial way with long barrows of the Chase. Hambledon Hill is a 100-meter high hill topographically isolated from, and about 2 km west of, the west side of Cranborne Chase. It is an erosional remnant of the Chalk situated between the River Stour to the west and the River Iwerne to the east. The west-facing scarp of the main body of the Chalk of Cranborne Chase prevents observation of much of the Chase from Hambledon Hill.

Mercer (1980:113; 2008) suggests a primary purpose for the central enclosure at Hambledon Hill was exposure of the dead. The importance of place and landscape at the enclosure location might have been recognized well before the Neolithic. Artifacts obtained at Hambledon Hill and additional archaeological sites in the region have been subjected to an extensive radiocarbon dating and modelling program discussed by Whittle *et al*. (2011:111). The two long barrows on Hambledon Hill likely date from 3500 B.C. (Castleden 1992). Initial construction of the enclosure, and the Dorset Cursus located 12 km to the east, likely date to 3385–3220 cal BC (Whittle *et al*. 2011:150). Modelling of an extended series of radiocarbon dates from Hamledon Hill indicates the enclosures were constructed intermittently over a period of 310 to 370 years (Bayliss *et al*. 2008). A pair of posts at Hambledon Hill traces use of the site to the 8th millennium (Ray and Thomas 2018:60).

F.2.c Cursus Monuments

The British 18th century antiquarian William Stuckley was the first to identify certain linear earthworks, that he interpreted as horse racing courses, as cursuses (Latin *cursus*: course). A cursus is a long, narrow enclosure that may be up to a hundred meters wide and have lengths that can be hundreds to thousands of meters long. The end of each monument, where evident, is defined by a curved or rectilinear bank and ditch tied into the lateral ditch networks (Condit 1995). Loveday (1985), updated and published in book form (Loveday 2006), provides a typology for cursus monuments based on length and terminal shape, and includes an extensive, detailed analysis of known cursuses in Britain including other banked enclosures and linear prehistoric features such as bank barrows and avenues. Cursuses are commonly located on well-drained gravel terraces, and upland and chalkland areas.

Scottish pit and post cursuses likely date from 4000 to 3600 BC, while cursus monuments defined by banks and ditches in southern England were probably constructed between c. 3640-3380 cal. BC (Barclay & Bayliss 1999: 29; Jones-Bley 2002; Thomas 2006; Thomas *et al*. 2009, Figure 7). Cursus construction in southern Britain began during a period of deteriorating climate and provisional abandonment of agricultural practices (Loveday 2016; Fari 2016). The monuments might have been in use for no more than one or two centuries (Brophy 2016).

Summaries of previous archaeological investigations of the Dorset Cursus are provided by Omish and Tuck (2002) and French *et al.* (2007). Material obtained from the primary silt layer of the monument's ditch has been radiocarbon dated to the latter half of the 4th millennium (Table F.1).

Table F.1: Radiocarbon Dates from the Dorset Cursus

Reference	Radiocarbon Dates
Entwistle and Bowden, 1991:22–23	3342-3042 cal. BC
Omish and Tuck, 2002	3650-3000 cal. BC
Barclay and Bayliss (1999)	3360-3030 cal. BC (91% confidence)
French et al. (2007:186)	3500-3200 cal. BC

The cursus is comprised of two smaller cursus monuments, the slightly earlier Gussage cursus in the south and the Pentridge cursus in the north (Barrett *et al*. 1991a:46). Brophy (2016:19) notes the dominant nature of the Dorset Cursus, the longest Neolithic monumental structure in Britain, extending 10 km across the downs of the Chase with a average width between the lateral ditches of about 100 m, and the original internal earthen bank alongside the ditches attaining a height estimated at up to 2 m. Construction of the cursus' ditches and banks is estimated to have required about 450,000 worker-hours (Barrett *et al*. 1991a: 46), including excavation and placement of 184,000 cubic meters of soil and stone to enclose an area of 90 hectares (Castleden 1992).

The time frame of construction post-dates construction of some portion of Neolithic long barrows in Britain, although the alignment of the cursus has been proposed to have been determined, in part, by locations of several long barrows, leading to the conclusion that the monument is related to a cult of the dead (Castleden 1992). The period of cursus construction occurring during climatic deterioration could be indicative of increasing transhumance associated with pasturing, or expressions of power in a changing world (Loveday 2016). Brophy (2016: 31) concludes that "cursus monuments would have been a major transformation of the landscape." Therefore, there is the potential to perceive development of cursus monuments in southern Britain as a response to conceived interactions between natural and cultural elements of landscape in the presence of deteriorating agricultural conditions during the mid- to later 4th millennium, a cultural response to a changing environment by replacement or over-printing former elements (such as long barrows) of the environment.

By the late 20th century, there were a number of attempts to interpret the morphology and cultural context of cursuses within their larger landscape (e.g. Barclay and Harding 1999), associating them with symbolic meaning or as prehistoric ritualized procession ways, given their general appearance as corridors delineated across the landscape. Harding (1999) related the apparent proximal relationship of some cursuses and tumuli as expressions of Neolithic social power and delineation of territory. At the same time, the form of earthen elements of cursuses are similar to those of long barrows constructed earlier across the landscape. Enlarged terminals at the Dorset Cursus and other cursus monuments in Britain have led to the idea that the structures might have been built as reflections of the form of long mounds (Barrett *et al*. 1991a; Barrett e*t al*. 1991b; Bradley 1993); Tilley 1994; Brophy 2016). Brophy (2016) notes that cursus monuments might have been associated with a continuum of rectangular monuments including long barrows, bank barrows, mortuary enclosures, timber halls and rectangular houses. It has been suggested that the Dorset Cursus was constructed in a landscape that was already full of cultural value and meaning, a landscape with 'topography embodying living mythology' (Tilley 1994: 43; Brophy 2016).

Maguire (2015) summarizes previous studies applying GIS-based methods for analysis of landscapes associated with cursus monuments. Cursus-related sites appear to be restricted to valley bottom or valley-traversing contexts, particularly on the chalklands (Loveday 2016). Variations in topography along alignments of cursuses do not appear to have been a concern to the builders (Loveday 2006:133), although the monuments tend to be generally situated at lower elevations of the landscape where some topographical variation – resulting in crossing of streams, marshes, slopes or hillcrests - might be associated with the purpose or use of the structures (Brophy 2016:163).

The alignment of the Dorset Cursus is an example of such valley-traversing monuments. Alternative alignments not far from the actual location of the cursus would have provided a far more level route, and Loveday (2016) questions whether alignment of each cursus was a matter of ideology rather than practicality that would maximize use of level land, and he considers the possibility that each cursus monument might have been sited and built to accord with "purely local norms and beliefs". In some cases, such as the Dorset Cursus, the monument changes alignment along its length, and Brophy (2016) suggests plans for the cursus might have changed or errors were made during design or construction.

Bradley (1993:57) notes contrasts in the form of ditches and banks even within certain cursuses, with various degrees of uniformity in width, depth and sinuosity of ditch works and variable use of causeways of unexcavated chalk, possibly associated with the pattern of movement across the landscape. Loveday (2006) states that cursus construction would likely have required clear lines of sight and possibly use of temporary erection of posts and use of ropes to lay out the location and form of ditches and banks. Establishment of one lateral ditch and bank and then setting the other side of the cursus based on that alignment could have been accomplished using offsets measured across the width of the monument. Atkinson (1955) and Case (1982) suggest methods to explain why some cursus monuments (including the Dorset Cursus) exhibit one straight side and one less regular side – the latter being offset from the former.

Some hypotheses regarding the purpose or use of cursus monuments concern associations with the dead and burial monuments such as long barrows. Others are related to perceived alignments with features of the landscape or skyscape as viewed for the interior of the respective cursus. However, as noted by Brophy (2016), demonstrating the significance of a relationship between a prehistoric earthen monument and an element of a landscape such as a river is difficult to prove. Brophy (2016:19) suggests the dominance of the Dorset Cursus to influence interpretation of other cursuses was unwarranted, even with consideration of the monument's great size. Bradley (1986:1) summarizes the difficulty in arriving at a satisfactory explanation for the purpose of constructing such large earthen structures, "How can we account for something so outrageous, so completely cut off from our experience?"

Numerous ideas for the purpose and use of cursuses have developed since Atkinson (1955) first proposed the ditch and bank delineated space of the Dorset Cursus for use during ritual procession (Brophy 1999; Loveday 2006:124-6). Proposed purposes include:

- places for various rituals and ceremonial activities
- pathways linking events in the skyscape
- representations of snakes
- delineations of tornado tracks
- structures linking previously known or significant areas
- pathways joining natural and ancestral places linked with ritual experience
- places for ceremonial rites of passage for young men
- procession ways memorializing historic routes
- physical barriers between areas of various significance
- structures aligned with another place or astronomical event
- representations of monumental or possibly secular symbolic rivers
- designated locations for pilgrimages or sacred journeys
- symbolic project – the physical expression of a social or ideological need
- arenas for celebratory activities and games
- places designated as a *temenos*, possibly delineated and devoted to a god or gods
- corridors for movement in general
- barriers to access to long barrows
- structural links to other monuments
- designated boundaries to movement between areas of the landscape

Most hypotheses concerning the purpose of cursus monuments consider them to have served in some enigmatic way with procession along the interior of the banked area, possibly related to veneration of the dead or astronomical observations (e.g. Lockyer 1906; Stone 1947: 18; Penny and Wood 1973; Megew and Simpson 1979:94-5; Tilley 1994; McOmish 2003; Loveday 2006; Fowler and Scarre 2015; Brophy 2016: 19). Barclay and Maxwell (1998), Loveday (2006), and

Brophy (2016) emphasize that each interpretation must not necessarily exclude the others, nor possibly additional potential purposes and uses.

Barrett *et al*. (1991a:56,58), Bradley (1993:50-2), and Tilley (1994:197,199) argue that spatial relationships between cursuses, burial monuments including long barrows, and topography must be understood in terms of human movement within cursuses themselves. Movement along pathways and crossing boundaries with ritual focus are key elements in religious architecture (Barrie 1996; Humphrey & Vitebsky 2003:128–43). Such liminal movement can create a sense of looking forward and backward in time, and produce memories and expectations as a result of experiencing the crossing (Vitebsky 2003:147). Harding (1999:30) states "the intrinsic layout and character of cursuses is obviously ideal for defining linear paths of movement – hence their interpretation as some form of ceremonial or processional way – and it has also been noted that the recorded association between the Dorset Cursus and the integrated long barrows is only significant when viewed or encountered by those moving along the interior of the monument." Further, Harding (1999:34) suggests cursuses might have represented symbolic boundaries constraining movement and interaction across the surrounding wider landscape.

With few breaks identified in the peripheral ditches of the Dorset Cursus, Johnston (1999:44) argues that the cursus might indicate the location of a path that extended across the Chase prior to its construction, and at the same time signifying the corridor as a sacred route closed to further human traffic by the continuous line of bank and ditch. Rather than corporeal movement along the alignment, Parker Pearson and Ramilisonina (1998) proposes that the Greater Stonehenge Cursus might represent a route reserved for ancestral spirits to travel. Devereux (2003:69-72) suggests cursuses delineated ritual spaces as corridors for spirits coursing toward the Otherworld.

The association between cursuses and observation of earthen monuments located in the surrounding environment is assessed by Chapman (2003) by applying a GIS-based approach to demonstrate a visual relationship between Rudston Cursus 'A' and locations of two long barrows situated at the western horizon near Rudston, in the East Riding of Yorkshire, England. Chapman (2003) finds that the form of Cursus 'A' and the two long barrows have a strong visual relationship, with the curving morphology of the cursus enabling a consistent view of barrows throughout its alignment and therefore, the area bounded by the cursus was specifically chosen with that association in mind.

The relationship between linear earthen monuments and landscape are similar across the Atlantic façade, with topography playing a crucial role in the siting and orientation for monumental constructions (Bradley 1993; Roughley 2014). Brophy (2016: 171) suggests cursus monuments might have been intended to link with natural elements of the surrounding environment, either above or below the horizon, that were perceived as sacred. However, cursus alignments have not been found to be oriented with any particularly significant features of the landscape, they seem to "flow nowhere" (Loveday 2006:136).

Roughley (2014) considers "constrained visibility" to be an intended feature of the Dorset Cursus and other British Neolithic linear monuments. The Dorset Cursus is oriented sub-perpendicular to river valleys it crosses, while its terminals were constructed at higher elevations (Barrett *et al*. 1991a). Tilley's (1994:173- 96) phenomenological ('embodied engagement with the landscape in the present' (Brück 2005)) engagement with physical attributes of Cranborne Chase included walking the length of the Dorset Cursus, and he argues that his sensorial encounters with topographic and hydrologic features such as a sudden dip, marsh or river crossing, or a steep incline might be similar to the effect those elements of the landscape had on Neolithic people as they traversed the earthen structure. Tilley (1994:199) surmises that the Dorset Cursus provided both an alignment for movement and a barrier to access with regard to long barrows on Cranborne Chase.

Loveday (2016) notes that the period of cursus construction might be contemporary with development of festival pilgrimages. Loveday (2015:469) proposes that cursus complexes across southern England express new ideations with linkage to a pilgrimage phenomenon and long-distance replication rather than regional invention, exemplified by the Thornborough complex of monuments in the Vale of Mowbray of North Yorkshire (Loveday 2015:474). However, Chris Scarre (2001:18) proposes the practice of a sacred journey rather than pilgrimage associated with various prehistoric sites in France, Britain and Ireland. For example, Moore (2016) suggests sacred journeys associated with Carrowkeel-Keshcorran passage tombs in Ireland c. 4th millennium BC were related to a transition of identity with the tumuli serving as portals to and from the Otherworld.

Barrett *et al*. (1991a) and Brophy 2016) propose that the Dorset Cursus was a key element in terms of the long-term development of the Cranborne Chase Neolithic landscape, with siting of the cursus determined at least in part by locations and orientations of early monuments including long barrows. Penny and Wood (1973) studies the Dorset Cursus in the context of its archaeological landscape a. 2500 B.C., about 800 years after initial construction of the monument, and notes the following relationships between the cursus and long barrows located on Cranborne Chase:

- the cursus crosses the crest of Gussage Hill where a prominent long barrow (Gussage St Michael 3) is located between the lateral banks of the cursus; the cursus includes a long barrow (Pentridge 4) in its west lateral bank;

- the center of the north end of the cursus is located at the intersection of lines of sight and axes of two long barrows (Pentridge 1 and Pentridge 2), the orientations of which appear to align with another long barrow (Pentridge 3) and another long barrow (Martin Woodyates 1) located about 1.5 km to the north;

- when standing at the center of the transverse bank of the cursus on Wyke Down, an orientation toward Gussage St Michael 3 long barrow represents alignment with the midwinter sunset c. 2500 BC, when the Sun would appear to set between the east end of the long mound and the east bank of the cursus;and

- the cursus shows lunar and solar alignments, with the three terminals serving as backsights and long barrows representing foresights.

Penny and Wood (1973) concludes that the Dorset Cursus served as a pathway with a series of viewing points related to long barrow locations, and solar and lunar phenomena. An apparent intention to relate the Dorset Cursus to long barrows that are proximal to, or incorporated into, the bank of the structure has been mentioned by a number of archaeologists (e.g. Atkinson 1955; Penny and Wood 1973; Barrett *et al*. 1991a: 46-47; Bradley 1993; Loveday 2006; Brophy 2016: 138). Thomas (1991:55) suggests Penny and Wood's (1973) finding that the Dorset Cursus was a complex observatory likely overstates the case for alignments between the monument and astronomical events. Thomas (1991:46) questions if the referenced solar alignments were intentional since monuments are known also to be oriented toward other monuments or natural elements of the landscape. In either case, the alignments proposed by Penny and Wood (1973) related to astronomical events in 2500 BC, about 800 years after the cursus was constructed.

Loveday (2006:140) notes a pattern of north-south oriented cursus alignments and the proximity of cursus monuments with river confluences, and suggests a possible link with observation of the star Sirius and the Belt stars in the constellation of Orion. Harding *et al*. (2006) notes the significance of heavenly bodies with regard to the monument complex at Thornborough, demonstrating deliberate alignments with Orion's Belt and the midwinter sunrise. Harding (2015) proposes that the monumental complex was "a carefully planned and long-term vision – or religious imperative" related to observation of Orion's Belt.

The relationship between the Dorset Cursus and topographic and geomorphic elements of the Chase might have been intended to effect certain physical and visual experiences between persons inside and along the confines of the cursus and long barrows proximal to the monument, or serving to divide the natural landscape while also inherently part of the cultural landscape (Barrett *et al*. 1991a: 46-7; Bradley, 1993; Tilley 1994; Brophy 2016). However, Brück (2005) suggests a need to identify particular elements of landscape that were significant criterion influencing monument location, and that such analysis requires attention to differences between association and causation. Brück (2005) concludes that while phenomenology can facilitate identification of monument-landscape relationships considered to be significant to the designers/builders, it cannot provide the meaning of those associations.

Harding's (1999:30) conclusion that the association between long mounds and cursuses such as the Dorset Cursus "is only significant when viewed or encountered by those moving along the interior of the monument" is challenged by Brophy (2016:171), concluding that, "On balance, the evidence to date suggest that cursus builders and users were more concerned with looking towards cursus monuments, than away from them." Maguire's (2015) GIS assessment of the cultural landscape in the Upper Thames valley supports that idea. Maguire (2015) evaluates the potential for cursus monuments to link earlier structures with certain topographical settings. Results of that study indicate:

- cursus monuments may have been situated proximal to areas of higher topography that could serve as 'viewing platforms' providing views toward the structures;
- cursus placement and orientation may be intentionally related to locations of rivers or streams; and
- aspects of the natural landscape were utilized to enhance or restrict views from cursus termini.

Maguire (2015) proposes that areas of higher topography could serve as "viewing platforms" providing views *toward* cursus monuments. That conception is a significant departure from many of the hypothesized uses of cursus monuments. Rather than features of the landscape or skyscape being observed from inside the corridor of the cursus, Maguire suggests that the cursus itself might have been intended to be observed from a specific location beyond the monument. That idea would support consideration of the purpose and use of cursuses in the context of large monuments set within the larger environment – the landscape, and skyscape – not as outrageously-sized structures, not so completely cut off from temporal and spatial human experience, but monuments potentially in tune with the macro-scale of worldviews.

F.3 Architecture and Landscape

> [The dates of the Dorset Cursus] ". . . . suggest a much more complicated picture, with the banks and ditches not at all the centerpieces of a single grand plan for the region, but almost an afterthought. The traditional idea is based on the feeling that the transverse 'bracketing' ditches are meant to seal off what is, de facto, an enclosure. Some archaeologists have seen in this a sign that this type of structure was designed expressly to exclude outsiders. It seems, however, that the 'terminals' were in place before there was anything for them to terminate. The lines of the banks and ditches are not crooked by virtue of incompetent planning, but simply because they were added as a frame to pre-existing components. As a frame, astronomically speaking, they were inspired by long barrow practice."
>
> – John North (1996)

Increasing recognition of the strong relationship between British Neolithic earthen monumental architecture and natural elements of the landscape indicates the need to understand the geologic and paleoenvironmental history of the Chase and SHL, including geomorphological processes that led to development of the unique cultural landscape during the 4th millennium. Darvill (2010) notes that most clusters of long barrows appear to be located in the vicinity of headwaters of rivers or along escarpment edges with relatively stable, generally open conditions, the siting of each mound unlikely to have been decided on a random basis. He is certain that each site was important and related to "topography, setting, views and position" representative of the wider landscape, designed with deliberate inclusion of a central axis, and that the significance of some long barrow locations is indicated by building mounds over earlier constructed monuments.

Geomorphological features of the landscape also might have influenced the form of the monuments (Millican *et al*. 2017). In a study of the relationship between monuments and landscape in southeastern Scotland, Millican *et al*. (2017) finds that the range of topography and positions of monuments created constraints yet offered options for ways to approach and use monuments, and ways in which the monuments could have been experienced and understood. Gianotti *et al*. (2011) considers Neolithic megalithic dolmens and mound architecture in the northwest Iberian Peninsula as a mechanism of spatial design in which an abstract model of the region's conception of monumental space originated within the landscape and became manifest by a combination of negative anthropogenic features (e.g. ditches), natural forms (e.g. rocky outcrops), geometrical forms (e.g. the circle) and architectural orientation (e.g. access to monuments from the southeast), all exhibited subsequently by a proliferation of those artificial elements beyond that region. With undertones related to social organization and ideology, the Neolithic lifeway varied significantly from region to region and was all the more complex in western France where Mediterranean and Danubian influences came together either directly or indirectly (Laporte and Tinévez 2004), with further development in Britain.

There are objective methods that can mitigate some of the difficulties in understanding the complexities of symbolism built into lithic and earthen monuments. Minerals have been associated with studies of materiality, identity, cosmology and spirituality (Saunders 2004). Selection and use of soils and stones in mound planning, design and construction was part of a creation process that included consideration for siting of monuments with views of the surrounding landscape and skyscape, reinforcing relationships between the living, the dead, and the World (Owoc 2004). The constructed pattern of cultural elements placed upon the landscape, in tandem with identification and classification of natural facts of landscape can be applied in analysis. The cultural landscape relied on the monument "creator's embodied and sensual encounters with the vertical and horizontal landscape/viewscape, and the colors, luminosity, textures, and hardness/softness of the mineral world (ibid. 2004). Owoc (2004) suggests the definition of material culture should consider the numerous ways humans used sediment, soil and stone in daily experience, minerals provided by the environment in material forming the background for human activities, to construct signifying elements within individual and community epistemological projects.

Landscapes with their complex network of shapes, elements, and patterns of elements, have a degree of uniformity of structure in which the details of each element and place are part of perception and comprehension of the landscape at micro-, meso-, or macro-scales (Ode *et al*. 2010). 'Place' may be defined by the flows and convergences experienced within and through it, in addition to its location, boundary or shape (Murrieta-Flores 2013). The pattern of elements and places of landscape may be considered at various scales. Gorman (2009) states that cultural landscape approaches in archaeological studies and cultural heritage management since the 1990s consider archaeological sites as relational entities embedded in landscapes where "off-site" areas may be just as illuminating. Identifying a meaningful landscape boundary is a matter of spatially or temporally defined purpose and, therefore, related to context. McGarigal (undated) states:

> "Landscapes do not exist in isolation. . . . each landscape has a context or regional setting, regardless of scale and how the landscape is defined. . . The importance of the landscape context is dependent on the phenomenon of interest, but typically

> varies as a function of the "openness" of the landscape. The "openness" of the landscape depends not only on the phenomenon under consideration, but on the basis used for delineating the landscape boundary. For example, from a geomorphological or hydrological perspective, the watershed forms a natural landscape, and a landscape defined in this manner might be considered relatively 'closed'."

L'Helgouach (1965:13 ff.) notes the apparent relationship between geology and distribution of megalithic tumuli in Brittany. Similarly, earthen long barrows are not uniformly distributed across England, with most documented mounds situated in areas underlain by limestone encountered at shallow depth (Ashbee 1970; Kinnes 1992). The highest densities of long barrows in England are encountered at higher elevations on the chalkland downs across Wiltshire, Hampshire, Dorset and West Sussex in the south, and Yorkshire and Lincolnshire in the north (Field 2006:99). Portions of Wessex downland are thought to have remained open throughout the Holocene (French *et al*. 2003; Field 2006: 80), and herds of red deer in tandem with grazing by aurochs could have influenced development of large, relatively open areas where long barrows are located (Field 2006: 80). The downs in England generally consisted of historically marginal agricultural land suitable for pasture, in areas where local customs and behaviors were influenced by local geography, climate and traditions that might have helped ensure extensive preservation of the barrows in those areas (Field 2006:17). To say that landscapes have *meaning* implies that they "employ signs that stand for something else" or "for something in respect to someone" (Liebmann 2017). For example, a person walking along a ridge might participate in conceptualizing monumental graves as part of communication (Von Hackwitz and Lindholm 2015). It is the interplay of elements in a landscape that define its relevance to culture and, therefore, relict components of prehistoric cultural landscapes are studied in terms of relationships between the cultural elements, barren of text, and facets of the surrounding environment. Darvill *et al*. (1993) proposes that relict cultural landscapes be defined on the basis of the *pattern of archaeological remains*. They note that relationships between sites, the environment, and cultural use of space are rarely detailed in the archaeological literature, yet are relevant to understanding history.

Significant contributions to investigation and understanding of the siting and construction of British long barrows and other Neolithic monuments in Wessex, including Cranborne Chase, were made between the late 18th and 19th centuries by Sir R.C. Hoare, William Cunnington, Dr. John Thurman, and General Augustus Pitt-Rivers (Thurnam 1869; Nature 1870a, 1870b; Pitt-Rivers 1898). Long barrows studied in South Wiltshire and Dorset at that time were found to be constructed of 'earth, chalk, and flints' and 'situated in some prominent position, usually the highest points of the hills, commanding extensive views over the downs" (Nature 1870a). While similar tumuli in Somerset, Gloucestershire and northern Wiltshire generally include chambers and cists constructed of stone, there is a conspicuous absence of stone construction material used for earthen mounds in southern Wiltshire, Dorset and Hampshire, including the study area. That difference in materials used in the creation of mounds is noted by Hoare (1812) who concludes that absence of stone in the south was the result of the sparsity of harder building stone in that region (Nature 1870b), the near-surface bedrock composed of the Chalk across Salisbury Plain, and the North and South Dorset Downs. Scattered sarsen stones (dense, hard silicified sandstone) are encountered in some areas of the south region, 'but they are neither numerous nor large enough' for purpose of mound construction in most instances (Thurman 1869; Nature 1870b). Cummings (2011) argues that use of soil, sediment and stone in chambered tomb architecture of Neolithic Britain (and Ireland) was determined based on certain qualities of those materials, and there is a need to focus on the qualities of building materials as transmutable substances in the context of monumental construction. For example, gypsum was used to coat henge banks at Thornborough, England, and quartz was deposited at stone circles and stone rows in western Scotland, possibly symbolizing and reflecting the light of the Moon (Ruggles 1999:98; Harding *et al*. 2006).

Networks of transportation and communication are closely related to elements of the British Neolithic landscape, particularly topography and surface hydrology. Peake (1939) states that much of the higher elevations of the chalklands remained uncultivated in part because of the thin, dry, porous of soil that also did not encourage development of deciduous woodland throughout the Holocene. He notes that prehistoric trackways were developed either on or alongside of the crests of the main ridgeways. One of those ancient trackways is the ‘West Way’, a drover’s road located along the crest of the Chalke Escarpment at Cranborne Chase (Peake 1939, Figure 2). A drovers' road, or droveway, is a route for walking (‘droving’) livestock between pastures, from farm to market, or other purpose. The droveway along the Chalke Escarpment is now named the ’Ox Drove’, part of a trackway that connected the Dorset/Exeter area with London and farther northeast (Peake 1939; Lane 2020). While some lengths of trackways are now gravel-surfaced or paved, as is the case for portions of the Ox Drove, most remain grassy and marked with cattle tracks. Peake (1939) notes that causewayed enclosures are often situated alongside many of the trackways. Hambledon Hill causwayed enclosure is situated just south of the Chalke Escarpment and Ox Drove, along the Stour River.

British rivers are boundaries and corridors that have both inhibited and facilitated transportation and communication since at least the Mesolithic (Brophy 2016). The relationship between river and ritual landscapes is significant. For example, Mesolithic cultures cleared land around Blick Mead – a chalkland spring of potential ritual significance located along the Avon River east of Stonehenge and about 15 km north of Cranborne Chase – between about 7,500 and 4,600 BC (Jacques 2016). The valley of the River Avon served as an important transportation and communication corridor (Griffiths 2014; Jacques 2016), and Mesolithic occupation at Blick Mead appears to have been the source location for development of the Stonehenge ritual landscape over the course of subsequent millennia.

Associations between rivers and monuments including long barrows, causewayed enclosures and cursus monuments, have been considered since the mid- 20th century because of the proximal geographic settings of many monuments to the courses of waterbodies (Loveday 2006; Brophy 2016). Thomas (1991:136) notes that Salisbury Plain and Cranborne Chase are located at the head of the Avon River watershed. The river flows south out of the Vale of Pewsey and passes through the Stonehenge landscape before flowing along the east side of Cranborne Chase and discharging to the Channel. Thus, the river is associated with two of the most prominent Neolithic ritual landscapes in Britain. In addition, the Stour River with headwaters at Stourhead in southwest Wiltshire, flows southeast and forms the southern limit of Cranborne Chase before discharging to the Avon in the South Hampshire Lowlands. Also, a significant amount of Mesolithic artifacts have been encountered at sites situated near the headwaters of the Allen River, in the central portion of the Chase (Barrett *et al.* 1991a, 29–30; M. Green, 2000, 20–8; Whittle *et al.* 2011:151, table 4.6, figs. 4.20-1).

Thomas (1991:39) notes that Neolithic monuments are inherently symbolic, constructed by convention defined per a set of rules, and potentially structuring landscape by the control of movement and supporting a cultural interpretation of the world. Whittle (2007) suggests the body might have been considered as a metaphor for ideas about transience, transition and transformation during first centuries of the Neolithic in southern Britain, exhibited in monumental form across the landscape. However, symbolism built into Neolithic architecture may be related to much earlier ideas about relationships between the living and the dead. Early Neolithic architecture of British earthen funerary monuments suggests a measure of continuity with Mesolithic relationships with the dead, expressing a theme of transformation related to certain conceptions of place and landscape (Thomas 2007, 432; 2004; Clark *et al.* 2019:212). Fleming (1999) suggests “landscape is a cultural code . . . a means of conceptual ordering that stresses relations.” In other words, the architecture (and therefore the symbolism) of monuments is in some ways the product of sensorial relationships people have with physical and/or biological characteristics of the surrounding environment and the conception of meaning derived from those relationships. Gebauer (2015) describes a model of

Neolithic tombs in the landscape in which distance is created between the living and the dead by placement of tombs at the margins of everyday, and in some instances overlooking the inhabited landscape. Whittle *et al*. (2008) concludes that while traditions of Neolithic monumental construction occurred over extensive areas of the British Isles, monuments were designed to "satisfy local circumstances, demands and pressures."

Geometry and proportion were incorporated with those designs to create critical relationships that are important to reasoned and effectual sacred architecture, with form, scale, and placement of architecture to establish formal hierarchies and underline significance of place (Barrie 2010). Architectural symbolism is applied through application of six ordering principles in architectural design (Ching and Ching 2014):

- Axis – a line defined by two points in space to create symmetry or balance of form and space;
- Symmetry – a balanced pattern of forms and spaces on opposite sides of an axis or plane;
- Rhythm – a unification created by patterned repetition or alternation of identical or similar formal elements or motifs;
- Hierarchy – articulation of the value placed on form or space based on size, shape, or location in relation to other elements of spatial organization;
- Datum – a line, plane, or volume that measures, organizes and brings together a pattern of forms and space using continuity and regularity; and
- Transformation – alteration of an architectural concept, structure, or organization by discrete manipulations and permutations within a specific context without loss of identity or concept.

Interpretation of sacred architecture can potentially require formal analysis of a breadth of formal, spatial, cultural, historical and other considerations, as well as means for recognizing and understanding why it expresses sacred meaning and how it is to be experienced (Barrie 2010). Moore (2016) combines definitions of space and place by Parsaee *et al*. (2015) to define space in terms of use of physical or conceptual boundaries that produces order from chaos with locations of transition given importance. Expression of space and place in Neolithic earthen monumental architecture is evident by use of the above-referenced ordering principles in architectural design. For example, most burials encountered beneath earthen barrow tumuli exhibit a moderate area typically along the axial plane of the mound and situated in the eastern, higher end of the barrow, bones of the deceased typically located on the former ground surface, or placed on pavements of stones, flints or blocks of the Chalk (Ashbee 1970). Those architectural elements express conceptualizations related to the living and the dead. Lewis-Williams and Pearce (2005: 278) suggest an important conception of the dead in Neolithic Britain was that they moved between Earth and sky, from the tomb (the point of transition) to mediate between levels of a multi-tiered the cosmos, assisted in each transition by rituals performed by the living. The process of movement by the dead was as follows:

> "The dead moved from the outside world, through the passage (vortex) to the underground realm of the chambers where, as numerous researchers suggest, seers performed various rituals with the (usually cremated) remains of the dead. At an appropriate time, the next leg of their journey was, we suggest, upwards, through the mound and up into the sky . . . . (Lewis-Williams and Pearce 2005:278)."

Gorman (2009) states that Earth is “an open system in a dynamic interchange with the cosmos”, an idea that parallels numerous indigenous, ancient and prehistoric worldviews in which the celestial sphere and Earth are of the same system. Neolithic landscapes were not only conceived as economic resources, but having an existential cosmological dimension (Larsson 2014). Hoskin (2015:923) concludes that patterns of orientation of burial monuments across Neolithic Europe could not have simply referenced local terrestrial ‘targets’ such as a particular mountain or conceptualized homeland, but must have developed customs referencing events in the sky that were significant in developing *cosmovisións*.

F.4 Architecture and Cosmology

> "Man is that uniquely conscious creature who can perceive and express. He must become the steward of the biosphere. To do this he must design with nature."
> – Ian McHarg (1969)

More than 500 Neolithic long barrows have been inventoried across Britain. Each barrow exhibits a unique set of mound dimensions, interior structure, exterior form and axial orientation, quarry ditch characteristics and variability in siting the mound upon the landscape. The practice of long barrow construction in Britain continued over the course of most of the 4th millennium. Long barrow design and siting, accomplished as ‘a matter of translation rather than transmission’ from across the English Channel through a melding of immigrant and indigenous peoples, can be viewed as representations of 4th millenium domestic ‘vernacular’ architecture constructed for funerary/ritual or other socially and culturally functional purpose.

Vernacular architecture (Letsson 2014) evolves over time by trial and error, yet can be recognized by the context of its integration within a particular socio-cultural landscape. Caves (2004) states that vernacular architectures have “great perceptual and associational meaning for their users. For example, religious or sacred buildings in traditional cultures are organized to conform to divine cosmologies that structure space and to rigorous guidelines that direct building construction. The organization of these spaces is understandable only in terms of the underlying sacred meanings.” Ashmore and Sabloff (2002:202) note that numerous parameters impact our ability to recognize and understand ideational bases related to archaeological sites. They state that the challenge “is not whether political or cosmological symbolism might be expressed in architecture and space, but whether and how one can recognize when such symbolic communication has taken place" (Ashmore and Sabloff 2002:233). Understanding of “intangible, ephemeral, and immaterial aspects of sacred architecture” is needed to unveil the full extent of its meaning (Barrie 2010). Stephen Holl (1989:9) states, “Beyond the physicality of architectural objects and practicalities of programmatic content, an enmeshed experience is not merely a place of events, things, and activities, but something more intangible, which emerges from the continuous unfolding of overlapping spaces, materials, in detail. . . the moment in which objects merge with the field.”

Hofman and Smyth (2013) note four core themes in their volume addressing relationships between vernacular dwellings, materials and cosmology with regard to the transformation of houses during the Neolithic: the materials used for construction of houses, daily practices associated with housing, their cosmological significance, and mechanisms of their transformation in which the inhabitants participated with the world. They state that the “house is a vantage point to enter the world.” As Ingold (2000:172–188) states, dwellings support human discovery through engagement with features of the material world, a world that is in itself in the process of transformation. Neolithic architecture became a “means of embodying abstract concepts, beliefs and ideas about [people] and their world in externalized, permanent forms” (Watkins 2004: 97). Forms of meaning and symbolism could be expressed in ways that could reach a wider audience without the need for the builders to be present (Hofman and Smyth 2013), and the symbolism often referenced death.

The physical features of the landscape – rivers, shorelines, heights, lowland, etc. – were fundamental features and mediums for rituals of death (Von Hackwitz and Lindholm 2015), with the place of burial exemplified by Neolithic long barrows and other tumuli. Megalithic tumuli and mound building, including earthen long barrows, transformed places and served to acknowledge a legacy of historical or mythical events linked to those locales. Continued development of monumental landscapes is evident during the British Bronze Age. Higginbottom *et al*. (2015, 2016) argues that British Bronze Age megalithic monuments were "the materialization of (people's) cosmology" and "an acknowledgement of belief in specific cosmological forces."

Symbols represent human "ideas that lie beyond the grasp of reason" and "because there are innumerable things beyond the range of human understanding, we constantly use symbolic terms to represent concepts that we can't define or fully comprehend. This is one reason why all religions employ symbolic language or images" (Carl Jung 1968; Barrie 2010). Symbolic meaning in architecture can be expressed through elements of geometrical proportion and perspective, spatial sequences, vistas and juxtapositions, environmental appropriations and displacements that are enhanced by communal rituals (Barrie 2010).

The root word of religion is Latin *reliquare* ('to bind together'), establishing connections with the divine (Barrie 2010). Barrie (2010) states "the primary goal of religion is to establish an ontological position in the world – an orientation for one's temporal existence. Its essential task is articulating where one is and is not, and in which direction one is to go. . . religion, culture, and place are so inextricably connected." Further, Barrie (2010) states, "The setting of sacred architecture is critical to its power and meaning . . . Sacred architecture employs a variety of means to establish a place that is both separated and connected to its contexts. A symbolic language, delimitation of space, articulate approach, entry and path sequence, geometry and proportion, and diverse representational media are employed – often in concert – in the creation of the sacred place." To mediate (Latin *mediare*, 'in the middle') and the Germanic root *midja-gardaz* ('middle zone' between heaven and earth) is to act as an intermediary between positions in space and time (Barrie 2010). Barrie (2010) contends that sacred architecture symbolizes and assists in crossing the 'narrow threshold' to the divine.

For Barrie (2010), architecture is most successful when it can be understood and remain relevant long after the culture that produced it has passed or lost relevancy. The quest for permanence is exemplified in Neolithic stone architecture. Lithic monuments are intended to endure (Loveday 2016). Megalithic builders applied raw mineral materials as means to symbolize myth and the powers of the supernatural in support of their conception of Neolithic cosmology (Cummings *et al*. 2015:828). Recognizing the means of designing and constructing long barrows, cursuses and other earthen monumental Neolithic architecture – focusing on the process of design and construction, materials of construction and their properties of import to the purpose of the construction, and ontological relationships between humans and their environment – can help us understand the purpose behind social and cultural organization of temporal and spatial aspects of experiencing the Neolithic environment, or "the organization of the cosmos and society" (Fowler 2021; Richards 1996). This is a recognition of the power of relationships derived "from the alignment of society with the cosmos – it is *cosmocentric*" (Fowler 2021).

Hofman and Smyth (2013) state that recognizing and understanding the symbolic role of architecture within the context of cosmogony requires investigation beyond a structure itself to assess a broader perspective to reveal the "more general aesthetic sense concerned with geometric order." Fowler (2012) outlines evidence for a formalization of temporal and spatial organization with respect to Neolithic social relations and burial practices, and describes approaches to interpreting "ontological effects of Neolithic processes of living, dying and becoming", with specific mention of earthen burial mounds, causwayed enclosures and cursuses located in southern Britain. He notes that certain places on the Early Neolithic landscape were altered by cultural elements such as earthen monuments to be sympathetic with local environmental characteristics (Fowler 2012; Robinson 2012). He suggests gatherings of large groups from widespread communities might have participated in construction of earthen monumental structures, feasting, and "cosmogenic acts" related to commemoration of the dead (Fowler 2012). Further, "Monument construction could be understood as part of dialogue with the landscape and its constituent features and materials—a dialogue that said different things in different places and over time. . . . all these interactions created and drew attention to different ontological effects for the human and other beings involved" (ibid.).

Cosmology (also worldview or cosmovision) "is a metaphysical view of the world in terms of the totality of phenomena in space and time" (Boeyens and Levendis 2008:183). Worldviews are integral to human society and culture (Pásztor 2009; Campion 2017), and they may be expressed in the architecture of earthen monuments. Archaeological evidence suggests cosmology in Neolithic communities was integral to conceived relationships between humans and the environment on the basis of subsistence strategies, cognitive and pragmatic conditions, and human skill (Rappenglück 2013). For example, manifestation of cosmological concepts is evident in the early Neolithic architecture and artifacts at the settlement of Çatalhöyük in southern Anatolia, occupied between the 8th to 6th millennium (Hodder 2011; Lewis-Williams and Pearce 2009:148). Regarding the earthen monuments in Britain, Thomas (2000) suggests long barrows were places of transformation and transition, places of ritual performance and places of powerful liminality. Articulated through culture, cosmology provided the framework for conception, understanding, expression and interaction of individuals, groups and society with the world. It could influence political and religious conceptions through its application in arts, and we may include architecture within that realm, particularly as it applies to tombs and other earthen monumental structures constructed during the Early- to Middle-Neolithic.

The strong relationship between myth, cosmology and architecture, was persistent and pervasive as Neolithic ideas, technologies and subsistence strategies spread from the near east across Europe and the British Isles over the course of millennia (ibid.:157). Lewis-Williams and Pearce (2009:85) describes Neolithic monuments as "exemplars of the cosmos above ground," noting their uncomplicated design (such as wood posts, monoliths, stone circles, aligned posts or megaliths, and earthen trenches and mounds) allowing people to increase control over the cosmos to suit the needs of both individuals and the community. Those geometrically simplified arrangements of natural materials, at the same time requiring significant human ingenuity and physical strength to construct, symbolized and provided access to "the tiers of the cosmos . . . the fundamental structure of the cosmos" (ibid., 85-86). This is recognized as "the real, innovative essence of the Neolithic: expression of religious cosmological concepts in material structures," encapsulating patterns of thought and unifying Neolithic cosmology, architecture and imagery (ibid., 153, 167).

Recognizing and understanding prehistoric cosmology often requires that material remains be studied using the perspective of living (current or historic) religious traditions (Ahola 2019). Anthropological, ethnographical and ethnoarchaeological investigations can provide analogies for reconstructing prehistoric cosmological conceptions, particularly when similar geographical, and environmental conditions (ecological as well as celestial) are compared (Pásztor 2010; Gauer 2020). Microenvironments consisting of natural materials and processes have provided not only proximity to natural resources, but the basis upon which conceptualization of social ideologies supports creation of direct connections between people, the environment, and ancestors (Gauer 2020). Those relationships are expressed in material culture.

Mesolithic and Neolithic cosmologies in northern Europe are understood as animistic–shamanistic (Ahola 2019). Religion likely permeated all aspects of Neolithic life and challenges archaeology because of intangibilities inherent in prehistoric iconography and myth (Loveday 2015:463). And yet, physical remains of burial can be used to understand the cosmology and beliefs, and study of religion and religious rituals in terms of 'memory', 'movement', 'time' and 'space' as the focus of research has become routine within archaeological investigations (Ahola 2019). Specific worldviews related to European prehistoric astronomy are indicated by location

(Pásztor 2009). Based on cosmological studies of prehistoric European astronomy, Pásztor (2009) concludes:

- different archaeological societies exhibit different preferences for culturally relevant cosmological symbols, house-orientations and grave-orientations; and
- different versions of cosmological ideas could be present within the same culture.

Significantly, there is evidence of celestial phenomena serving a vital role in the cosmology of prehistoric Europe (Pásztor 2009, 2010; Roslund *et al*. 1999). Cosmographic classification schemes of prehistoric cultures were products of observation and emotional response, mood and cognition, to certain locations and circumstances related to the surrounding environment – the landscape and skyscape (Kerr and Tacon 1999). Prehistoric cultures appear to have mapped the cosmos and described their worldviews in symbolic form since the Paleolithic, and memorialized links between life, death and the afterlife on a grand scale through construction of megalithic and earthen monuments across the Atlantic façade, central and eastern Europe, the British Isles and other regions of the world.

In a discussion correlating sky movements and traditional practices for farming and religious beliefs in Neolithic northwestern Europe and elsewhere, Hollestelle (2016) states, “The star sky was imagined by the living to be the best intermediary towards the souls of the ancestors.” The skyscape was a significant and unchanging metaphorical resource used for symbolic correspondence with the cultural landscape, inviting a conceptual correlation between things on the terrestrial sphere with those perceived across the skyscape (Ruggles and Saunders 1993).

Monument data from southwest Britain indicate that questions about how people in the past interacted with the mineral world must also extend below and beyond the ground surface (Owoc 2004). In other words, the conceptual environment includes not only the landscape, but the environment perceived above the horizon. The earliest Neolithic monuments in northern Europe signified local places and features of the landscape as special, while monuments were increasingly linked with celestial bodies and events, and cosmos on a grand scale (Fowler *et a*l. 2015:18). The skyscape in wooded areas of moderate relief might be viewable in gaps or clearings between vegetation, and use of distant horizon markers would imply a clear line of sight between monument and horizon (Brown *et al*. 2015:43). Open areas would assist inclusion of natural features or phenomena during the conduct of ritual and social behaviors (Brown *et al*. 2015:43).

A holistic approach to study of landscape emphasizes spatial and temporal interrelationships between people and the places and features of the environment, including but not limited to culturally determined significance of the pattern of natural or geographic features (Knapp and Ashmore 1999). Parcero Oubiña *et al*. (1998:159) states, ”Like any other human product, landscape objectifies an intention, meaning and rationality.” However, recognizing and understanding Neolithic ways of conceptualizing the world requires minimizing our inclination to assume modern knowledge and abilities that were not necessarily known, important, or meaningful to prehistoric societies, and taking into consideration the social and cultural contexts related to prehistoric behaviors, including astronomical activities (Ruggles 1999:81).

Distinct sets of architectural orientations are a significant source of data with regard to archaeoastronomical studies (Šprajc 2018). In addition, beyond simply an astronomical focus for those alignments, the orientations may concern the broader context of landscape archaeology (Belmonte 2012; Iwaniszewski 2015; Ruggles 1999; Šprajc 2005; Šprajc 2018). Ruggles and Barclay (2000) notes the importance of recognizing and understanding the importance of celestial referents with regard to relationships between landscape cognition and Neolithic cosmology as astronomical events were perceived in meaningful associations with life on Earth. The study of British Neolithic monumental architecture, including application of archaeoastronomical methodologies in the study of prehistoric sacred geography and cosmology, can yield valuable insights into how monuments constructed upon the natural landscape were perceived to interact with the celestial sphere (Ruggles and Barclay 2000). Knapp and Ashmore (1999) suggests the sky supplied cues to terrestrial spatial order more frequently than archaeologists recognize.

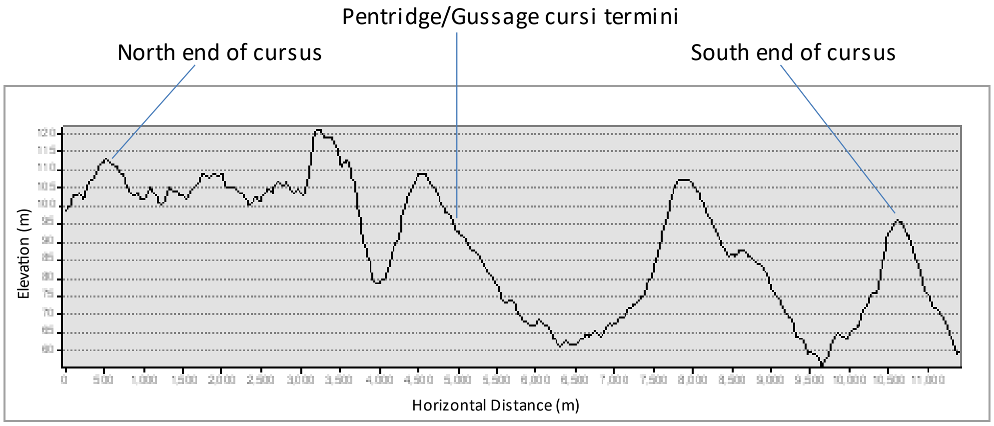
Appendix G

Supplemental Ground Profiles

This appendix includes one ground surface profile (Profile G.1) showing the centerline profile along the Dorset Cursus, and twelve ground surface profiles between Winklebury Hill and locations southeast of the Dorset Cursus. The latter twelve profiles are arranged to provide cross sections beginning at the south end of Gussage Cursus (Profile G.2) and ending at the north end of Pentridge Cursus (Profile G.13). The cursus is visible from Winklebury Hill along eleven of the twelve profiles. The possible exception is along the sightline oriented toward Vale Acre Farm (Profile G.6), with the cursus situated immediately east of a low hill. Note that locations of the possible long barrow or mortuary structure at Knowle Hill Farm (Profile G.4) and long barrow Verwood 1 (Profile G.7) are situated within the viewshed of Winklebury Hill.

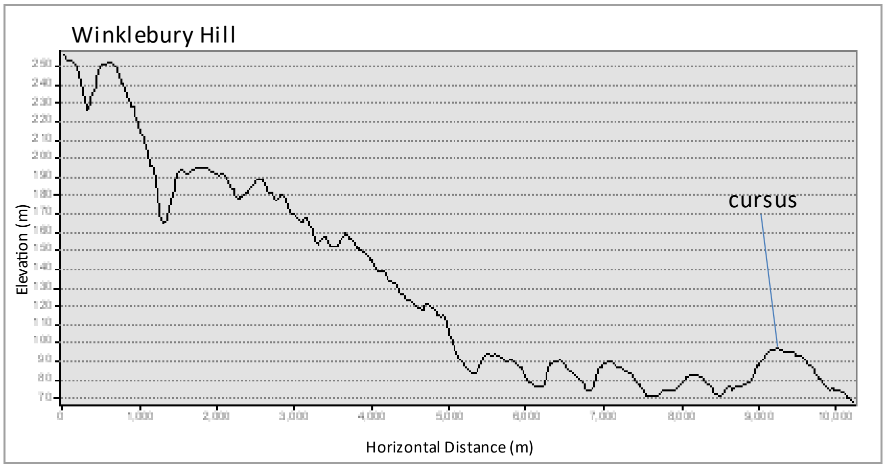
Profile G.1

Ground Surface Profile along Centerline of Dorset Cursus with Extensions beyond Cursus Termini



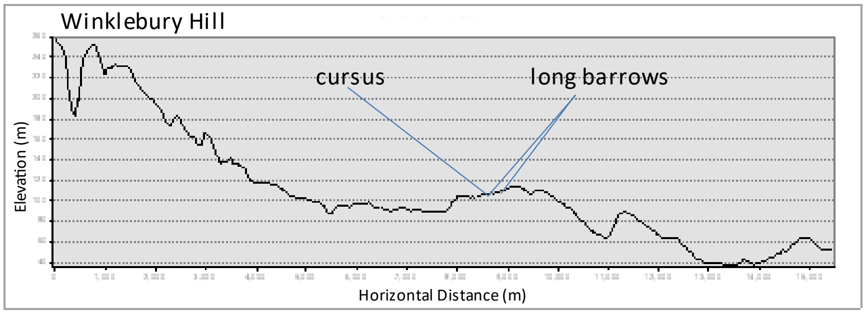
Profile G.2

Winklebury Hill to south end of Gussage Cursus



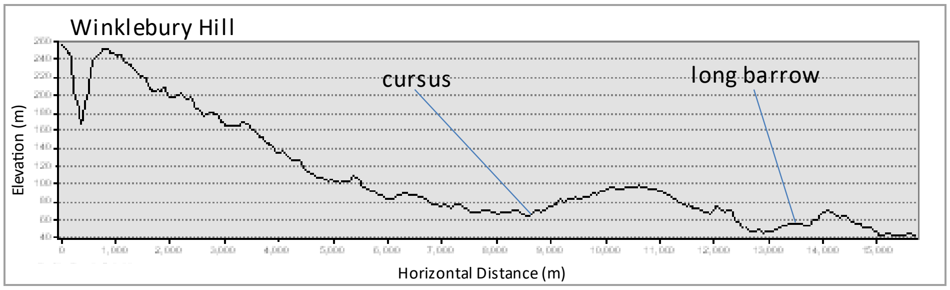
Profile G.3

Winklebury Hill to Horton Tower via Dorset Cursus and Gussage Down long barrows on ridge



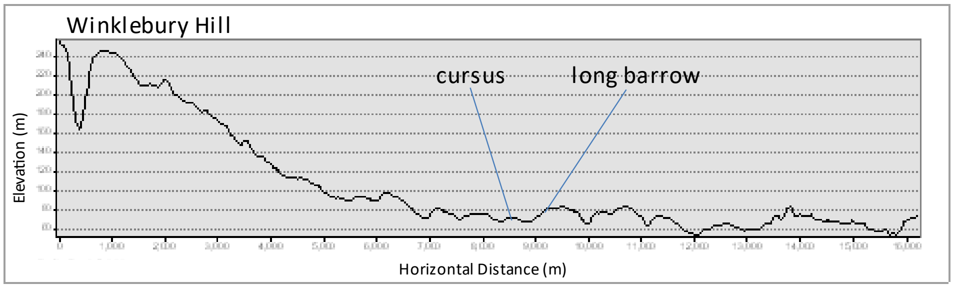
Profile G.4

Winklebury Hill to Knob's Crook through Knowle Hill Farm long barrow

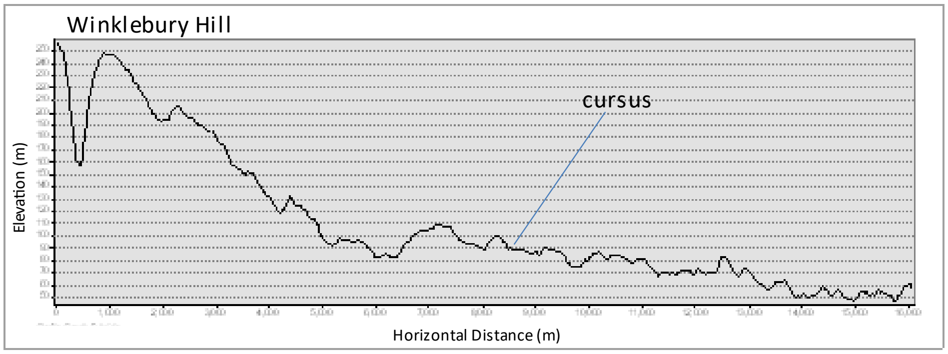


Profile G.5

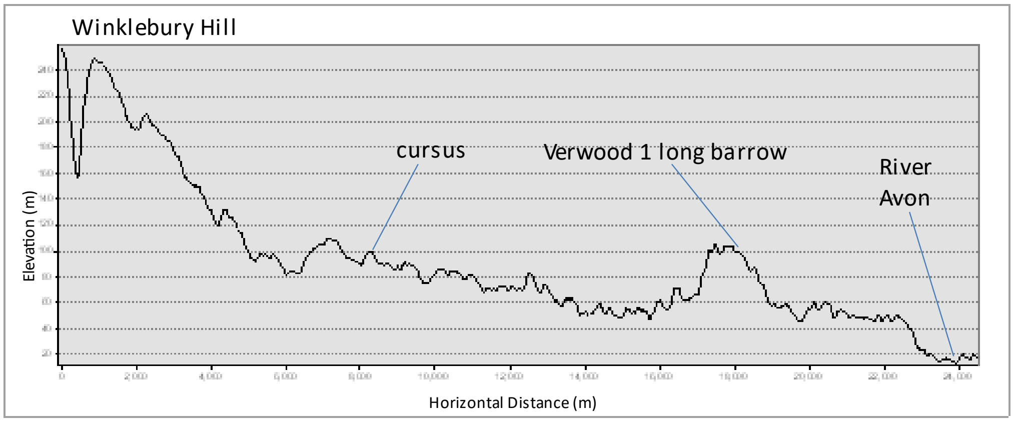
Winklebury Hill to Woodlands through Wimborne St Giles Long Barrow



Profile G.6
Winklebury Hill to Vale Acre Farm

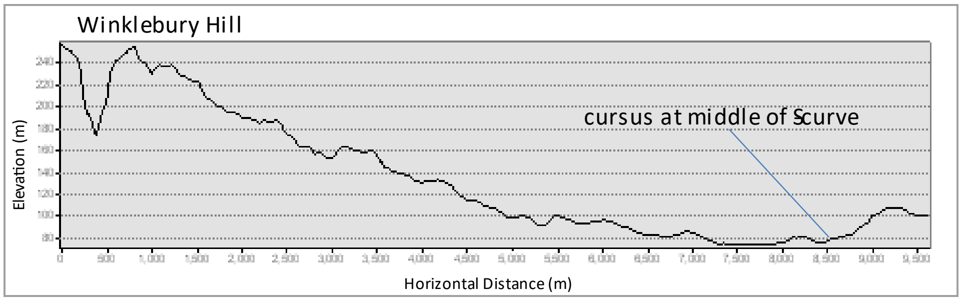


Profile G.7
Winklebury Hill to Avon River
via Vale Acre Farm and Verwood 1 long barrow



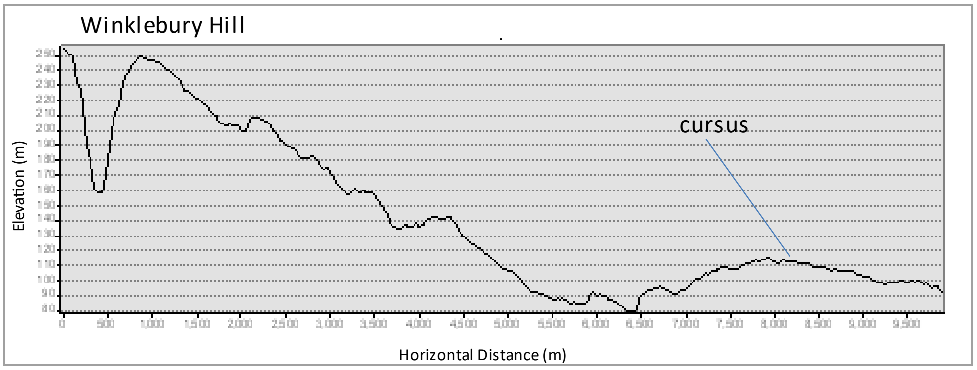
Profile G.8

Winklebury Hill to Cursus through Gussage Down S-curve



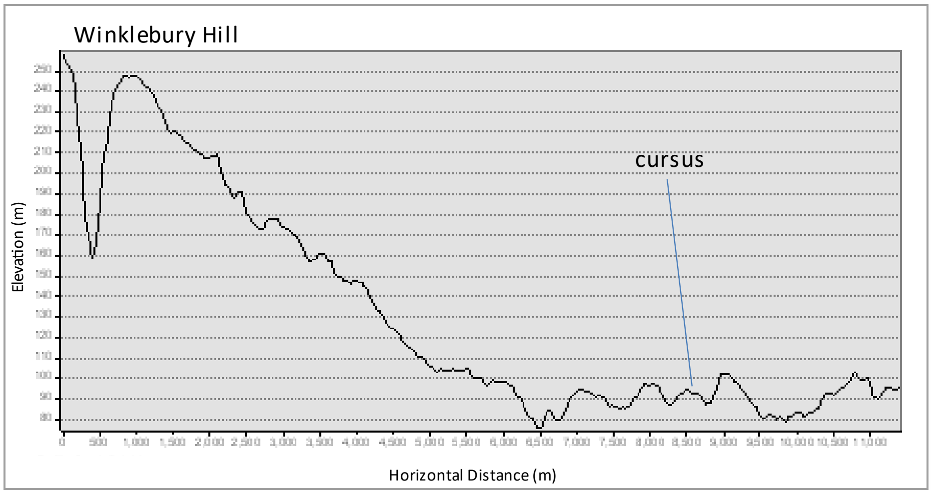
Profile G.9

Winklebury Hill to Squirrel's Corner on Bottlebush Down



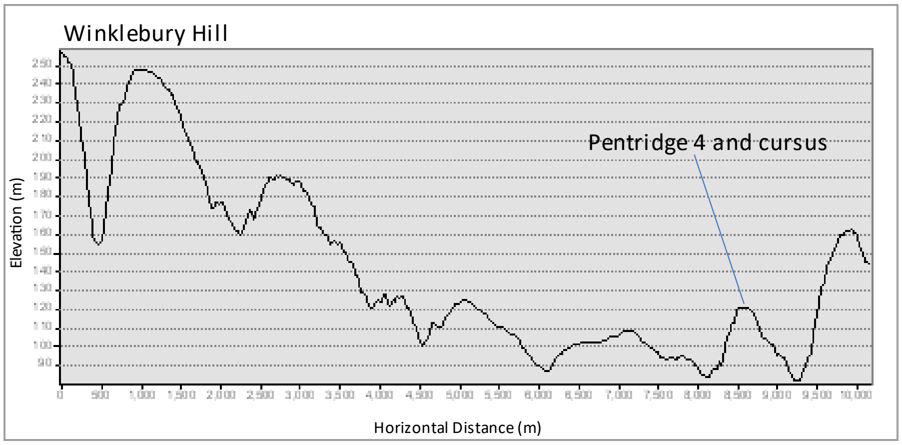
Profile G.10

Winklebury Hill to Nine Yews through north end of Gussage Cursus



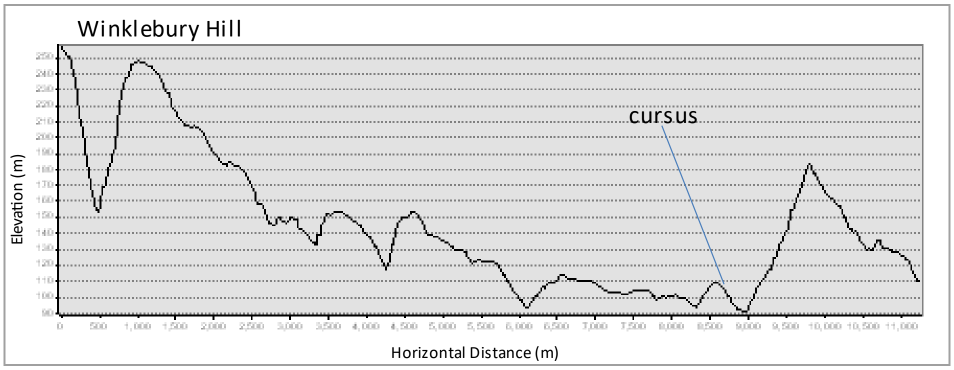
Profile G.11

Winklebury Hill to Pentridge Hill through Pentridge 4 Long Barrow



Profile G.12

Winklebury Hill to Penbury Knowle



Profile G.13

Winklebury Hill to Allenford Farms through north end of Dorset Cursus