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Understanding the Archaeology of Landscapes

A guide to good recording practice

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The land, both urban and rural, is a document recording the lives of countless past generations. Existing route ways, buildings and boundaries, trees and hedges, as well as structures now reduced to earthworks, are all part of the beauty and fascination of the landscape. They can also be analysed to tell the story of the past – economic, social, aesthetic and religious. This document provides practical guidance on the recording, analysis and understanding of earthworks and other historic landscape features by non-intrusive archaeological survey and investigation. Through enhanced understanding comes enhanced care and enjoyment.

Abbreviations used throughout text:

AMIE = Archives and Monuments Information, England
CAD = Computer Aided Design
CBA = Council for British Archaeology
DTM = Digital Terrain Model
EDM = Electromagnetic Distance Measurement
EH = English Heritage
GIS = Geographical Information System
GPS = Global Positioning System
GSB = Geophysical Survey of Bradford
HER = Historic Environment Records
IFA = Institute of Field Archaeologists
lidar = light detection and ranging
NMR = National Monuments Record
OS = Ordnance Survey
RCHME = Royal Commission on the Historical Monuments of England
SAM = Scheduled Ancient Monument
SMR = Sites and Monuments Records
ULM = Unit for Landscape Modeling

Cover: Middleton Dean hillfort, Ilderton, Northumberland (photograph by Alun Bull)

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Introduction

The analytical survey of earthworks and landscapes is a particularly valuable contribution to archaeology, and to related disciplines such as historical geography and local history. It is a tradition spanning 300 years in Britain and is the oldest of archaeological techniques.

It has become increasingly apparent, however, that there is need for wider dissemination of the approaches to investigating and interpreting archaeological sites and landscapes that have been developed over the centuries and that have culminated in the work of the Ordnance Survey Archaeology Division and the Royal Commissions on (Ancient and) Historical Monuments in Scotland, Wales and England (the latter now part of English Heritage). There is great demand for skills that can be brought to bear on the analysis of historic sites and landscapes. This need has been addressed recently in a number of publications (eg Bowden 1999; 2002; Ainsworth and Thomason 2003; Bedford *et al* forthcoming). This guide builds on those and is an updated and expanded version of the English Royal Commission's 1999 publication *Recording Field Monuments: a descriptive specification*. It is also designed to stand alongside *Understanding Historic Buildings: a guide to good recording practice* (Menuge 2006).

The demand comes from archaeologists working in the commercial sector and, at the other end of the spectrum, from voluntary community groups. Such survey is ideal for the latter, being non-intrusive, requiring little equipment or back-up and producing worthwhile results as it progresses. In the commercial field, time and resources will be limited and a brief set by a curator or consultant will necessarily be followed exactly by a contractor. In the voluntary sector there may be much flexibility and the original 'brief' may be considerably modified in the course of the work. This guide attempts to cover all such eventualities.

The aim is a representation, appropriate to the scale, of all visible features of archaeological interest. In the case of earthworks, which form a considerable proportion of such remains, the preferred representation is by means of hachures. Contouring has sometimes been employed but rarely with success, for the reasons set out below.

There is much to be gained from the non-intrusive techniques described here (and the related techniques of building, aerial and geophysical survey, and surface artefact mapping), at a time when it is increasingly important to emphasise that archaeology is much more than merely excavation. Analytical survey provides an understanding of sites and landscapes for conservation and management, for the provision of broad context to more narrowly focused investigations, and for public enjoyment.

This guide describes and illustrates approaches to archaeological survey, drawing conventions and Levels of Survey for record creators and users.

Approaches

An archaeological survey can be done by an individual or a team, does not necessarily require expensive equipment and is, therefore, an economical means of analysing archaeological sites and landscapes, providing much new knowledge for a small outlay.

Survey provides useful information on the *form* and *condition* of earthworks; it is also extremely good at identifying the *chronological relationships* of the elements of the landscape to one another. By interrogating these relationships a *relative chronology* can be built up. Surface examination is less good at producing ideas on *function* (while some classes of earthworks are readily recognizable, the use that others were put to may remain obscure), or on *absolute dating*. A feature may be of a type that, by analogy, is likely to be of a period but analytical survey cannot usually identify dates with any precision. Nevertheless, form and relative chronology are valuable indicators and usually provide a sufficiently clear picture for the interpretation of a site's history and development. This information can be used to frame further research, to inform site management or as the basis for public presentation.

The record resulting from an analytical survey must be appropriate to the original requirement, and will be dictated by the method selected. A rapid, *extensive* survey of, say, all the surviving earthworks in a given area may result in summary information and a graphical record that is limited to a locating cross or a pecked line on a map (Level 1). At the other extreme, an *intensive* survey of an individual earthwork will produce a detailed textual report and a plan that depicts every significant feature (Level 3).

No interpretation of the landscape, whether extensive or intensive, ever provides all the answers. Like any other method this is only a stepping-stone towards an understanding of former structures that can, at best, be only imperfectly known. However, we can come closer to the truth by using a variety of retrieval methods. This is an important consideration because a normal result of any landscape investigation is a host of new questions best addressed by other techniques, eg geophysical survey, analysis of environmental remains, or selective excavation. If such needs can be identified at the outset this information should be included in the project design. At the least they should be included in suggestions for further work.

In summary, the analytical investigation, interpretation and recording of extant earthworks are economical and inform a variety of needs at differing levels of detail. They are a key part of a longer process that will include preparation by searching existing records and that may end with recommendations for further investigations.

Every initiative should have clear objectives, targets that should be set out in a formal or informal project design (Lee 2006). It is the aim of this guide to aid the articulation of those objectives and bringing them to fruition.

Case Study 1

The rock art recording pilot project, Northumberland and County Durham: a Level 1 survey focussed on demonstrating best practice for the creation of a national database

The rock art pilot project was conducted as a methodological trial for a national project. It was supported by EH in partnership with Northumberland and Durham County Councils and it had four main aims:

- to record all rock art sites to a common standard;
- to ensure that the locations of all the sites are recorded as accurately as hand-held navigation-grade GPS sets and/or

simple graphical survey techniques allow;
- to report briefly on the present condition of known examples;
- to develop a Web-based database that could form the basis of an accessible national archive.

Following recruitment and training of local volunteers at the end of 2004, more than 50 people worked in small teams to review the extensive records of rock art sites compiled by local enthusiasts. As a pilot project, it was important to develop a consistent, repeatable and user-friendly recording system that could be applied by anyone, with a minimum of training.

The methodology was refined in the course of the fieldwork, taking on board specialist advice and feedback from the volunteers themselves. To ensure that there was negligible impact on the rock surfaces and fragile motifs, the recording methods employed were non-invasive. For each engraved panel, the volunteers took high-resolution digital photographs and panoramas. They also completed a specially designed recording form, covering various categories of information, mostly in the form of tick lists, including the content of the motif, its immediate context, present condition and any identifiable threats. In addition, the volunteers experimented with low-cost photogrammetry to capture 3D imagery of the motifs. This innovative approach proved successful and extremely cost-effective: it could potentially replace traditional recording techniques such as tracing and rubbing, which can be inaccurate and harmful to the rock surface.

For the purposes of determining the OS National Grid Reference of each site, the volunteers primarily used hand-held navigation-grade GPS satellite mapping sets. Rock art commonly survives in open moorland, which is often completely devoid of mapped features, making GPS the ideal surveying tool for this purpose. The project particularly attracted walkers and other outdoor enthusiasts, so many of the volunteers proved to be already familiar with the operation of the GPS sets, or to own one themselves. All the same, to ensure consistency, training was provided by EH field surveyors. The volunteers, even those with long experience of using hand-held GPS, were generally surprised to learn that their navigation-grade sets could not be relied upon for accuracy of better than 10m, notwithstanding the accuracies displayed on screen, which might be as little as ±4m (Ainsworth and Thomason 2003, 9). It came as a real shock to hear that better accuracy could often be achieved using simple, old-fashioned taped survey, in conjunction with OS maps at 1:2 500 or 1:10 000 scale. Wherever convenient (or necessary, for example due to overhanging trees or rock outcrops obscuring the reception of the satellites), the volunteers were encouraged to qualify the GPS readings they obtained by using 30m tapes to plot the sites graphically against a map background. Where rock art survives within enclosed fields, and especially where rocks bearing motifs have been incorporated into post-medieval field walls, it is neither difficult nor time-consuming to determine locations, sometimes with map accuracy as good as ±2m. The recording form required the volunteers to state which survey technique(s) they had used and to draw sketch plans if appropriate.

In addition to describing the topographic setting of each site, volunteers were also asked to record briefly their comments on any other features in the environs which they considered might be of relevance to the survival or condition of the rock art. For example, prehistoric field clearance cairns or post-medieval quarrying in the environs of a rock art panel might well shed a very different light on the distribution pattern of sites. However, there was no expectation that these written observations would approach the detailed, contextual study that a Level 3 Survey should constitute.

As a pilot, the project was expected to be a learning process for professionals and amateurs alike, and so it proved. The digital archive of recording forms and photographs resulting from the project will be invaluable in helping to inform conservation and management decisions about the sites that have been examined. It will improve access to the sites, both physically and through remote research. Above all, perhaps, the pilot has created a pool of enthusiastic and skilled volunteers, who are already beginning to turn their attention to other fieldwork.

Volunteers recording rock art at Gled Law in Northumberland (photograph by Tertia Barnett).

Preparation

Depending on circumstances, background research begins before or concurrently with field reconnaissance. At this stage all that may be necessary is a check of the standard archives and main published references. Detailed study of historic maps and documents is often better done at a later stage. The desire to know as much as possible in advance about the site or landscape to be surveyed, has to be balanced against the wish to see that site or landscape with fresh eyes and without prejudice (Bowden 1999, 31–2).

Archaeological databases in Britain contain a wealth of existing records of the sort created by the activities described here. These include antiquarian drawings, plans and reports, OS Archaeology Division records, aerial photographs and excavation records. Some of these have inherent problems, but careful study may, nevertheless, reap substantial rewards.

A number of organisations compile indexes to sites and other information that might be relevant in the planning stages of a survey project. The addresses of these organisations (in Britain) can be found in the yearbooks and directories published by the Council for British Archaeology (CBA) and by the Institute of Field Archaeologists (IFA) and on their websites.

The main sources of information are:

- National Monuments Records (NMR)
- Historic Environment Records (HER) or Sites and Monuments Records (SMR)
- Ordnance Survey (OS) plans: basic scale, derived and historical maps
- EH (or equivalent), particularly in

respect of Scheduled Sites, Monument Class Descriptions, etc
- published sources (authoritative books and journals)
- historic maps (pre-OS): tithe maps, estate maps, enclosure awards, etc
- British Geological Survey maps at 1:50 000 and 1:10 000 scales
- air photographs: the principal collections (verticals and obliques) in England are held by the NMR and Unit for Landscape Modeling (ULM: formerly Cambridge University Committee for Aerial Photography); contract and independent photography
- other local or specialist data, such as museum, archaeological unit, university or local knowledge
- County Records Offices, private records collections and National Archives

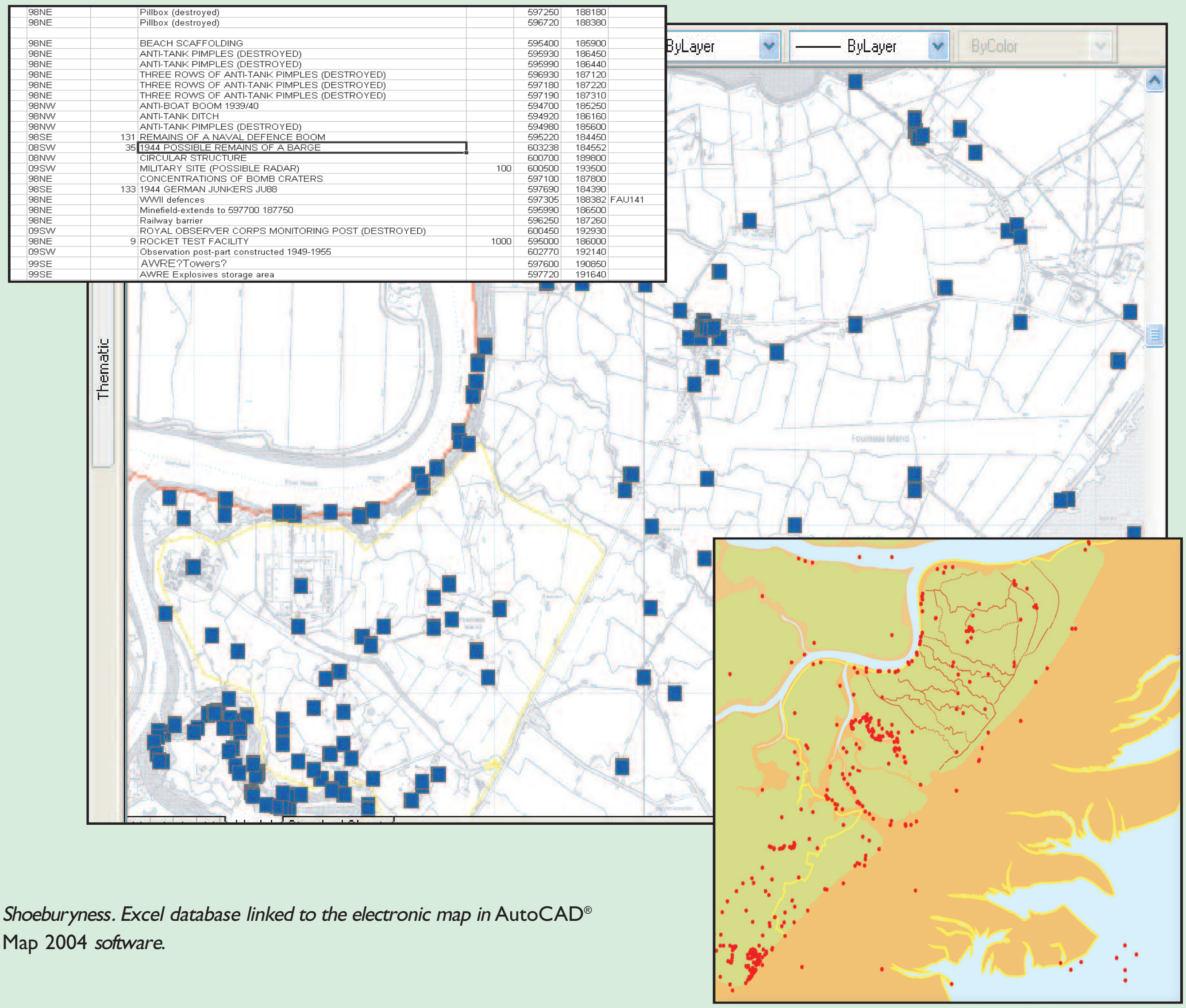
Case Study 2

MOD Shoeburyness Range, Essex: a Level I study of a diverse archaeological landscape

Five of the six low-lying islands forming the Foulness archipelago on the north side of the Thames estuary in Essex lie within the boundary of the Ministry of Defence Shoeburyness artillery range. In 2003, the Shoeburyness range was chosen by EH for one of a number of pilot studies to investigate how changes to the legislation covering the protection of archaeological sites and historic buildings might be implemented. The range was selected because it has a diverse historic environment and is in single ownership (Defence Estates). The historic features include seventeen listed buildings, one scheduled Romano-British burial site, the former Atomic Weapons Research Establishment (AWRE), a section of model Atlantic Wall used in Second World War military training and extensive evidence for medieval and later land-reclamation. The intertidal zone also preserves a variety of archaeological remains, while there are records of over 70 shipwrecks in the part of the estuary covered by the range.

The first stage of the pilot study involved a Level I survey of the range. The survey was a restricted to a desk-top study aimed at assembling information on historical and archaeological sites and finds within the range in a single database linked to a digital map of the area in order to form a GIS.

The study began by assembling a base map for use in the GIS in AutoCAD® 2004. The requirement was for a large-scale background map onto which data produced by the pilot study could be overlain and therefore the OS 1:10 000 Raster® map was selected in preference to the more complex 1:2 500 scale MasterMap®. As the name suggests the OS Raster® map is a scanned map background offered in 5km by 5km tiles in either black and white or colour. The black and white version was selected in order to lessen the file size and also to ensure that



98NE		Pillbox (destroyed)		597250	188180	
98NE		Pillbox (destroyed)		596720	188380	
98NE		BEACH SCAFFOLDING		595400	185900	
98NE		ANTI-TANK PIMPLES (DESTROYED)		595930	186450	
98NE		ANTI-TANK PIMPLES (DESTROYED)		595990	186440	
98NE		THREE ROWS OF ANTI-TANK PIMPLES (DESTROYED)		596930	187120	
98NE		THREE ROWS OF ANTI-TANK PIMPLES (DESTROYED)		597180	187220	
98NE		THREE ROWS OF ANTI-TANK PIMPLES (DESTROYED)		597190	187310	
98NW		ANTI-BOAT BOOM 1939/40		594700	185250	
98NW		ANTI-TANK DITCH		594920	186160	
98NW		ANTI-TANK PIMPLES (DESTROYED)		594980	185600	
98SE	131	REMAINS OF A NAVAL DEFENCE BOOM		595220	184450	
08SW	35	1944 POSSIBLE REMAINS OF A BARGE		603238	184552	
08NW		CIRCULAR STRUCTURE		600700	189800	
09SW		MILITARY SITE (POSSIBLE RADAR)	100	600500	193500	
98NE		CONCENTRATIONS OF BOMB CRATERS		597100	187800	
98SE	133	1944 GERMAN JUNKERS JU88		597690	184390	
98NE		WWII defences		597305	188382	FAU141
98NE		Minefield-extends to 597700 187750		595990	186500	
98NE		Railway barrier		596250	187260	
09SW		ROYAL OBSERVER CORPS MONITORING POST (DESTROYED)		600450	192930	
98NE	9	ROCKET TEST FACILITY	1000	595000	186000	
09SW		Observation post-part constructed 1949-1955		602770	192140	
99SE		AWRE?Towers?		597600	190850	
99SE		AWRE Explosives storage area		597720	191640	

Shoeburyness. Excel database linked to the electronic map in AutoCAD® Map 2004 *software.*

data added from the pilot study would stand out clearly from the base map. Fifteen map tiles were obtained to cover the study area and as the OS have edge-mapped each tile with its neighbours, it was a simple task to bring them together using AutoCAD® software to form a single, uninterrupted base map.

A database of historic and archaeological sites and finds was compiled for the area covered by the map base using Microsoft Excel 2002 software. The area of the map base was chosen rather than just the study area in order to highlight significant sites on the periphery of the study area. The records forming the database came from two main sources. The first were the AMIE, Listed Building and SAM records held in databases administered by the NMR in Swindon, all of which are retrievable through the EH WebGIS system. The second is the Essex HER database, which is available on-line (SEAX). Records that did not appear in either of these two databases were added from other sources, such as the reports produced by the Foulness Archaeological Society, the Defence of Britain project and through the interrogation of historic OS mapping.

The completed database was attached to the base map using AutoCAD® Map 2004 software in such a way that each record in the database appeared as a dot. This linkage allowed the results of queries formulated in the database to appear on the map and also provided access to individual database records through highlighting data points on the map.

Two main problems were encountered when compiling the project database. The first was the poor quality of the positional information recorded in the existing databases. Of the 400 records in the area of the pilot study, about 50 (12%) are located to an accuracy of worse than 100m. The second was the lack of detail contained in the majority of the recorded descriptions, which limits the use of the existing records as a decision-making tool for heritage protection. In some instances it was not clear if an individual record referred to an extant site or one that had been destroyed. Nor was it always clear when records from different data sources referred to the same site. These issues will be addressed in a later phase of the pilot study, which will allow for more detailed background research and for the checking of selected features on the ground.

The main product of the survey was the GIS created by linking the database to the map. Through use of the GIS it is possible to create distribution maps and to locate specific sites earmarked for inspection on the ground. Information was taken from the GIS to compile an assessment report highlighting those sites recommended for designation in the register of historic assets. The text of the assessment report was supported by a series of distribution maps created directly from the GIS and brought into Adobe Illustrator software for completion to publication standard. The project archive will be deposited in the NMR in Swindon.

Analytical earthwork survey

Survey techniques

The process of archaeological field surveying and plan production, at any scale, can be broken down into three tasks: Reconnaissance, Observation and measurement, and Depiction.

Reconnaissance

Reconnaissance (`recce') is the process of preliminary inspection and is critical to the success and cost-effectiveness of any survey. Thorough reconnaissance pays dividends in the long run by identifying problems at an early stage and allowing them to be quantified, rather than emerging as surprises later. Time spent on reconnaissance is rarely wasted, although it should be proportionate to the size and extent of the survey.

Although reconnaissance belongs within the earliest stages of a survey, before venturing into the field the fieldworker (or a colleague) should undertake some preliminary 'desk-top' appraisal so as to get the best value from the time spent on the reconnaissance. Armed with this material the fieldworker can assess the quality of information for any site or landscape and thus identify gaps or weaknesses in the record; reconnaissance time can then be targeted at specific sites or questions, as necessary.

Perceptions of a site or landscape acquired through the desk-top assessment are often radically altered once the ground evidence is examined. During the reconnaissance itself the fieldworker should address the site from three main perspectives: Archaeological Assessment, Survey Strategy and Site Logistics.

Archaeological assessment
One objective of the reconnaissance might be to identify the archaeological significance and extent of a site or landscape. This may result in identification of previously unrecognised earthworks, re-interpretation of known features or confirmation of existing knowledge. It is not, however, necessary to make detailed observations about archaeological interpretation at this stage; understanding of the archaeological remains may only come during, and because of, the survey.

It is good practice to perambulate not only the site but the surrounding area; this will ensure that its full extent can be determined and its landscape context established. The archaeological hinterland can often reveal as much evidence for interpretation as the site itself. Modern land use, which might have influenced the physical form of a monument, needs to be considered as part of this process, as well as the historical and archaeological influences.

Survey strategy
The choice of survey strategy will then come into consideration. That choice can range from a line or dot on a map with the briefest of notes (Level 1), to a large-scale measured survey and detailed report (Level 3). A number of factors will have to be taken into account:

- **purpose of the survey.** Is it a detail survey for management purposes or a rapid identification survey? The time and cost of large-scale surveys has to be justified. The level may have been specified by a client but flexibility of approach has to be built into the reconnaisaance, as field observations may change the initial desk-based perception and lead to re-definition of the brief. In a commercial situation the brief will be prepared by a curator or consultant and they should satisfy themselves, through reconnaissance, that the level is correctly set; once the contract is awarded the contractor will not exceed the brief.
- **size of area**. This is often the biggest single influence on the choice of surveying methodology. If the area is large but adequately covered by large-scale OS maps (1:2 500 or 1:1 250) surveying within mapped detail, such as field boundaries, may be the most cost-effective method; any surveying technique can be applied to recording the archaeology within a map base. Where

there is no large-scale map detail to work from, surveys of large areas become more demanding in terms of maintaining accuracy (*see* Case Studies 4 and 5).

- **survey methodology and equipment.** What are the most appropriate techniques and equipment to suit the proposed task? Methodology may be dictated by the available equipment but one of the tasks at the reconnaissance stage is to identify the most appropriate equipment to undertake the task.
- **scale of survey.** Scale will be influenced mostly by the purpose of the survey. If it is intended to be used as a management document and has to include fine detail of earthworks and structures, then the largest scale practical is required (1:500 or occasionally 1:250). A scale particularly suited to earthwork portrayal, showing detail and yet covering large areas sensibly, is 1:1 000. If the purpose is less geared to detail and more to wide coverage, identification and basic interpretation, OS large-scale mapping at 1:2 500 or 1:1 250 offers a solution. Large areas can be covered at 1:2 500 while still allowing the salient details of individual monuments to be portrayed. Very large area landscape recording is best addressed at 1:10 000 scale, the most detailed map scale available in upland Britain; alternatively, air photographic transcription provides a method of supplying custom-made, accurate large-scale maps, and lidar may be of value here. Doubling the scale may mean quadrupling the number of measurements needed, and therefore the time taken. As a rough guide, at 1:1 000 scale it is possible for an experienced team to survey 1ha of open ground in a day. The use of electronic survey equipment does not absolve the surveyor from thinking about scale at the reconnaissance stage, because the scale of the final product dictates the level of detail to be recorded and therefore the number of measurements that must be taken.
- **personnel.** Identification of the number and skills of people required for the survey, and any training requirements (*see* Case Study 1).
- **timescale.** Time limits, possibly subject to external factors over which the fieldworker has no control, can be a significant influence on the choice of methodology. It may be more efficient when dealing with large areas to undertake rapid surveys to identify the nature and extent of archaeological remains, followed by more detailed survey of specific areas, rather than attempting large-scale survey at the start.

Case Study 3

Stafford Common, Staffordshire: a Level 2 survey arising from a national study of town commons

As part of a project studying archaeological remains on urban commons, EH carried out Level 1 (reconnaissance) surveys across England and followed this up with a number of Level 3 (detailed) surveys of selected sites. During a Level 1 survey of Stafford Common, archaeological earthworks of field boundaries and ridge-and-furrow dating from the time before the Common was created in the late 18th century were discovered. In addition to this, there were old quarries and the site of a pumping house used to supply the town's brine baths. Combined with interesting documentary information about the Common, the features still visible on the ground today illustrate well the story of the Common's past, and it was felt that they were sufficiently important to warrant a higher level of recording. However, as time and resources were limited, Level 2 rather than Level 3 was the chosen option.

The method selected was to use navigation-grade hand-held GPS with data recording capability to survey the features discovered on the Common at a final plan-scale of 1:2 500. This would normally give an accuracy of only 10m, which would produce errors unacceptable at that scale, but by using a post-processing option (where the data collected by the hand-held navigation-grade receiver is processed against the OS Active GPS base stations after downloading to computer) this error was refined to an order of 1m. The method was found to be fast and cost effective, taking a single person 4.5 days to survey an area of 45ha, much of which was densely covered with earthworks. This methodology adequately filled the gap between reconnaissance and detailed survey. The EGNOS satellite was not functional at the time of the survey, but when it is available the accuracy of surveys using hand held GPS equipment such as this will be increased, such that errors are always better than 1m (*see* Ainsworth and Thomason 2003).

The survey data was converted into AutoCAD® drawing files, and a finished plan is to be prepared using Adobe Illustrator software. The information gained from the survey will be published and the project archive will be deposited in the NMR in Swindon.

The new generation of hand-held, mapping-grade differential GPS enables positioning against OS mapping to within 0.5m to 1.0m accuracy in real time, and is highly portable. This technology is therefore ideal for small-scale and medium-scale survey and mapping. The system comprises a hand-held unit and a beacon (here mounted on a belt). The beacon tunes into a network of broadcast maritime navigation signals that provide real-time corrections into OS National Grid, and thus no post-processing is required. These are transmitted by Bluetooth connection to the hand-held unit into which OS digital maps can be uploaded. When combined with feature-coding software, survey data can be recorded directly onto the map.

Site logistics

Some of the unpredictability of fieldwork can be eliminated by assessing:

- ownership and access
- health-and-safety
- legal constraints. Is the site a SAM or a Site of Special Scientific Interest (SSSI) or is there any other constraint on the land?
- other potential problems. Is the site frequently used by the general public? Will there be grazing animals on site? Will vegetation (trees, undergrowth, bracken) preclude survey at certain times of the year?

Observation and measurement

Principles of surveying

The main principles of survey must be applied to all surveys whatever the extent or final scale of plan: (1) Control, (2) Economy of accuracy and consistency, (3) The independent check and (4) Revision and safeguarding. Work should always proceed from control to detail – making sure the whole framework is accurate before surveying individual components within that framework.

1. Control

Control is an accurate framework of carefully measured points within which the rest of the survey is fitted. Survey of detail between these control points can then be carried out by less elaborate methodology or equipment. Control can take the form of a network of points placed by the surveyor, such as pegs, or existing features, such as telegraph poles, fence junctions, building corners, whose relative positions are carefully measured. The principle of control applies regardless of the scale of survey, although generally the larger the scale the more carefully control has to be measured. The accuracy of the finished plan is determined by how carefully this control is surveyed; the larger the scale, the more errors become identifiable.

Previously mapped features are a ready-made control framework to which archaeological detail can be related, but only at the scale at which they were originally surveyed; enlargement of a plan will enlarge any errors in the original. Control can also be established by using GPS and tied to OS National Grid using the network of 'active stations' (details on the OS website). However, the accuracy of the control is dependant upon the type of GPS equipment used (see Ainsworth and Thomason 2003).

2. Economy of accuracy and consistency

This applies to both *linear* and *angular* measurements; as a general rule, the higher the standard of metrical accuracy, the higher the cost in time and money. It is important therefore to decide at the planning stage what standards of accuracy are required. In determining accuracy requirements, the main considerations are: the best method of presenting the survey information, the scale of final plot or maps and possible re-use of data (such as co-ordinate values).

Accuracy is usually quoted as a representative fraction that shows the ratio of the magnitude of the error (the difference between true value and measured value of a quantity) to the magnitude of the measured quantity. An error of 0.10m over 1,000m gives 1/10 000 – high accuracy (the error would not show on most map and plan scales). An error of 1.0m over 1,000m would result in an accuracy of 1/1 000, which would still be acceptable for most archaeological surveys. To achieve 1/10 000 over large areas requires precise techniques and equipment, whereas 1/1 000 can be achieved with careful tape measuring and basic equipment. Because accuracy is a relative term it is important to define the context of its use in relation to archaeological survey.

There are three areas of accuracy that the archaeological surveyor needs to be aware of:

- accuracy of measurement – governed by care and consistency in reading measurements
- accuracy of equipment – ensured by choosing appropriate equipment for the task
- accuracy of portrayal – equivalent care and precision is required in drawing technique and employing methods of depiction appropriate to the scale of survey, to ensure that the final plan reproduces the field observations faithfully

The archaeological surveyor should also be aware of three categories of error which are likely to affect accuracy:

(a) *gross* – eliminated by care in observing, measuring and drawing
(b) *systematic* – caused by a constant factor such as a stretched tape, or a poorly calibrated theodolite or EDM; these errors are cumulative – their effect will increase throughout the survey
(c) *random or accidental* – less quantifiable errors can still occur even though all effort has been made to eliminate (a) and (b). Checking a finished survey 'by eye' is often the best way of identifying such errors (*see* 3 below).

The standard of accuracy can change with each stage of the survey but it can never be more accurate than the control. Standards at each stage of survey must be consistent. Therefore, economy dictates that accuracy at all stages is of the necessary standard to achieve consistency and that time and resources are not wasted trying to achieve a higher standard of accuracy than necessary.

3. Independent check

Checks should be undertaken at each stage, so that any errors or problems are solved before moving on to the next. Some methods are self-checking, such as mathematical solutions when computing co-ordinates; others may be more mechanical, such as checking regularly that a plane-table is correctly aligned. Clearly it is important to ensure that the control is right before moving on to detail survey. At the end of the job, the surveyor should walk over the ground with the finished field plan in hand to see if it 'looks right' and to make sure that nothing has been missed.

4. Revision and safeguarding

It is usually possible to plan and execute a survey so that it can be added to or revised at a later date, thus increasing the value of the original investment in time and resources. This process can be aided by simple procedures, such as recording the positions of ground markers in relation to nearby permanent features, so that they can be found again and re-used, or ensuring that topographical detail that is likely to have permanence, such as walls and buildings, forms part of the control and appears on the final plot.

Surveying equipment

Surveying is about measuring two components: *angles* and *distances*. All surveying equipment is designed to measure one or both of these. What usually differentiates equipment, and consequently cost, is the accuracy attainable.

It is quite possible to produce surveys with basic equipment, although when the area is large and there is a requirement to preserve accuracy more sophisticated equipment may be necessary. However, lack of access to modern electronic surveying equipment should be no barrier even to undertaking large surveys. Before the 1970s *all* surveying was undertaken with manual theodolites, plane-tables and chains, to very high accuracies; the principles never change, only the practice and level of technology. Surveys of almost any size can be achieved with a combination of a theodolite, plane-table and tape measures. Small to medium-sized areas can be recorded, even at large scales, using a plane-table, optical squares and tapes. Compass and pacing alone can be perfectly adequate for small-scale (1:10 000) surveys, although hand-held GPS now offers a cheap solution and is rapidly coming into universal use.

Personnel

Most instrumental survey, optical or electronic, requires a team of two, or occasionally three. Tape-and-offset can be done by a single person but the advantages of working in teams must be considered; solving problems in survey and in archaeological interpretation benefits from dialogue, and working alone can be a health-and-safety risk.

Usually one person, who will be responsible for drawing the final plan and writing the report, will take the lead. This is because there is no single 'right' way to survey any site or landscape; decisions have to be made at every stage and those decisions must be consistent. The part of the job requiring skill and thought is knowing *what* to record, ie positioning the prism or staff, and consequently the team leader generally takes this role.

The process of surveying

At small to medium scales (1:10 000 – 1:2 500) archaeological detail can be added to existing map bases by taping or pacing, and the use of simple angle-measuring instruments such as optical squares and compasses (Farrer 1987). In remote areas, where local map detail is sparse, archaeological features can be supplied by resectioning or traversing (Bowden 1999, 52–3, 56–7), but hand-held GPS is now frequently deployed (Ainsworth and Thomason 2003).

After reconnaissance the process of measured survey at larger scales (1:2 500 and larger) can be broken down into two main tasks: (1) Control survey and (2) Detail survey.

1. Control survey

Where the control framework is not provided by map detail it must be supplied from scratch. Factors identified at reconnaissance stage such as the size of the area, accuracy, scale and equipment required will all influence the most appropriate control methodology. There are two main types of survey control, *regular grid* and *irregular grid*. A rectangular grid of pegs as control for an excavation is an example of a regular grid.

The *irregular* or mathematical grid is a scatter of detail control points observed from control stations and placed on or near to archaeological and topographic features at the will of the surveyor; the grid is invisible and exists only as a mathematical background when computing co-ordinates. This is the type of grid system used by most surveyors and mapping organisations.

The mathematical grid used by the OS is known as the National Grid. If an archaeological survey project utilises the same system of co-ordinated control points established by the OS this will ensure that it can be fitted to existing mapping. This is automatically supplied by the use and transformation of differential GPS, but it is not necessary for small, discrete archaeological sites surveyed by more traditional methods, although sufficient immovable detail must be surveyed to 'fix' the site so that the survey can be related to OS mapping for location. These 'divorced surveys' can be referenced to a site grid with a false origin. Although convention expects surveys to be oriented to the north this is not necessary with divorced grids as the control is laid out to suit the site. To avoid any confusion north arrows should appear on all plots and drawings.

Most modern electronic survey tools have on-board co-ordinate displays and calculation facilities, which allow divorced grids to be defined, and most will accommodate OS National Grid calculations on site, or via computer software. Values read from any angle measuring instrument and any linear measurement technique (*polar co-ordinates*) can be converted to *rectangular co-ordinates* for plotting on a grid system with a calculator with trigonometric functions, or they can be plotted manually on graph paper; it is not necessary to have electronic instruments to establish this type of grid system for a site.

Control consists of two parts, *Control Stations* (where instruments are set up during control survey) from which *Detail Control* (points from which the detail will be surveyed) is supplied. The control scheme should also include 'hard' detail. 'Hard' detail consists of objects where there is no question as to the point to be measured, including buildings, walls and telegraph poles, but also any masonry elements of archaeological interest. Many natural features, such as rock outcrops, boulders and cliffs can often be treated as 'hard' detail, as can well developed and distinct ridge-and-furrow. 'Soft' detail includes all other archaeological earthworks where the points to be measured are a matter for subjective judgement.

The control plot

However control survey is undertaken the final result will be a control plot, on polyester film for stability and ease of use, showing all the positions of the stations, detail control and 'hard' detail. Because of the variety of printers and plotters, and rapid advances in technology, defining standards is difficult. However, the minimum recommended thickness for plotter film for use in the field is 100microns. As most plotter inks are not waterproof it is advisable to print a reverse image of the plot and place this face-down on the drawing board to protect it from rain. This plot will then be taken into the field to form the basis of the detail survey.

Case Study 4

The South-East Cheviots Project, Northumberland: a Level 2 survey of an upland landscape for management purposes

This project was undertaken by the former RCHME (now part of EH) between 1985 and 1989 to record and study this remarkably well preserved historic landscape. The project area covered 66 km^2, mostly within the Northumberland National Park, and was designed to inform research and management of this upland landscape. Because of the size of the area, recording against a map background was considered essential. However, the area was only covered by 1:10 000 scale OS mapping, which was not considered to be sufficiently detailed to allow portrayal of the