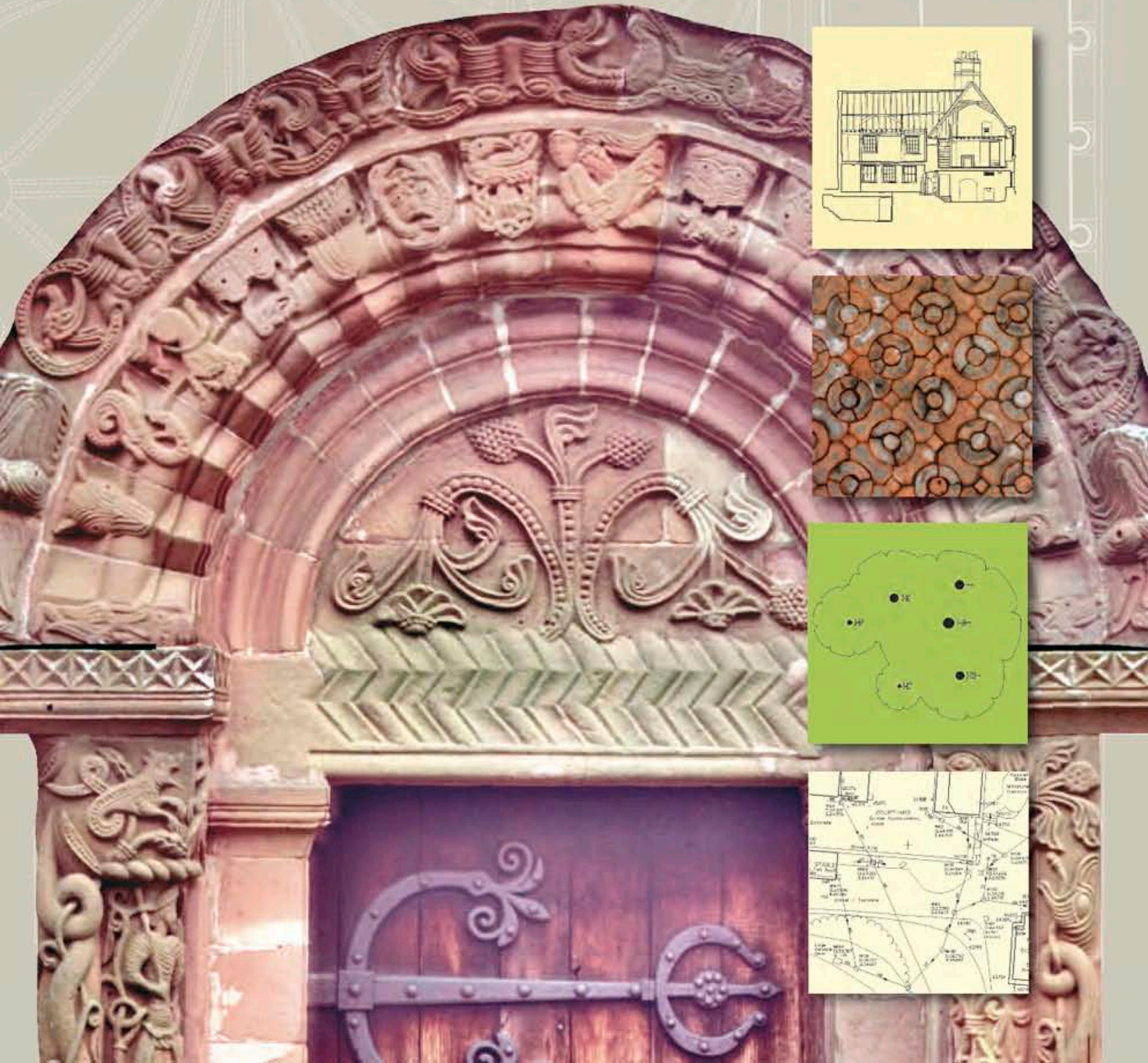
ENGLISH HERITAGE

Metric Survey Specifications for Cultural Heritage

Authors: **Paul Bryan, Bill Blake and Jon Bedford**
with contributions from: **David Barber and Jon Mills**
Editor: **David Andrews**



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Contents of Metric Survey Specifications for Cultural Heritage

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Preface

The survey brief

The preparation of a brief for the supply of survey services based on the options in this specification should ensure the necessary communication between the information user (the client) and the information supplier (the surveyor) required for the successful application of metric survey.

Performance of metric survey in heritage documentation

In order to obtain metric survey fit for the purposes of heritage management it will be necessary to consider not only the metric performance of measured data but also the required quality of work needed to act as both a record and an archive of the cultural heritage. The conventions of selection and presentation of measured drawing in architecture constitute a visual language that requires careful consideration. This specification contains both descriptions and illustrations of the required standard.

Use of the specification

This document is a description of the services and standards required for the supply of various types of metric survey. Sections 1, 2 and 3 describe the general terms, performance and presentation requirements common to all services. Sections 4, 5, 6 and 7 contain standards specific to image-based survey, measured building survey, topographic survey and laser scanning, respectively. The use of any part of this specification without reference to the appropriate clauses of sections 1, 2 and 3 plus the appropriate service description from parts 4, 5, 6 and 7 will be a miss-use of the document and is very likely to result in an unsatisfactory product. While it is hoped that this specification will be distributed widely and is available for anyone to use, its use is not a guarantee of the required results and it is recommended that, if in doubt, professional advice is sought.

Structure of the document

This document follows the Royal Institute of Chartered Surveyors (RICS) standard for specifications. The contents of the right-hand pages constitute the clauses of the specification, while the left-hand pages contain guidance pertinent to those clauses. Where the title of a clause on a left-hand page is prefixed by a # symbol, then the clause requires intervention from the user of the document. This usually takes the form of making choices from a list by deleting the options that are not required, but may also require ticking required options in a list or the insertion of text. If a clause is not edited, then the first option should be taken as the default. In most cases this will be the recommended option.

Acknowledgements

The preparation of this specification would not have been possible without the work of those, past and present, charged with the survey of the historic estate in the care of English Heritage. This edition has particularly benefited from the input of all at the Metric Survey Team: David Andrews (sections 1–7), Paul Bryan (sections 1, 2, 3, 4 and 7), Bill Blake (sections 2, 3 and 5) Jon Bedford (sections 2, 3, 5, 6 and 7). Publication collation by Heather Papworth with technical support from Mick Clowes, Andy Crispe and Steve Tovey. Section 7 is derived from text supplied by Dr David Barber and Professor Jon Mills of the School of Civil Engineering and Geosciences, University of Newcastle upon Tyne, with support from English Heritage Archaeology Commissions.

Section 1

General Conditions and Project Information

1.1.2 #Purpose of project

Give a brief description of the type of survey required and the intended end use.

1.1.3 #Location

Give as much detail as possible including a full postal address with post code.

1.1.4 #Access arrangements

Give opening hours where applicable the name and telephone number of a site contact plus any one else who would need to be informed of, or give permission for, attendance on site.

1.1.5 #Health and safety statement

Make reference to the client or site owner's health and safety policy, any existing risk assessment or any particular hazards the contractor should be aware of.

1.1.6 #Copyright

State who is to retain copyright of all materials resulting from the survey.

1.1.7 #Contract

State the conditions of contact that are to apply to the project. If the client does not have their own conditions it is recommended that the following is used.

RICS Terms and Conditions of Contract for Land Surveying Services 2001, available from RICS Books ISBN 1 8421 9012 1; www.ricsbooks.com

1.1.8 #Site clearance

State whether or not the site is free from obstructions and whether any clearance will be undertaken prior to the survey commencing. This is particularly relevant for image-based surveys.

1.1.9 #Completeness of survey

State, given the above, the degree of completion required and whether field completion by other means will be required for image-based surveys.

1.1.10 #Area and scale of survey

Describe the area and scale of survey required as comprehensively as possible preferably with the aid of a map.

1.1.11 #Type of survey required

Indicate the type of survey that will be required for each area.

1.1.12 #Delivery schedule

Give the final deadline plus any phasing of delivery that may be required. Allowance will need to be made for lead times, fieldwork and office processing.

1.1.1 Name of project

1.1.2 Purpose of project

1.1.3 Location

Address …

Directions …

National Grid Reference …

1.1.4 Access arrangements

1.1.5 Health and safety statement

1.1.6 Copyright

1.1.7 Contract

The conditions of contract are …

1.1.8 Site clearance

1.1.9 Completeness of survey

1.1.10 Area and scale of survey

1.1.11 Type of survey required

1.1.12 Delivery schedule

1.2 Introduction

The general conditions cover aspects of undertaking survey that are common to most metric survey activities carried out on historic sites. The project information will consist of the administrative and logistical aspects of a particular project.

1.2.1 Pertinent legislation

Contractors are to be aware of all current statutory requirements relevant to the contract for survey work. The contractor's attention is brought to:

- Ancient Monuments and Archaeological Areas Act 1979
- Planning (Listed Buildings and Conservation Areas) Act 1990
- The Construction (Design and Management) Regulations of 1994, introduced under the Health and Safety at Work Act 1974

Copies of the above legislation can be obtained from The Stationery Office

www.tsoshop.co.uk

tel 0870 242 2345

Where the survey work occurs in countries other than England the law of that country will apply.

1.2.2 Client's guidance on matters concerning survey

Contractors are required to comply with the client's guidance on matters of safety and standards of work regarding the historic fabric.

1.3 The contract and other documentation

1.3.1 Contract

The contract will consist of the conditions noted in section 1.1.7 of the project brief, this specification including any edits made specifically for the project plus any attached documents or diagrams.

1.3.2 Method statement

In response to a request for a quotation or invitation to tender a method and resource statement is to be provided by the contractor. It must include:

- method proposed for providing survey control and the required detail;
- number of and positions of staff to be employed on project, including project leader;
- survey equipment, cameras etc to be used;
- access equipment to be used;
- lighting and electrical equipment to be used;
- any proposed alternative survey methods and their performance;
- the anticipated level of possible 3-D site completion;
- anticipated use of oblique imagery;
- proposed output device, resolution and media;
- data retention and archiving arrangements;
- and delivery schedule.

1.3.3 Risk assessment

A risk assessment must also be supplied with the quotation or tender.

1.3.4 Site visits

The contractor may wish to visit the site to verify the requirements of the project and facilitate the production of the quotation or tender, the method statement and the risk assessment.

Where access to land not in the client's care is necessary, assistance will be provided to secure the appropriate way-leaves.

1.4 Contractual details

1.4.1 Completion of survey

The client will seek agreement with the contractor on the extent of cover, within the acceptable limits of tolerance and method (ie are there areas that require an alternative survey technique or that cannot be covered). Where obstructions to survey exist, the client will seek agreement about the possible extent of completion.

1.5.2 #Health and safety requirements

Edit as appropriate.

1.4.2 Right of rejection

The client reserves the right to reject the application of any proposed survey technique or submitted survey product.

1.5 Health and safety

1.5.1 Contractor's responsibilities for safety

The following requirements are included here as a guide and contractors must ensure that all relevant safety requirements, associated with provision of survey on behalf of the client are met during the contract period. The contractor's attention is brought to the need for best practice in matters of safety.

1.5.2 Health and safety requirements

The client's health and safety requirements are either

(a) found at 1.1.5; or

(b) attached to this document.

Use of artificial illumination in historic buildings

English Heritage Fire Safety Instruction No. 3 (*see* Appendix 1.1), gives advice on the use of artificial illumination at historic sites that will be of use to the client and contractor.

1.5.3 Health and Safety at Work Act 1974

Under this Act employers have responsibilities to their employees and those affected by their work (eg members of the public and staff on the site). Further information on this can be obtained from:

Health and Safety Executive
www.hse.gov.uk
Infoline tel 0845 345 0055

To order a publication

www.hsebooks.com
tel 01787 881165

1.5.4 Construction (Design and Management) Regulations 2007

The Construction (Design and Management) Regulations 2007 introduced under the Health and Safety at Work Act 1974 relate to contractor's responsibilities for safe working practice on construction projects. These regulations exclude site survey work prior to a contractor starting on site but it is good practise to apply the principles of the regulations, so that the client, surveyor and designer plan for the safety of everyone involved in the project.

The points below do not constitute an exhaustive list but are considered relevant to contractors undertaking survey work on historic sites.

Risk assessment

The client will require a risk assessment from the contractor prior to the site survey work commencing. This will identify hazards during the fieldwork stage and set out the contractor's method of eliminating or managing the risks.

Access equipment

Access equipment supplied or used by contractors or their agents must conform to the current safety standards. Contractor's attention is drawn to:

- Work at Height Regulations 2005 SI 2005/735 The Stationery Office 2005, ISBN 0 7176 2976 7; www.opsi.gov.uk/si/si2005/20050735.htm
- Lifting Operations and Lifting Equipment Regulations 1998. Found in *Safe Use of Lifting Equipment* available from HSE Books, ISBN 0 7176 1628 2
- Provision and Use of Work Equipment Regulations 1998. Found in *Safe Use of Work Equipment* available from HSE Books, ISBN 0 7176 1626 6

Full details, certification and nominated safety contacts on proposed access equipment, where relevant, are to be included in the method statement. The contractor will comply with English Heritage Safety Instruction No. 7.4, Safe Use and Maintenance of Ladders (*see* Appendix 1.3).

Electrical equipment

Where applicable electrical equipment (the use of domestic/battery operated equipment is not included) must meet the requirements of the Electricity at Work Regulations 1989. Found in the *Memorandum of Guidance on the Electricity at Work Regulations 1989* available from HSE Books, ISBN 0 7176 1602 9.

On inspection, all mains powered equipment, including extension leads, shall have a Portable Appliance Test certificate that is no older than three months.

The contractor will comply with English Heritage Safety Instruction No. 7.2, Portable Electrical Equipment (*see* Appendix 1.2).

Survey equipment

Survey instruments or associated laser pointing devices, which may be a health hazard to people working in or visiting the site during the project, must be included in the risk assessment. Any certificates or statements from the manufacturers concerning the safety of the equipment must be included in the assessment along with any requirement for notification of 'lasers in operation' on site. English Heritage requires all such equipment to comply with:

> BS EN 60825 *Safety of Laser Products: Equipment classification, requirements and users' guide*.

1.6.1 Use of marks

For further details on obtaining scheduled monument consent see the following link to the Department of Culture, Media and Sport.

> http://www.culture.gov.uk/what_we_do/Historic_environment/historic_property/scheduled_ancient_monuments.htm

1.6 Damage to site and fabric

Contractors are reminded that there is a range of penalties and powers of prosecution under the provisions of the Ancient Monuments and Archaeological Areas Act 1979 and the Planning (Listed Buildings and Conservation Areas) Act 1990 should unauthorised work be carried out or damage be caused to the building or monument.

1.6.1 Use of marks

The use of nails, permanent station markers, etc is subject to approval of the mark and its location. The insertion of any mark may require scheduled monument consent (SMC) and must not be done without the permission of the client.

1.6.2 Use of surface attachment for targets

Surface-mounted targets, such as for photographic control, must be fixed with an approved adhesive that will allow removal without damage to the surface.

1.7 Survey material supplied

1.7.1 Copyright

The copyright of all materials generated as part of the contract is to be transferred to the client unless stated otherwise in section 1.1.6.

1.7.2 Retention of survey documentation

On request the contractor shall make available to the client all materials used for the compilation of the required survey. This information must be retained on file by the contractors for a minimum of six years.

This material will include: field notes and/or diagrams generated while on site; the raw and processed data used for the final computation of co-ordinate and level values; and a working digital copy of the metric survey data that forms each survey (including formatted 2-D and ‘raw’ 3-D data files).The precise digital format and file type of this archive will be specified in section 3.1. If during this period the contractor wishes to change the format of this data archive, they are to seek the client’s permission.

APPENDIX 1.1

Fire Safety Instruction No. 3, Use of Temporary Lighting in Historic Buildings

This Fire Safety Instruction is for the particular attention of all staff who may use or specify heat producing lamps in historic buildings. It is also for the general information of custodial staff and site managers.

Use of temporary lighting in historic buildings

Several fire incidents and near misses involving portable and fixed halogen lamps have occurred in our properties. In view of these incidents the following guidance should be adopted at all properties controlled by English Heritage.

1 'Hot Work' policy

1 Halogen lamps and lamps that operate at high temperatures should not normally be used as temporary lighting in historic properties.

2 Temporary lighting units that produce excessive heat, such as halogen lamps should be considered as 'heat producing appliances' coming within the terms of the 'English Heritage Hot Work Policy'. As alternative lighting equipment is usually available, and will provide an adequate substitute (*see* Alternative Sources of Lighting.), there will be very few cases where there is a need to issue a 'Hot Work Permit' for heat producing lamps.

2 Permitted exceptions

See also Particular Guidance on Heat Producing Lamps.

(a) *Long term specialist conservation work*

In some circumstances where long term specialist conservation work may require the use of portable halogen or similar lighting, a written 'Risk Assessment and Method Statement', should be drawn up for the duration of the work and approved by English Heritage Health & Safety section and the Regional Director.

(b) *Specialist contract conservation work*

In the case of contract work where none of the alternative lighting systems are suitable an approved 'Risk Assessment and Method Statement' should be written into the contract documentation. Approval should only be given at Regional Director level and the work on site frequently monitored by English Heritage 'Client Side' Staff.

(c) *Specialist photographic work*

Where Halon type lamps are constantly in use by English Heritage photographic staff, a general 'Risk Assessment and Method Statement' is to be drawn up in conjunction with the English Heritage Health & Safety section, to cover use in all Historic Properties. A copy of the 'Method Statement' should be available for inspection and carried by every staff member permitted to use heat producing lamps.

(d) *Conservation inspection lamps*

It is accepted that small portable mains/battery operated halogen lamps are required by English Heritage staff for conservation inspection work subject to all staff members using the lamps abiding by the following 'Method Statement'.

1 Whenever used they must not be left unattended until the equipment has cooled.

2 In the case of mains operated lamps, they must also be unplugged from the wall socket when left unattended.

3 They should not be used when flammable liquids are being used or present in the same area.

Portable inspection lamps used by conservation staff from organisations other than English Heritage must be covered by a full 'Risk Assessment and Method Statement' written into the contract documentation.

(e) *Special events and salvage use*

When the use of Halon type light units is permitted, there is a management responsibility to ensure, that the necessity for their use is justified and that the fire risk is minimised.

1 When the use of halogen or similar lamps is justifiable, a 'Risk Assessment and Method Statement' should be drawn up and approved by the Regional Director and the Local Authority where Entertainments Licensing is involved.

2 Special attention should be given to the positioning of the lamps and the proximity to combustible materials. It is also essential that the potential for accidental contact or being knocked over is considered when agreeing the siting of the lamps.

(f) *Requirements for electrical installations*

All electrical installations shall conform to the IEE Wiring Regulations Sixteenth Edition. Particular attention is drawn to the following clauses:

422-01-06 'Fixed equipment causing a focusing or concentration of heat shall be at a sufficient distance from any fixed object or building element so that the fixed equipment cannot cause a dangerous temperature in the fixed object or building element. 422-01-07 materials used for the construction of enclosures shall comply with the resistance to heat and fire requirements in an appropriate product standard. Where no product standard exists, the materials of and enclosure constructed during erection shall withstand the highest temperature likely to be produced by the electrical equipment in normal use'.

3 Alternative temporary lighting

Alternative Sources of Lighting details some alternative lighting units that have been evaluated. In normal circumstances temporary lighting should operate on 110V from a transformer specifically designed for temporary lighting. This list is by no means comprehensive and further research is being carried out. If alternative lighting other than those listed is in use it should be submitted to Professional Services Mechanical and Electrical Team, in the first instance, for evaluation.

January 2001

Alternative sources of lighting

Following a study by the National Trust, Queen Anne's Gate Conservation Service, the following replacements for halogen lamps have been assessed and are recommended:

- They all fall into the category of fluorescent or compact fluorescent lamps.
- The approximate light output is given where possible for comparison with:
- 300 W Tungsten-Halogen 5250 lumens
- 500 W Tungsten-Halogen 9500 lumens
- Class 1A Colour rendering: the best possible colour rendering for use when colour matching tasks or visual 'correctness' is required.
- Class 1B Colour rendering: for less critical colour discrimination tasks.

Class 1A

Description: CPL3114 – 240 V. 5800 lumens.
2 × 36 W. Maintenance Luminaires complete with Electronic
Ballast Wire Guard and Colour 21 class 1A lamps.
Suitable for tripod mounting. Finished in white.

CPL3115 – 110 V.
as above

Class 1B

Description: CPL3134 – 240 V. 9500 lumens
2 × 55 W. Maintenance Luminaire complete with Electronic
Ballast Wire Guard and class 1B lamps. Suitable for tripod mounting.

CPL3135 – 110 V.
as above

Available from: Compact Lighting Ltd
Unit 1,The Nelson Centre
Blueprint 3200, Portfield Road
Portsmouth, Hampshire, PO3 5SF
tel 08707 332233

Class 1A

Twin fluorescent 4' lamps

Description: Streampak AST2594 with Colour 94 lamps.
3960 lumens

Available from: Philips Lighting UK Ltd
The Philips Centre, 420-430 London Road
Croydon, Surrey, CR9 3QR
tel 020 8665 6655

Further information will be made available on other acceptable lighting units as information is received.

General use

Alternative sources of light for more general cleaning and building work use have already been identified by most regions, these include:

Twin fluorescent lamps with wire guard
Ominlite, Colour rendering Class 1B
4 × 9 W. 2400 lumens.
Goliath, Similar to above.
All 110 V

GUIDANCE NOTES ON AUTHORITY TO CARRY OUT HOT WORK PARTICULAR GUIDANCE ON HEAT PRODUCING LAMPS

Risk assessment and method statement

In cases dealt with under FSI. No. 3 Paragraph 2 Permitted Exceptions a '*Risk Assessment and Method Statement*'

Form EH160 will have to be submitted using similar guidelines to those indicated below.

Risk assessment

In these cases the ignition source will be the heat producing lamps and the need to ensure any combustible building fabric and artefacts in the working area are adequately safeguarded

General precautions

All temporary lighting fittings shall be checked weekly by the user, subjected to a formal visual inspection monthly and inspected and tested three monthly in line with the English Heritage 'Safety Instruction No. 7.2' 'Inspection and Testing of Electrical Appliances'. All lighting systems to be used while the public are present or in public areas shall be inspected and approved by a qualified electrician (employed by a firm on the roll of approved electrical contractors issued by the National Inspection Council for Electrical Installation Contracting) upon installation and at regular intervals while the temporary lighting installation is in place.

Appropriate fire fighting equipment for dealing with electrical fires (eg 2 kg Carbon Dioxide extinguisher and 1200mm × 1200mm fire blanket) shall be provided and suitably located on site.

All lamps should be fitted with a guard to prevent hot surfaces coming into contact with any form of material.

Normally all lamps and light units should operate on 110V. Temporary lighting operating at 240V must be supplied via a 30mA residual current device or from a 110V earthed centre tapped transformer.

Precautions to be observed in the area at risk

All personnel working in the vicinity of the temporary lighting should be aware of the fire precautionary arrangements for the site and be shown the nearest fire alarm call point or telephone for calling the fire brigade.

Special attention should be given to the positioning of the lamps to ensure that no combustible or heat transmitting material is less than two metres from the source of light within the spread of the illuminated area of the lamp.

It is essential that the potential for accidental contact or lamps being knocked over is considered when agreeing the siting of the units. All lamps should be secured in position to avoid any movement where visitors are likely to be present.

No lamps are to be left unattended unless the electricity supply is switched off and disconnected at source.

No lamps are to be fitted to combustible material or historic fabric and lamps are to be checked regularly for signs of discolouration caused by overheating.

Where lamps are used for conservation works in close proximity to historic surfaces or artefacts, all surfaces, other than the object under inspection, should be covered with non-combustible blankets or sheets.

No flammable liquids or gases are permitted in the same area as the lamps.

All equipment is to be monitored for not less than two hours after shutdown, unless the equipment is removed from site.

APPENDIX 1.2

Safety Instruction No. 7.2 Portable Electrical Equipment

This Safety Instruction is for the information of all staff and particularly those responsible for the provision and maintenance of portable electrical equipment.

1 Introduction

1.1 Electrical equipment is so widely used both at home and at work that it is easy to become complacent and disregard the dangers that can arise, if the equipment is allowed to become damaged, is misused or inadequately maintained.

1.2 This Safety Instruction is intended to ensure that all portable electrical equipment used by English Heritage employees, and by others on English Heritage property, is maintained in a safe condition. The Instruction sets out for those responsible for this the procedures for complying with the statutory requirements detailed below.

1.3 In addition to all routine maintenance procedures reliance must be put on all users to make a brief visual inspection of equipment before use to ensure that there are no obvious signs of damage or defects, (ie broken plugs, or damaged cables) (*see* the list, User Visual Checks, at the end of this instruction).

2 Statutory requirements

2.1 It is a requirement of the *Electricity at Work Regulations 1989* that precautions are taken against the risk of death or personal injury from the use of electricity in work activities. Where necessary to prevent danger all systems shall be maintained so as to prevent such danger so far as is reasonably practicable.

2.2 *The Management of Health and Safety at Work Regulations 1999* require risk assessments to be carried out of hazards at work and this includes risks from the use of electrical equipment.

2.3 *The Provision and use of Work Equipment Regulations 1998* require that work equipment is maintained in an efficient state, in efficient working order and in good repair.

2.4 General guidance on the practical application of the legislation may be found in the HSE publications HSG 107 Maintaining Portable and Transportable Electrical Equipment, and INDG236 Maintaining Portable Electrical Equipment in Offices and Other Low Risk Environments. More specific guidance on how the inspection and testing should be carried out and suggested intervals for a wide range of equipment is given in the IEE Code of Practice for In-Service Inspection and Testing of Electrical Equipment. These documents are written for those with administrative responsibility for the maintenance of electrical equipment as well as for those responsible for carrying out the work. Compliance with the guidance will in general ensure compliance with the legislation, however, the overriding requirement is the avoidance of danger.

3 Responsibilities

3.1 Building Services Managers and Facilities Managers must organise formal periodic testing and/or inspection and maintain records. Where the equipment is not owned by English Heritage but is operated on English Heritage properties (eg equipment on hire or equipment used by contractors) there is still a responsibility to ensure that the operators of the equipment comply with the Regulations.

3.2 Users of equipment should be encouraged to participate by visually checking equipment on a regular basis and reporting any defects to the building services or facilities manager. Users should not however attempt to carry out any repairs. User Visual Checks lists things users should check visually on a regular basis.

3.3 Those carrying out inspection and testing must be competent to undertake this work, usually by having undertaken a recognised course of training. One such course is available from the City & Guilds of London Institute in conjunction with the IEE. A course is also available for building managers.

4 Frequency of inspection and testing

4.1 The frequency at which inspection and testing is carried out depends on the type of equipment and the environment in which it is used, whether low risk or otherwise. Where equipment is used in offices and other low-risk environments, which will include most but not all English Heritage sites, the intervals suggested in HSE leaflet INDG 236 *Maintaining Portable Electrical Equipment in Offices and Other Low Risk Environments*, may be followed. These intervals are shown in Table 1, reproduced from INDG 236.

4.2 It can be seen from the table that although all equipment requires a formal visual inspection not all equipment requires testing.

4.3 In situations where equipment is being used in what may be considered other than low-risk environments, which may include construction sites, industrial areas such as workshops, commercial kitchens and laboratories, also areas used for training and presentations, more frequent inspection and testing is required, in some cases in terms of months rather than years. Combined inspection and testing may also be required. For equipment used in these situations, the recommendations of Table 1 Suggested Initial Frequency of Inspection and Testing of Equipment of the IEE Code of Practice should be followed.

5 Inspection and testing of equipment

5.1 The first level of inspection is the duty of every user of equipment to keep an eye on any wear and tear of cables, plugs and equipment generally. Any cuts or abrading of cable sheaths, cracked or damaged plugs, switches etc should be reported to the facilities team. *See* User Visual Checks.

5.2 Formal inspection and testing is to be carried out by competent persons (*see* definitions) and is to be arranged by the Building services Manager for HQ buildings and the Regional M&E Technical Officers (on behalf of the Facilities Managers) for regional properties and sites. However, visual inspection of low-risk equipment may be by a nominated competent person with only basic training. The inspection and testing shall generally be carried out in accordance with the IEE Code of Practice but should include the procedures detailed in below.

5.3 Inspection is to include a visual check of the appliance and cable to check for signs of deterioration or damage, and that there are no joints in the cable. The plug is to be opened to check that connections have been correctly made and are tight, and that the cord grip is secured so as to prevent tension on the conductors. Fused plugs are to be checked for correct fuse rating. A check should also be made to ensure that appliances with detachable mains leads have the correct three-core cable if the appliance is one that requires an earth, and that a two core cable has not been substituted by mistake.

5.4 Testing should include a continuity test of the assembled appliance and its flexible cable, and an insulation resistance test of the appliance and flexible cable. Where the appliance contains electronic components that could be damaged by such testing, then the maintenance should be restricted to inspection only. Where the mains lead is detachable from the appliance by means of a plug and socket, then it should be removed and fully tested. Permission should be obtained from the user of the equipment before any testing is carried out.

5.5 Testing is preferably carried out using portable appliance test (PAT) equipment although other types of instruments where appropriate may be used. All instruments should be in good working order and calibrated and operated in accordance with industry standards. (*See* the IEE code of Practice and BS 7671 [the IEE Regulations] for further information).

5.6 Where instruments other than portable appliance testers (which usually indicate pass or fail) are used, the criteria should be as detailed in the IEE Code of Practice. Where equipment fails a test, minor repairs may be carried out as necessary at the time of the inspection, otherwise the equipment must be withdrawn from service until repairs have been carried out and the tests passed. After inspection and testing the appliance should be checked to ensure that it functions correctly.

6 Records

Details of all portable, movable and held-held electrical appliances are to be kept in a log-book or on a computer data base. The information shall include a unique reference number for each item of equipment, a description of the equipment and serial number, its normal location, class and risk category and frequency of testing and inspection. The date and result of all inspections and tests, together with details of any defects and repairs shall be recorded for each appliance. (Appendix V of the IEE Code of Practice has models forms for the keeping of records).

Every appliance shall have a label attached showing the reference and the date and result of the most recent test.

Anyone acquiring a piece of electrical equipment is to notify the Building Services Manager (HQ) or M&E Technical Officer (regions) so that it may be entered on a register of equipment to be inspected and tested.

7 Defects

Any person discovering a defective electrical appliance is to withdraw it from service, attach a label on it stating the nature of the defect, and that it is NOT TO BE USED. The appropriate Building Services Manager or Regional M&E Technical Officer should then be requested to arrange for its repair. **Unauthorised repairs are not to be made by site staff**.

8 Electrical supplies for plug-in appliances in workshops and construction sites

Plug in tools and appliances used in workshops and construction sites should normally be 110V. Where exceptionally 240V models are needed in workshops or laboratories, their supply must be protected by a residual current circuit breaker (RCCB). **240V tools must not be used in construction site environments**.

8.1 Reducing transformers supplying 110V tools to BS 4363 with their centre tapped earth connected to the main transformer frame, as required by BS, must be sited as close as possible to the point of supply, thus keeping 240V cable lengths to a minimum. The 110V extension cable and transformer must be fitted with plug and socket connectors manufactured to BS 4343 of the voltage discriminating type (eg yellow for 110V and preferably with yellow cable sheath).

8.2 Temporary lights (eg festoons etc) are to be low voltage, ie the supply voltage between conductors is not to exceed 110V or 55V between conductors and earth. They should be of the moulded on type, not the pin piercing type, since dampness can enter via the pin holes.

8.3 Temporary floodlights, where required, should preferably be of the low temperature fluorescent type, operating at 110V. Tungsten halogen lamps or any lamps that create heat are NOT to be used inside buildings. Where existing halogen lamps are provided for salvage work their use should only be at the discretion of the fire brigade officer in charge and senior English Heritage officer on site.

8.4 Portable generators for 110V site supplies are to be centre-tapped to earth, with the tapping connected to the machine frame. This must be specified when the machines are purchased as some manufacturers do supply generators without centre-tapping, or the frame connection.

8.5 Any temporary 240V cabling that runs through a construction works type environment, and could possibly be subjected to damage, is to be steel wire armoured.

Table 1 Offices and other low-risk environments only – suggested initial* intervals

equipment/ environment	*user checks*	*formal visual inspection*	*combined testing and inspection*
battery operated: (less than 20V)	no	no	no
extra low voltage (less than 50V AC): eg telephone equipment, low voltage desk lights	no	no	no
information technology: eg desktop computers, VDU screens	no	yes, 2–4 years	no, if double insulated – otherwise up to five years
photocopiers, fax machines: NOT hand-held rarely moved	no	yes, 2–4 years	No, if double insulated, otherwise up to five years
double insulated equipment: NOT hand-held moved occasionally, eg fans, table lamps, slide projectors	no	yes, 2–4 years	no
double insulated equipment: HAND-HELD, eg some floor cleaners	yes	yes, 6 months–1 year	no
earthed equipment (Class 1): eg electric kettles, some floor cleaners	yes	yes, 6 months–1 year	yes, 1–2 years
cables (leads) and plugs connected to the above; extension leads (mains voltage)	yes	yes, 6 months–4 years, depending on the type of equipment to which it is connected	yes, 1–5 years, depending on the type of equipment to which it is connected

* Experience of operating the maintenance system over a period of time, together with information on faults found, should be used to review the frequency of inspection. It should also be used to review whether and how often equipment and associated leads and plugs should receive a combined inspection and test.

It is also noted that combined inspection and testing should be carried out where there is reason to suspect that the equipment may be faulty, damaged or contaminated but this cannot be confirmed by visual inspection; and after any repair, modification or similar work to the equipment, when its integrity needs to be established.

User visual checks

Look for signs of:

- damage to the cable covering such as cuts and abrasions, (apart from light scuffing);
- damage to the plug (eg the casing is cracked or the pins are bent);
- non-standard joints including taped joints in the cable;
- the outer covering (sheath) of the cable is not being gripped where it enters the plug or the equipment. Look to see if the coloured internal wires are showing;
- equipment that has been used in conditions where it is not suitable (eg a wet or dusty workplace);
- damage to the outer cover of the equipment, or obvious loose parts or screws;
- and overheating – burn marks or staining.

APPENDIX 1.3

Safety Instruction No. 7.4 – Safe Use and Maintenance of Ladders

This Safety Instruction is brought to the attention of all staff responsible for providing and maintaining ladders for use at work, and all staff who may need to use them.

1 Legal requirements

The *Working at Height Regulations 2005* include the use of ladders as access or working position (*see* Safety instruction 6.7).

The *Provision and Use of Work Equipment Regulations 1998* require that ladders, along with all other work equipment, are suitable for the use that will be made of them, and are efficiently maintained and repaired.

More specifically *Schedule 5 of the Construction (Health, Safety and Welfare) Regulations 1996* requires that:

(a) any ladder shall be suitable and of sufficient strength for the purposes for which it is to be used;

(b) be so erected as to ensure that it does not become displaced;

(c) if it is more than 3 metres long it should be secured if practicable, if not a person must be positioned at the foot of the ladder to prevent it slipping at all times when it is being used;

(d) the top of any ladder used for access to another level must extend to provide adequate hand hold;

(e) ladder runs in excess of 9 metres must be provided at suitable intervals with landing areas or rest platforms;

(f) Any surface upon which a ladder rests shall be stable, level and firm, of sufficient strength and of suitable composition safely to support the ladder and any load intended to be placed upon it.

While these requirements are for 'construction' work, they provide a good guide to the safe use of ladders in other work scenarios.

2 Safe use of ladders

Except for very short duration tasks ladders should not be used as a 'place of work', and only then if the user can carry out the task without over-reaching. They should always be secured but if this is impracticable, they must be footed by a second person. Reaching sideways from a ladder must be avoided as there are severe hazards of the ladder slipping. Standing on a ladder for lengthy periods is also very uncomfortable on the feet. Care should be taken when using an extension ladder, particularly when descending past the overlap as it is very easy to miss your footing.

Portable step ladders:

These should also only be used for very short term access, rather than relying on them as a work platform. Always ensure that the ladder is fully opened and that the restraining cord is in good condition. The surface underneath must be flat and firm. Never climb beyond the point where you have a secure handhold. For regular use in stores etc, step ladders with built in hand rails should be used. (*See* note at end for safety advice when using ladders and step ladders).

3 Maintenance procedures

To meet the statutory requirement in respect of such items of plant used by English Heritage it is the responsibility of Maintenance Managers to ensure that:

(a) all items are regularly inspected by a competent person;

(b) records of these inspections together with details of the condition are kept up to date in a register, (*see* 3.4 below);

3.1 Competent person

To be considered a 'Competent Person' that person should possess the technical knowledge, practical experience, and ability to carry out this function. It is not essential that this person is a tradesman.

3.2 Identification

Each timber or metal step ladder, trestle, crawling ladder, crawling board and component tower must be marked with a serial number for identification purposes, together with the date at which it is next due for inspection.

3.3 Inspection

Each item is to be inspected upon receipt from the supplier, and at six-monthly intervals. This period may be reduced in the light of local conditions and frequency of usage at the discretion of the local manager.

Inspection should include checks for:

(a) corrosion, warping, cracking and splintering of rungs;

(b) wear and condition of rungs, especially at stile fixing;

(c) tightness of wedged joints;

(d) loose corroded tie rods and reinforcing;

(e) corrosion, wear and security of hinges, check stops, locking stays, cords, screws and bolts;

(f) condition of operating cords;

(g) corrosion, wear and security of pulley wheels, latch locks and guides;

(h) correct fitting and wear of pads on levelling and non- slip feet attachments;

(i) condition of varnish or other protective coating (paint must not be used);

(j) legibility of identification mark.

3.4 Keeping of records

A register is to be maintained in the manager's office and should include the following information, recorded on the appropriate planned maintenance log book sheet:

(a) description

(b) identity mark;

(c) date of receipt into store;

(d) date of periodic examination;

(e) name and grade of person carrying out inspection;

(f) condition at time of inspection ie serviceable or details of defects found.

3.5 Defective equipment

Any item found to be defective is to be labelled as such and impounded until remedial or disposal action can be taken. Items beyond economical repair must be destroyed. Details of remedial action and disposal are to be entered in the register.

SAFETY NOTES FOR WORKING ON STEP LADDERS

For example access or as place of work for painting, decorating, ceiling work, electrical wiring, light fittings, etc.

Hazards

OVER-REACHING: The steps can become unstable and you, the steps and any tools can fall; and possibly strike persons below.

SIDEWAYS LOADING (EG DRILLING): You push yourself off the steps and fall; and you, the steps and tools possibly strike persons below.

LOSING BALANCE: You grab the steps and they become unstable; you, the steps and any tools fall, possibly striking persons below.

Check

- Is the step ladder capable of reaching the working height?
- Is there any wear tear or damage affecting safety? (eg hinges, rivets and dents)
- Can you carry the step ladder and position it safely without slipping, tripping or falling?
- Is your footwear suitable for working on a ladder?
- Are ground conditions firm, level and stable?
- Do weather conditions allow safe use of the step ladder? (eg wind, rain, snow, ice, lightning)
- Duration of task without a break will not exceed 30 minutes.
- Can you carry any materials, equipment or tools safely maintaining a handhold?

- Can you place steps to avoid over-reaching and sideways loading on each task?
- Could sudden unexpected movement cause you to fall off step ladder and how serious would be the consequences?
- Should you segregate the work area to protect any other personnel?

Section 2

General Performance and Control of Metric Survey

2.1 General performance requirements

This document is a performance-based specification that describes two types of survey product. The survey product types are:

- vector presentation in computer aided draughting (CAD) software (see sections 4 , 5 and 6);
- and image-based presentation (see section 4).

The performance of the survey types is compared against the following criteria:

- measurement (accuracy and precision);
- selection of features;
- and presentation of the survey data.

2.1 General performance requirements

Metric survey techniques are required to deliver data that can be verifiably repeated. There are three aspects to the required performance of metric survey data. These are:

- measurement performance;
- feature selection performance;
- and presentation performance.

2.1.1 Measurement performance

Measurement performance may be considered in terms of both accuracy and precision. There will also be different requirements and constraints on 3-D data as compared with 2-D data.

Definition of accuracy

Accuracy describes the closeness between measurements and their true values. The closer a measurement is to its true value the more accurate it is.

Definition of precision

In surveying precision is taken to describe the consistency with which a measurement or set of measurements can be repeated.

3-D data performance

There may be a variation in the performance of height or depth measurements compared with those in plan. Any variation must, however, remain within the tolerances stated in section 2.1.2. Where a separate technique is used to derive height values (eg levelling for heights on a building plan) variation in the acceptable performance will allow for this.

2-D data performance

The performance of 2-D data is dependent on the data source and the projection used to present it. This is to be an orthogonal projection unless described otherwise in the relevant section according to survey type. The performance of the data is to be equal in both axes used.

2.1.2 Scale tolerance and point density

The performance of measurement methods is categorised by the dependency on point selection at capture or post-capture. The variation in point sampling with direct techniques is because of the selective nature of the technique. Point densities will be increased at points of detail and decreased if the surveyor judges there to be no information to be recorded. Stating a maximum distance between points will allow the data to be used for digital terrain model (DTM) generation if required.

Indirect techniques of data capture (particularly laser scanning) need to meet a capture density that is at most half the size of the smallest object to be recorded. The advantage of an indirect technique is the capture of information without selection but this needs to be balanced against end use and cost.

Data captured by reflectorless electromagnetic distance measurement (REDM) can be spurious if the beam is interrupted or affected by multiple reflections, such as when aimed at the edge of a wall. Monitoring the data to ensure that lines clearly describe the true edges of the building or monument is essential.

2.1.2 Scale tolerance and point density

The precision of a survey is to be commensurate with the intended scale of presentation within the tolerances tabulated below. It is expected that surveyed data will allow repetition of a given measurement as presented on a plotted drawing within the following maximum tolerances when checked from the nearest control point.

Precision

Required maximum tolerance for precision of detail

scale	*acceptable precision*
1:10	+/- 5mm
1:20	+/- 6mm
1:50	+/- 15mm
1:100	+/- 30mm
1:200	+/- 60mm
1:500	+/- 150mm

No less than 67% of a sample is to be within the stated tolerances and no less than 90% is to be within 1.65 times the stated tolerances.

Point density/Rate of capture

Required distribution of measured points

scale	*point cloud*	*digitising**	*field survey†*
1:10	1mm	1–15mm	2–30mm (max 0.5m)
1:20	3mm	3–30mm	5–60mm (max 1m)
1:50	5mm	5–50mm	10–100mm (max 2m)
1:100	15mm	15–100mm	20–200mm (max 3m)
1:200	30mm	30–300mm	50–600mm (max 5m)
1:500	75 mm	75–750mm	0.1–1.5m (max 10m)

* From photogrammetric stereo model or point cloud: the higher value in each range represents the maximum permissible point interval.

† For example by electromagnetic distance measurement (EDM) or global positioning system (GPS). Where lines appear straight or detail is sparse the interval may be increased up to the maximum shown in brackets.

2.1.2 #Scale tolerance and point density

Appropriate orders of control

Choose an option. If (a) add further details to project brief.

2.1.3 Performance of feature selection and presentation

The differentiation of data in order to make the required delineation needs two key principles to be met:

- a specification indicating the features required, presentation style and scale to be used;
- and a survey method that allows the capture of clearly defined features.

Reliance on, for example, low density (say 10mm × 10mm array for 1:20 scale work) point clouds without supporting imagery of sufficient resolution (see section 4.4.6) to resolve objects of 5mm to 10mm in size will result in feature extraction of a poor parity.

Repeatability of capture method

Data capture must be by a method that can be repeated, by the use of similar equipment and personnel to that described in the method statement, to the appropriate order of precision. For this reason the provision of data by a unique or undisclosed method is unacceptable.

Consistency of precision

The precision achieved must be commensurate with the required scale across the entirety of the survey.

Appropriate orders of control

The provision of control points by a method without full rigorous observation (eg the extension of a ground transverse to high level floor plans) is either

(a) accepted by agreement depending on the requirements of the project and the constraints of the site; or

(b) unacceptable.

2.1.3 Performance of feature selection and presentation

The performance requirements for feature selection and presentation are described in detail in the subsequent sections for each type of survey. General principles for each type of presentation are shown below.

Vector presentation

The products of measurement systems are variable and dependant on both measurement performance and feature selection performance. The indicator of performance is, in all cases, a comparison between the subject of the survey and the final product. Feature selection is dependent on both the effective density of measured points and the differentiation required to meet the presentation standard at the requested scale.

image-based representation

The performance of images (rectified photography and orthophotography) as survey products is determined by the image resolution and the quality of the captured image (eg coverage, attitude, exposure, sharpness, extent of shadow and incident illumination) as well as the reproduction standard used.

2.1.4 Completeness of survey

It is the responsibility of the surveyor to meet the requirements for coverage and completeness as set out in the project brief. The required extent of the survey should, however, be stated as clearly as possible by use of one or more of the following:

- site boundary marked on a sketch plan;
- elevations highlighted on a sketch plan;
- written description;
- or marked up photographs.

2.1.4 Completeness of survey

It is not acceptable for survey coverage to be determined by the performance or limitations of a given method unless by agreement between the surveyor and the client.

Survey coverage, with regard to both the extent of the survey and the completion required within that extent, is to be determined by the needs of the project. Elevations and sectional elevations shall be complete to full height unless otherwise specified in section 1.1.10 of the project brief. Any requirement for the field completion of obscured areas in a photogrammetric survey is addressed at section 4.1.5.

2.1.5 Meta-data, materials and data formats

Meta-data should be supplied in accordance with the principles of the Dublin core.

http://dublincore.org/

Transparency of data provenance provided in the meta-data is essential for both the quality assessment of the data supplied and its subsequent use as a basis for the development of design, analysis etc.

2.1.5 Meta-data, materials and data formats

The table below describes the general requirements for meta-data. Any specific requirements will be described in later sections. All information supplied must be clearly referenced to the associated records, component records and the originator(s) thereof.

Meta-data requirement for all metric survey material supplied

required field	*encoded as*	*issued from*	*presented as*
project title	ASCII/written record	client	ASCII/typewritten record
site name			
site location			
site component			
date of record		supplier	
authorship			
project reference number		client	
Associated records			
control data: to include schedule, witnessing and network diagram	data file, digital or paper plan/diagram	supplier	ASCII data, digital co-ordinate file or drawing on drafting film
point cloud registration data	data file	supplier	ASCII data
photo location	digital or paper plan/ diagram	supplier	Digital file or drawing on drafting film
colour index	reference to colour index used and its manufacturing details	supplier	
camera calibration	ASCII/written record	supplier	ASCII/typewritten record
process history	ASCII/written record	supplier	ASCII/typewritten record
origin of request	ASCII/written record	client	ASCII/typewritten record

2.2.1 #Accuracy of site control

Choose an option. Option (a) ±5mm will be suitable for most sites. For larger sites a part error may be more suitable. For example, 1 part in 20,000 for distances greater than 200m.

2.2.2 #Control observation

Choose option (a) or insert own values at (b).

2.2.3 #Existing co-ordinate system

Indicate whether there is a previously used site grid. If so supply the necessary details as an attachment.

2.2 Control of Survey

The control for all survey projects must be reliable, repeatable and capable of generating the required co-ordinates within the tolerances stated. The method, network and equipment for providing survey control are discretionary, however; details of the method and equipment proposed must be included in the method statement.

2.2.1 Accuracy of site control

The maximum error between permanently marked survey stations is to be no greater than either

(a) ±5mm; or

(b) other (specify).

An estimate of the precision achievable is to be included in the method statement.

2.2.2 Control observation

All co-ordinate and level values generated must be expressed in metres to three decimal places and presented in the order of easting (X), northing (Y) and height (Z). They are to be derived from a rigorously observed traverse and/or global positioning system (GPS) network to ensure that the following tolerances are satisfied before adjustment, either

(a) The horizontal closure error of any traverse shall not exceed ±10mm;
the vertical closure error of any traverse shall not exceed ±20mm; or

(b) The horizontal closure error of any traverse shall not exceed … .
The vertical closure error of any traverse shall not exceed …

Adjustments carried out to the observed network, including type and method of adjustment used and the results of transformations, are to be detailed in the final survey report.

2.2.3 Existing co-ordinate system

There is either

(a) an existing site co-ordinate system; or

(b) no existing site co-ordinate system.

Where a previously defined site co-ordinate system exists, the necessary information will be supplied by the client to enable the re-occupation of permanently marked points. This will include a full listing of 3-D co-ordinates and witness diagrams. During re-occupation and re-observation the precision of any co-ordinate and level information provided must be evaluated to ensure the new survey can be generated within the appropriate tolerances. Where discrepancies are found, the client is to be contacted to agree any necessary variations.

2.2.4 #New co-ordinate system

Choose an option. If the data is to be used for geographical information system (GIS) applications or inserted into Ordnance Survey (OS) mapping then choose option (b) The scale factor, however, will distort facade control so the use of a local grid derived from the OS coordinates will be required.

2.2.5 #Vertical datum (height control)

Choose an option. The Ordnance Survey no longer maintains benchmarks and recommends that GPS is used. For further details see

http://www.ordnancesurvey.co.uk/oswebsite/gps/

2.2.6 #Establishment of permanent survey marks

Choose an option and if (a) edit as follows:

- insert the number required, if known;
- if not, insert 'at least 4' to allow for subsequent re-occupation;
- or delete the field and leave to the contractor's decision.

If a local site grid is to be established for the first time it will be essential to have at least four permanent marks installed to allow subsequent re-occupation. Each marked survey station should be inter-visible from at least one other. Where an existing local site grid is to be re-occupied for work in a different part of the site it will be prudent to have further permanent marks installed. If the Ordnance Survey National Grid (OSNG) is to be used it will still be useful to have permanently marked stations to allow re-occupation of the grid without the need for GPS.

2.2.4 New co-ordinate system

If no previous survey co-ordinate system has been installed on site, either

(a) a local co-ordinate system is to be established. The origin is to be positioned such that all grid values will be positive. The orientation is to be either as close to grid north – defined as the direction of a grid line that is parallel to the central meridian on the OSNG – as is practicable or parallel to the principal axis of the historic building or monument being surveyed; or

(b) The Ordnance Survey National Grid (OSNG) is to be used by means of GPS observation as described in section 2.5.1. If the control is for an image-based or measured building survey, a local grid with no scale factor applied is to be derived from the OSNG values. Listings of both sets of co-ordinates are to be supplied.

2.2.5 Vertical datum (height control)

The vertical datum for the survey is to be

(a) the OS height datum. This is to be achieved by means of GPS observation as described in section 2.5.1 and the OSGM02 transformation; or

(b) levelled to at least two local OS bench marks. Where disagreements are found between benchmarks the client is to be contacted to agree any necessary variations prior to the survey continuing. The most recent OS height data to three decimal places and a location description of the bench marks must be included on the data sheet and/or the title box of each drawing sheet; or

(c) an arbitrary site bench mark. Full details of the site bench mark are to be included with the permanent survey mark witness diagrams.

2.2.6 Establishment of permanent survey marks

Either

(a) The establishment of [insert number] new permanent survey marks is required. Disturbance to the historic fabric must be kept to a minimum, (see sections 1.6.1 above and 2.2.8 below); or

(b) The establishment of new permanent survey marks is not required.

2.2.7 Witnessing of stations

Full witness diagrams are to be provided with the survey for all permanently marked stations. Witness diagram sheets must include:

- co-ordinate values to three decimal places as eastings (X), northings (Y) and height (Z);
- a sketch diagram and dimensions to at least three points of hard detail;
- a written description of the mark;
- and a photograph of the location.

A traverse diagram must also be provided (see sections 3.3.6 and 3.4.5).

2.2.8 Use of ground marks

For further details on obtaining scheduled monument consent see the following link to the Department of Culture, Media and Sport.

http://www.culture.gov.uk/what_we_do/Historic_environment/historic_property/scheduled_ancient_monuments.htm

2.2.9 Use of targets on historic fabric

If the fabric is fragile or historically significant, such as a wall painting or timber beam, guidance on suitable areas for target application should be noted here. A conservation professional should be consulted if there is any doubt about the suitability of a particular adhesive.

2.2.8 Use of ground marks

Permanent or temporary ground marks are to be as non-invasive as possible and preferably existing detail should be used. The type and location of any permanent mark must be approved by the client before insertion. In some cases scheduled monument consent (SMC) will be required.

The following may be used to mark control points within buildings:

- an existing nail in a sound floor;
- a discrete pencil mark;
- marked adhesive tape;
- or a removable non-permanent mark.

The insertion of nails may require SMC. In any case nails must only be driven into a suitable material, for example earth, gravel or a mortar joint, not historic floor boards etc.

2.2.9 Use of targets on historic fabric

Where survey targets are to be applied to historic fabric, a suitable non-marking, non-destructive adhesive must be used. This must allow the removal of the targets without damage to, or marking of, the fabric. Details of the proposed adhesive are to be included in the method statement for the survey. The client reserves the right to refuse application if the proposed substance is deemed to be unsuitable for historic buildings or monuments. All targets must be removed before the commission is completed; any targets still remaining after completion will still have to be removed at the contractor's expense.

2.3.1 #Accuracy

Choose an option. Option (a) ±3 mm is sufficient for the standard architectural scales.

2.3.2 #Control of subject

Choose an option. Minor control generated by triangulation techniques is not usually accurate enough for photogrammetry. It may be suitable and more economical for smaller rectified photography projects.

2.3.3 #Use of detail points

Choose an option. Access problems may mean it is necessary to use solely detail points on upper levels. Some historic fabric may be too fragile for the application of targets (see section 2.2.9 above).

2.3 Image-based surveys

2.3.1 Accuracy

Image control points and/or targets are to be provided to an accuracy of either

(a) ±3mm; or

(b) other (specify).

A listing of the 3-D co-ordinates, with details of the computed residuals for each point observed, is to be provided with the survey report to demonstrate the accuracy achieved.

2.3.2 Control of subject

For photogrammetric and orthophotograpic surveys a minimum of four co-ordinated control points, directly observed in the field (see section 2.3.1) are to be provided for each stereo-image. Where practicable, targets are to be placed on the fabric (see sections 1.6.2 and 2.2.9).

The targets must

- be no larger than 60 mm × 40 mm and no thicker than 0.5 mm;
- be large enough to allow a unique number, discernable on the negatives under a maximum 8× magnification, to be written on them;
- and have a matt and non-reflective surface finish.

Either

(a) It will not be; or

(b) It will be acceptable to use minor control generated by triangulation techniques for the project.

2.3.3 Use of detail points

Where targets cannot be placed on the fabric it is acceptable to use detail points. A sketch diagram is to be made showing point location that must be transferred to the reverse of the set of control prints (see section 3.4.3). Detail points must be easily identifiable and must not be taken from the extreme edges of the subject.

There are three options:

(a) It will not be acceptable; or

(b) where absolutely essential it will be acceptable; or

(c) it will be necessary

to use solely detail points in a stereo pair.

2.4 Measured building surveys

2.4.1 Control of survey data

The control of measured building surveys is to be achieved principally by use of an adjusted traverse network and must meet the performance described in section 2.1.2. However, this may be supplemented by the use of control methods suited to graphical survey techniques to achieve the necessary distribution of control stations. Suitable methods may include:

- local datum points;
- plumb lines;
- base lines tied and fitted to the site co-ordinate system;
- and triangulation from detail points.

The method used must be adequately recorded either in the survey data or in an associated report to show the

- position of plumb lines used;
- recorded height measurements taken and the distribution of height error if applied;
- triangulation diagram;
- and dimensions used for transferring co-ordinate values to baselines.

The method statement is to describe the methods proposed and include how they are to be monitored to ensure the required level of precision.

2.4.2 Local datum

Local datum points must be transferred from the site vertical datum by an appropriate method such as surveyors' level or theodolite observation and recorded on the drawing as

- a vertical datum plotted at metre intervals;
- or a reference datum line marked with the datum value;
- and annotation of detail with recorded height.

The transfer should be checked from two points of verified height. A chalk line may be used to mark a datum only if the surface of the elevation will not be damaged by the mark. Use of line levels is to be restricted to line lengths of less than 1m.

The use of an arbitrary datum is permissible if a building element is to be fitted to other controlled elements such as existing photogrammetric data or an REDM trace.

Heights on floor plans

Where plans for more than one floor level are required the heights shown for each floor must be given relative to a single datum. Multiple arbitrary datum points for each floor must not be used.

2.4.3 Accuracy of survey data

In general, when accuracies or tolerances have been specified, they refer to vector errors and are defined statistically as root mean square errors (rmse). The rmse is equivalent to a 67% tolerance, and a 90% tolerance is 1.65 times the rmse when a representative sample of points is tested. Thus an rmse of ±0.1m indicates that in a representative sample of 100 points, not less than 67 shall be correct to better than ±0.1m, and not less than 90 points shall be correct to better than ±0.16m. Any errors exceeding three times the rmse, in this case ±0.3m, may be regarded as mistakes.

Surveys of Land, Buildings and Utility Services at Scales of 1:500 and Larger – Client Specification Guidelines 2nd Edition RICS 1996

Applying the above to measured building surveys means that the following accuracies are required at the standard architectural scales.

At 1:50 a 0.3mm rmse is equivalent to 15 mm at actual size, therefore 67% of points in a representative sample must be better than ±15mm. Errors exceeding ±45mm are to be regarded as mistakes.

At 1:20 a 0.3mm rmse is equivalent to 6mm at actual size, therefore 67% of points in a representative sample must be better than ±6mm. Errors exceeding ±18mm are to be regarded as mistakes.

2.4.3 Accuracy of survey data

For fully controlled surveys the plan position of any well defined detail shall be accurate to ±0.3mm rmse at the specified plan scale when checked from the nearest survey control station.

To verify the achievement of the specified tolerances, the following may be required:

- booked data showing directly measured dimensions;
- co-ordinate data and their provenance, where dimensions between points have not been directly measured.

2.4.4 Precision of detail measurement

The precision of detail measurement is to be as specified in section 2.1.2.

2.5.1 Co-ordinate system

For more details on the use of GPS and the OSNG see the following

http://www.ordnancesurvey.co.uk/oswebsite/gps/

Where on Earth are We? The Global Positioning System (GPS) in archaeological field survey English Heritage 2003 Product code 50788 available as free download from http://www.english-heritage.org.uk/upload/pdf/where_on_earth_are_we.pdf

and for what to expect in a method statement refer to the following publication

Guidelines for the Use of GPS in Surveying and Mapping- RICS Guidance Note RICS 2003 ISBN 184219 093 8.

For guidance on the use of network real time kinematic (RTK) GPS services please see the following publications:

'Best Practice Guidance Notes for Network RTK surveying in Great Britain'. The Survey Association 2008

'An Examination of Commercial Network RTK GPS Services in Great Britain'. University of Newcastle (on behalf of The Survey Association) 2008

Both are available for free download from http://www.tsa-uk.org.uk/guidance.php

2.5.2 #Adequate site cover

Choose (b) if stations are required in certain areas to allow, for example, later re-occupation to facilitate a subsequent survey. Include a diagram showing where stations are to be located. It may also be necessary to show areas where stations are not to be inserted.

2.5.3 Contours

See section 2.4.3 for an explanation of rmse.

If the contour interval is to be 0.25m, then 67% of a representative sample of points forming a contour should be correct to better than ±0.08m and 90% to better than ±0.13m.

2.5.4 Spot heights

If for example, the contour interval is to be 0.25m, then 67% of a representative sample of spot heights should be correct to better than ±0.06m and 90% to better than ±0.1m.

2.5 Topographic surveys

2.5.1 Co-ordinate system

Where use of the OSNG is specified, the primary site control is to be established by means of GPS observation. The WGS84 values are to be transformed to the National Grid using the OSTN02 transformation. Height values are to be transformed using the OSGM02 transformation. The scale factor is to be reported in the survey documentation.

The method statement must describe the equipment and procedures to be employed so as to achieve the precision specified in section 2.1.2.

Secondary control may be achieved by traverse observations.

2.5.2 Adequate site cover

The control network or traverse must extend so that stations are in reasonable proximity to the perimeter of the survey area and the detail to be mapped.

The distribution of stations is to be either

(a) at the discretion of the surveyor; or

(b) decided in consultation with the client.

2.5.3 Contours

Contours shall be correct to an rmse of better than one third of the contour interval, where a representative sample of points on contour lines is checked by precise measurement from the nearest control point (and hence 90% of a representative sample shall be correct to better than half of the specified contour interval).

2.5.4 Spot heights

Spot heights shall be correct to an rmse of better than one quarter of the contour interval, where a representative sample is checked by precise measurement from the nearest control point (and hence 90% of a representative sample shall be correct to better than 0.4 of the specified contour interval).

2.5.5 Precision of detail measurement

The precision of detail measurement is to be as specified in section 2.1.2.

Section 3

Format, Presentation and Provision of Survey Data

3.1 Digital data

3.1.1 #CAD and digital image filenames

Choose an option or edit option (a) as required. For option (a) give the appropriate three-letter abbreviation. Although most computer operating systems no longer restrict filenames to eight characters, the ISO 9600 standard for compact disk (CD) writing still requires an 8.3 character format.

3.1.2 #CAD data format

Choose an option. If image files are to be attached to the CAD files, ensure that the selected program and version supports this. For example, AutoCAD files will have to be R.14 or later.

3.1.3 #Digital image format

Choose an option. TIFF files are recommended because they are not compressed and the format is non-proprietary. The English Heritage digital archive only accepts TIFF files. To save storage space it may, however, be preferable to specify JPEG files for rectified photography projects but not for photogrammetry and orthophotography.

3.1 Digital data

3.1.1 CAD and digital image filenames

All CAD and digital image filenames are to be eight characters in length and must follow either

(a) the following file referencing system. The standard abbreviation for the site is …

characters	*description*
1–3	standard abbreviation of monument name, eg FON (Fountains Abbey)
4–5	year survey/plotting carried out, eg 07 (2007)
6	type of survey
	P (photogrammetry – original images and 3-D CAD data)
	Q (photogrammetry – CAD drawing sheets)
	O (orthophotography – images and CAD files)
	R (rectified photography – images and CAD files)
	M (measured survey)
	T (topographic survey)
7–8	sequential file number from 01 to 99

eg FON07P01.DWG, FON07R01.TIF

or

(b) the system as described below (specify).

3.1.2 CAD data format

All CAD files, including any drawing sheets used to provide rectified photography or orthophotography and any digital elevation model (DEM) data, are to be either

(a) AutoCAD version … .DWG; or

(b) other (specify).

3.1.3 Digital image format

Digital images are to be supplied either

(a) as shown below

- where film negatives have been scanned, original uncompressed TIFF files;
- where digital cameras have been used, one set of the original RAW image files, if applicable, plus TIFF versions;
- where the product is rectified photography or orthophotography the processed images as TIFF files; or

(b) as follows (specify).

3.1.4 #Storage medium

Choose an option. It will be possible to supply some types of survey by e-mail. Where large numbers of digital images are involved it may be easier to use a portable hard disk.

3.2 CAD requirements

This specification is written for AutoCAD users. The following clauses may need to be edited for use with another CAD system.

3.2.1 #Use of CAD co-ordinate systems

Choose an option.

3.2.2 Insertion point

This is so that so that all drawing files for a survey relate to a common origin.

3.2.3 #CAD drawing unit

Choose an option. AutoCAD is unitless, that is the co-ordinates are displayed simply as numbers and the software has no knowledge as to what unit they represent. It is therefore essential to know what units the numbers represent so that dimensions are correct and plots are to the right scale. Architects, for example, may wish to have the drawing unit represent 1mm. Other CAD systems allow the units to be set in the drawing.

3.1.4 Storage medium

All of the required CAD data, image files and associated listings (eg the results of photogrammetric orientation) are to be supplied

(a) on CD-ROM written using the ISO9600 standard; and/or

(b) DVD –R; or

(c) other (specify).

All disks are to be suitably labelled with the site name, date and survey reference number if provided (see section 1.7.2).

3.2 CAD requirements

3.2.1 Use of CAD co-ordinate systems

A user co-ordinate system (UCS) other than the world co-ordinate system (WCS) can be used to facilitate the presentation of the survey (or part thereof) on the desired sheet layout (see section 3.3.2 for further details). Any such UCS must be saved with a name related to its function (eg 'SHEETVIEW' for a UCS set up for a drawing sheet).

Original 3-D photogrammetric data, without the addition of any title or border information, is to be provided set up in the following AutoCAD co-ordinate systems

- The 'WCS' related directly to the site (ground control) co-ordinate system
- A 'UCS' called 'FRONT' to enable the separate elevations to be viewed and edited directly as an orthogonal view. The origin of the UCS must ensure that all elements within the object area are positive with low co-ordinate values (eg the lower left-hand control point given arbitrary values of 10m for the X and Z axes). The Y axis must be set to the true heights of the ground control (Fig 3.1).

As well as the original 3-D data, the data for each formatted drawing sheet is to be provided in either

(a) 2-D form only; or

(b) 3-D form only with a suitable UCS.

3.2.2 Insertion point

The default origin of (0,0,0) in the WCS is to be used for insertions.

3.2.3 CAD drawing unit

The CAD drawing unit is to be either

(a) 1m; or

(b) other (specify).

3.2.4 #Other CAD variables

Choose an option. Unless it is set up as described in the specification, paper space can be confusing for non-specialist CAD users. If paper space is not used AutoCAD drawings are plotted from model space. In this case the following table of plot scale settings may be useful, assuming the drawing unit is 1m.

scale	plotted mm =	drawing unit
1:1	1000	1
1:5	200	1
1:10	100	1
1:20	50	1
1:50	20	1
1:100	10	1
1:200	5	1
1:500	2	1
1:1000	1	1
1:1250	1	1.25
1:2500	1	2.5
1:5000	1	5
1:10000	1	10

3.3.1 #Drawing sheets

Choose an option. See Fig 3.2 for an example of a drawing sheet.

3.2.4 Other CAD variables

Where possible, a dashed line-type is to be used for dashed lines as opposed to using a broken line. The line-type scale is to be commensurate with the plot scale so that it actually appears as a dashed line when plotted.

Use of Paper space

Either

(a) Paper space is to be used for the production of all drawing sheets and is to be set up as follows:

1 plotted mm = 1mm in paper space

There is to be a specific paper space tab for each view or drawing sheet.

or

(b) Paper space is not to be used. Each printed drawing sheet must be represented by a unique CAD file.

3.3 Presentation

3.3.1 Drawing sheets

All hard-copy output is to be printed on ISO A size standard sheets.

Either

(a) The client will supply the contractor with a standard sheet format (including a standard north arrow, scale bar and rubric), as a CAD file, that must be used for all plotted sheets; or

(b) The contractor is to prepare a suitable sheet format for approval by the client. See Fig 3.2 for an example of a drawing sheet.

Where hard copy is required, each formatted CAD drawing sheet or paper space view is to be printed.

3.3.2 #Standard views

Choose an option. This is a matter of personal preference.

3.3.2 Standard views

Elevations

Each subject to be surveyed is to be presented as an orthogonal view and, as far as is practical, all data should be presented 'square-on' to the plotted sheet.

Where an elevation or image extends over more than one sheet either

(a) an overlap between sheets of at least 0.5m in reality is required; or

(b) the detail is to be butt jointed. Small registration crosses are to be printed on each sheet so that adjacent sheets can be accurately aligned.

Measured building plans

Plans are to be orientated so that north is towards the top of the sheet or the principal axes of the building are parallel to the sheet edges. Where possible, the grid should be parallel to the sheet edges. If a skewed grid is unavoidable to fit the subject logically on the sheet, then text associated with the grid must be on the same alignment as the grid with all other text aligned parallel to the sheet edge (Fig 3.3).

Topographic surveys

Either

(a) must be orientated so that north is at the top of the sheets; or

(b) may be orientated so that the detail fits the sheet and the grid is skewed.

In either case each drawing sheet must have a north arrow.

3.3.3 Layout

The following project specific information is to be included within the standard sheet layout.

- Each area surveyed is to be named correctly on the drawing sheet with reference to the actual orientation of the historic building or monument.
- Sub-titles should be placed to the bottom left of the subject where possible so that there is no risk of a title being shared by two different views. Sub-titles such as 'section at AA looking west' must refer to a clearly marked key plan or accompanying plan sheet.
- A location diagram is to be included in the title box of each drawing sheet. The diagram may be schematic if necessary and should be easily understood by a third party.
- The name of the CAD file, used to generate each sheet is to be included in the title box (see section 3.1.1).
- A grid for plans and topographic surveys is to be shown as intersection points or rapier marks on the sheet edge.
- Level ticks for elevations, related to the site datum are to be placed down each side of the drawing sheet.
- A north arrow, scale bar, benchmark description or reference and a key to any abbreviations used are to be included.
- Where detail extends over more than one sheet a reference diagram of the sheet layout is required (Fig 3.2).

3.3.4 #Plotting of drawing sheets

Choose an option. Images will appear brighter and clearer when plotted on glossy paper but will not be so suitable for use on site. Images printed on film are more robust and reproduce well as dyelines where this is still available.

Insert the required scale.

3.3.4 Plotting of drawing sheets

Accuracy

Drawing sheets must be plotted with sufficient accuracy, so that any distance measured along or across the format is within 0.5mm of the true value at plot size.

Media and resolution

Each drawing sheet supplied as the final submission of the survey is to be of archival quality and must meet the following criteria.

- The drawing is to be plotted onto stable double-matt polyester film of at least 100 microns thickness.
- The drawing is to be plotted using an ink-jet or similar plotter that has a minimum output resolution of at least 600dpi.
- The substrate must be compatible for use with traditional draughting inks.
- The ink is to be printed on the top surface of the film.

Rectified photography and orthophotography are to be printed either

(a) on photographic-quality glossy paper of at least 90gsm (grams per square metre); or
(b) as described above.

The required scale of the plotted drawing sheets is 1: …

The proposed output device, media and resolution are to be included in the method statement.

3.3.7 #Printing of rectified photography

Choose an option.

3.4.1 #Samples required

Choose an option. It may be helpful to require samples for large or complicated projects or from un-tested contractors.

3.3.5 Numbering of sheets

Each sheet of the survey should have a unique reference number starting at Sheet 1.

3.3.6 Data sheet for measured building and topographic survey

One sheet is to be the data sheet and must contain the following details.

- a traverse diagram
- witnessing diagrams
- the schedule of co-ordinates for stations in eastings (X), northings (Y) and height (Z) to three decimal places
- a full description of benchmarks used with the levels to three decimal places

3.3.7 Printing of rectified photography

Scaled and/or co-ordinate controlled rectified imagery is required in the following format(s).

There are three options

(a) Separate rectified images are to be printed to the required scale, on ISO A4 or A3 photographic-quality paper. A margin of 10 mm is to be left around the perimeter of each image, widened to 20 mm on the left-hand edge to allow for hole punching; or

(b) Rectified montages inserted into a standard CAD drawing sheet and printed to the required scale; or

(c) Other (specify).

Wherever practicable, the joins between adjacent images of a montage should not be visible. Any non-controlled planes, or surrounding detail off the principal planes of the historic building or monument, are to be cropped prior to final output.

3.4 Image-based survey

3.4.1 Samples required

Either

(a) An initial sample of the survey is to be provided to the client for approval before the rest of the survey is processed as described below.

- For photogrammetry and orthophotography, a sample hard-copy plot and associated CAD data.
- For rectified photography, a sample single hard-copy image and associated digital data.

or

(b) Samples are not required.

3.4.4 #Labelling of final material

Insert the required information for the label fields and choose an option for the supply of labels.

3.4.2 Archiving

Where digital images have been used refer to sections 3.1.3 and 3.1.4.

Photographic negatives, transparencies (if required) and positives are to be supplied in individual archival quality sleeves that allow for vertical hanging. Each sleeve is to be labelled (see section 3.4.4).

3.4.3 Control prints

One set of 5in × 7in size (130mm × 180mm) control prints is to be provided, either as contact black-and-white glossy prints or where digital images are used, ink-jet prints on a suitably photographic-quality gloss paper. These are to be annotated clearly in red on the front with the control point positions and numbers. Any detail points observed are to be described on the reverse with a sketch diagram. All control prints are to be labelled (see section 3.4.4).

3.4.4 Labelling of final material

Each print and archival sleeve is to be labelled with the following information.

Monument name.....

Monument number .....or part of site

Survey number .....or project reference number

Image number ..... each image must have a unique number

Camera Type ..... make and model

Survey Date .....month and year

These should be placed on the reverse of each print and on the front of each archival sleeve. There are three options:

(a) The client will provide suitable pre-printed labels; or

(b) the client will supply a suitable label template; or

(c) the contractor is to supply suitable labels.

3.4.5 Survey material to be supplied

The following material is to be provided separately:

1 The original digital images as specified in sections 3.1.3 and 3.1.4, or film negatives if applicable and a copy of the photography diagram in one binder, suitably labelled on the front.

2 The marked-up set of control prints is to be provided together with any diapositives and a copy of the photography diagram in another binder.

A survey report is to be supplied containing a brief description of the project plus the following:

- photo location and target diagrams
- traverse diagram and station descriptions for permanent markers
- a full listing of the 3-D co-ordinates of all control points and traverse stations
- camera calibration certificates

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3.5.2 #Delivery of material

Insert delivery requirements and address etc.

3.5 Provision of survey material

3.5.1 Preliminary plots

Before the final plots on film are despatched, a complete set of preliminary plots on paper is to be supplied to the client. Plotting of the final drawing sheets should only commence after these preliminary plots have been approved.

3.5.2 Delivery of material

The survey material is to be delivered to the following addresses

Name and address 1

1× set of preliminary plots on paper for approval before final delivery

1× set of final plots on stable polyester film

1× set of digital data

All deliverables described in section 3.4.5 as applicable.

Name and address 2

1× set of final plots on paper

1× set of final plots on stable polyester film

1× set of digital data

Name and address 3

Fig 3.1 CAD co-ordinate systems – WCS and a UCS.

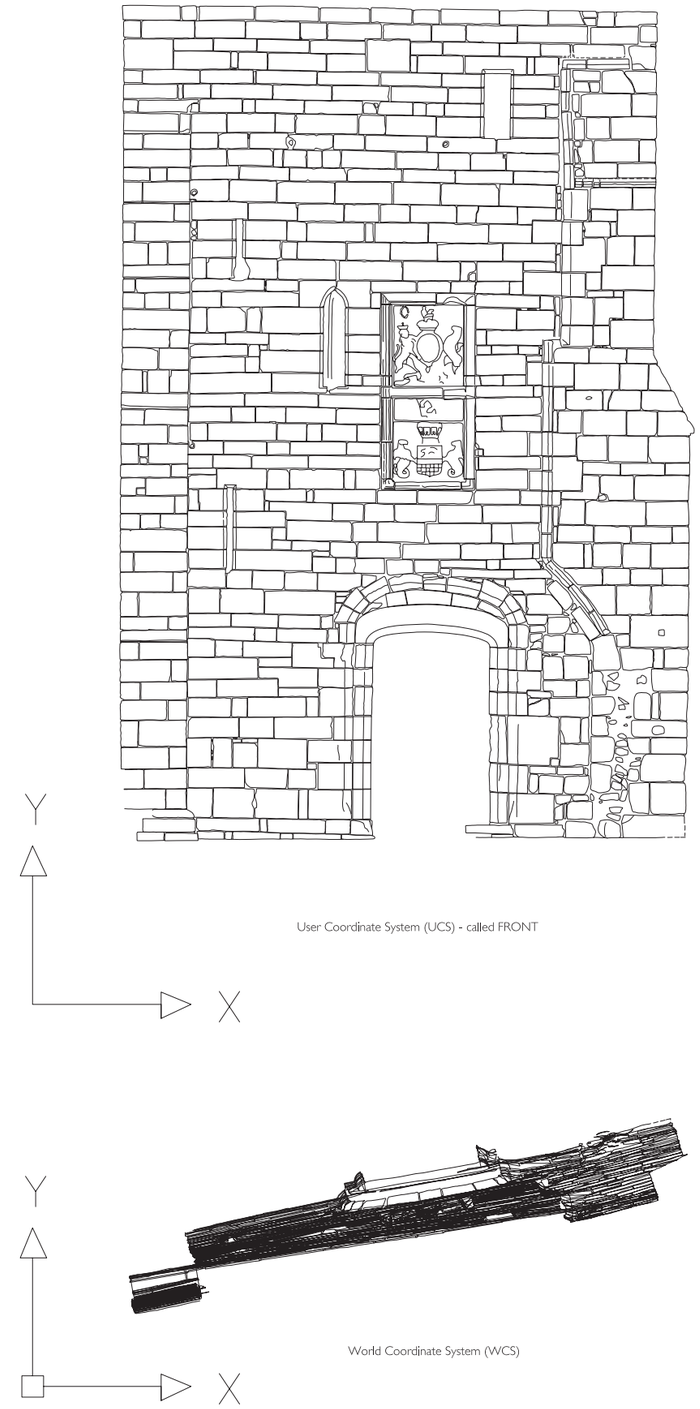


Fig 3.2 Standard English Heritage drawing sheet format.

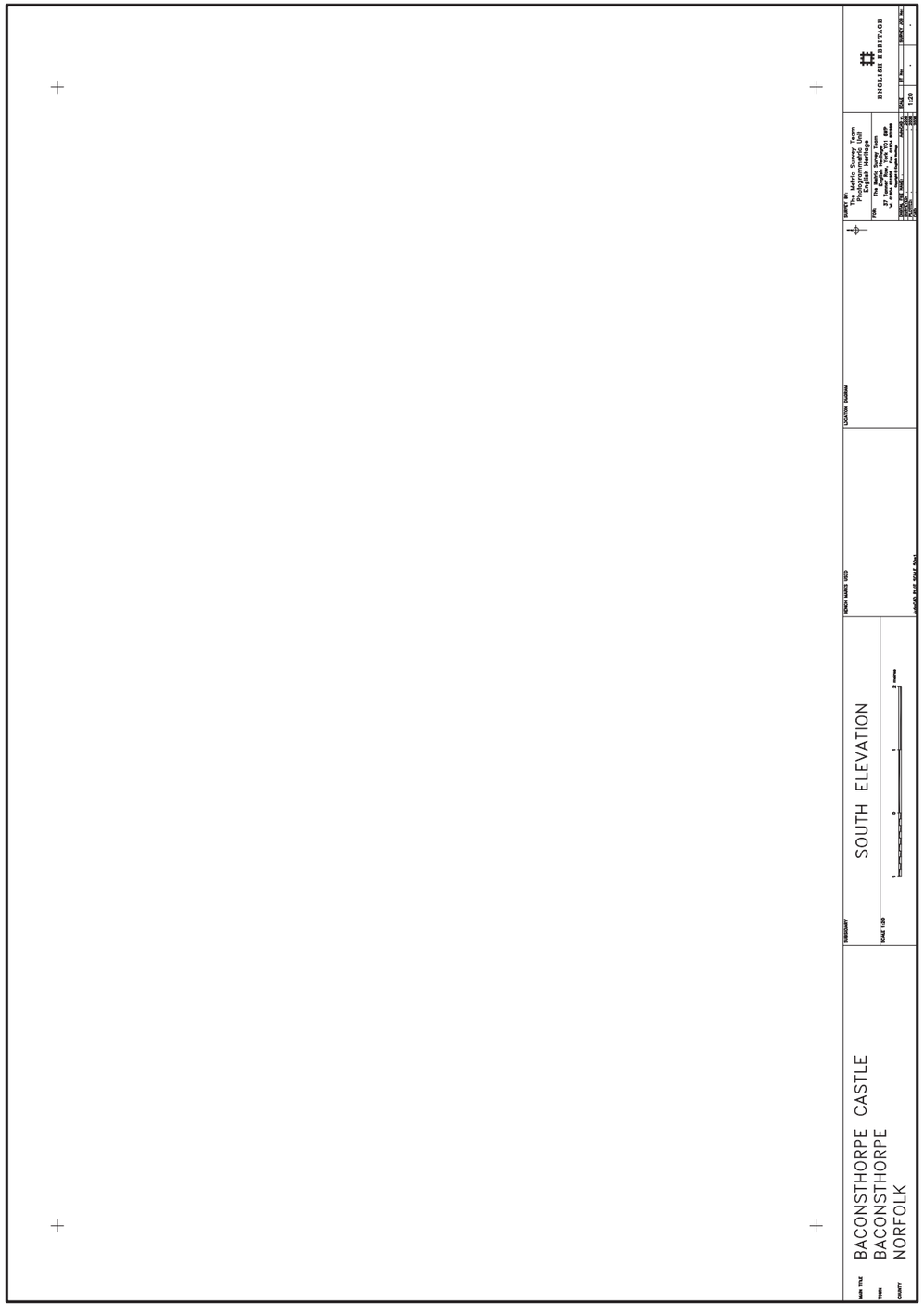


Fig 3.3 Long and cross sectional elevations with plan.

Section 4

Standard Specification for Image-based Survey

4.1 Image-based survey techniques

4.1.1 Extent of three-dimensionality of survey

This document is not a specification for a fully surfaced 3-D model of architectural detail. It is intended for the generation of base survey data, located accurately in its true 3-D position into which specific thematic input can be added if required.

4.1.2 Photogrammetric survey

The accepted meaning of the term 'photogrammetry', as seen below, could be regarded as encompassing all image-based measurement techniques.

> Photogrammetry: *the science, and art, of determining the size and shape of objects as a consequence of analysing images recorded on film or electronic media.*
>
> K B Atkinson 1996 Close Range Photogrammetry and Machine Vision

Even though scaled outline drawings can be generated using digitising techniques to record common points from overlapping images viewed monoscopically, this technique is not covered in this document. If a contractor wishes to use this technique to provide drawings he/she must be able to demonstrate that the performance criteria for 3-D data, set out in section 4.4.2, have been fully satisfied and that the specified standards for drawing detail and presentation are met.

4.1.3 Orthophotography

An orthophotograph is defined as a digital photographic image that has been corrected for scale errors due to tilt and depth displacement. Each pixel will have been individually scaled and shifted in order to produce an orthographic projection, as opposed to the perspective projection of ordinary photographs (Figs 4.3 and 4.4).

4.1.4 Rectified photography

Rectified photography surveys are defined as those where single photographs are taken with the image plane of the camera approximately parallel to the principal plane of the object and then printed to scale. Scale errors due to tilt, but not those due to relief, will have been corrected by means of a projective transformation. The traditional product of the technique is a scaled photographic print or, if adjacent images are combined together, a scaled photographic montage (Figs 4.5, 4.6 and 4.7).

4.1.5 Completion of survey

Choose an option. Field completion will add to initial costs but may reduce those of subsequent work, such as archaeological analysis.

4.1 Image-based survey techniques

Image-based surveys are defined as surveys where photographic images, in either a digital or film form, together with an element of scale, have been used to generate the required detail, presented in either a line drawing or scaled image format. The generation of scaled outline drawings using digitising techniques to record points from rectified photographs is not covered in this document. If this technique is proposed to provide the required survey drawings, it must be demonstrated that it is able to meet the performance criteria set out in sections 4.4 and 4.8, and that the specified standard for drawing detail and presentation is met. Where a photogrammetric survey has been specified, this 2-D approach will not be acceptable.

4.1.1 Extent of three-dimensionality of survey

This specification is intended for the generation of base survey data, located accurately in its true 3-D position, into which specific thematic input can be added if required.

4.1.2 Photogrammetric survey

For the purposes of this document photogrammetric surveys are defined as surveys where overlapping stereo-images are used together with control to generate the required detail. The traditional product is a scaled outline drawing (Figs 4.1 and 4.2). It is also possible to present detail in a scaled image format, such as an orthophotograph (see section 4.6 for specification of this technique).

4.1.3 Orthophotography

For the purposes of this specification an orthophotograph is defined as a digital photographic image that has been corrected for scale errors due to tilt and depth displacement.

4.1.4 Rectified photography

Rectified photography surveys are defined as those where single photographs are taken with the image plane of the camera approximately parallel to the principal plane of the object and then printed to scale.

4.1.5 Completion of survey

Survey data obtained using photogrammetry is to be as complete a record as is possible using image-based techniques. The client will endeavour to provide a clear and unobstructed view for photography prior to survey commencing, but where obstructions prevent the use of images it will be acceptable to omit detail that cannot be clearly seen (see section 4.5.1). Field completion by another method will either

(a) not be required; or

(b) be required. Describe the proposed method in the method statement.

4.2.1 #Image provision

Delete the item that does not apply. It is unlikely that a contractor will want to use glass plate negatives, however, if they do this should only be allowed if the negatives are not required to be archived.

4.2.2 #Digital cameras and scanning

As technology advances it is increasingly likely that digital cameras will be used for most photogrammetric projects. There are, however, many conventional metric or semi-metric cameras still in use. These cameras have been specifically manufactured or adapted for photogrammetry and using images scanned from conventional negatives taken with them is still an efficient method.

Experience shows that while the image resolution specified in section 4.3.4 could be achieved using a digital camera with an array of less than 13 million pixels this would, in most cases, result in uneconomic coverage as the photographs would have to be taken closer to the subject.

Standard digital cameras can be calibrated for photogrammetry as long as some way is found to fix the focus of the lens so that a precise focal length or principal distance can be measured. As there is no film to suffer from distortion fiducial marks are not required.

Ideally a dedicated photogrammetric scanner should be used as this will have been especially designed to not introduce significant distortions. Conventional scanners must be of the flatbed type.

For production of colour orthophotographs good colour balance is essential. However, photographs for close range applications will, unlike aerial photography, usually have been taken under varying exposure conditions. This means that automatic colour balance routines are unlikely to work well and therefore settings should be checked before each photograph is scanned.

Option (b) should be invoked if high accuracy is essential, for example, in a monitoring project.

4.2 Photogrammetric and orthophotographic surveys

4.2.1 Image provision

All stereoscopic imagery is to be captured using cameras specifically manufactured, adapted or calibrated for the application of close-range photogrammetry. The use of glass-plate negatives is either

(a) not allowed; or

(b) allowed.

4.2.2 Digital cameras and scanning

Where the use of either a digital camera or scanned images is proposed, the following criteria must be fulfilled:

- Digital cameras must have an array greater or equal to 13 million pixels and must also meet the requirements of section 4.3.4.
- Digital cameras must have a fixed-focus lens with minimal distortion. This is to be calibrated to provide both a precise focal length measured to within 0.01mm, and the precise distortion characteristics measured to enable compensation to occur during processing. A copy of the calibration certificate is to be supplied with the final survey materials. Details of proposed cameras and lenses are to be included in the method statement for each survey.
- If scanning of film negatives is proposed, this must be carried out to an optical resolution without interpolation of at least 1200dpi (dots per inch), if using a standard scanner; or a pixel size no greater than 20 microns, if using a dedicated photogrammetric scanner. The chosen equipment must be capable of scanning the negatives without introducing any significant distortion and the resultant digital images must be capable of being processed to the tolerances stated above and in section 4.4.2. Details of the scanning equipment and proposed resolutions are to be included in the method statement for each survey.
- If scanning of colour negatives is proposed, this must not introduce any changes to the colour balance of the original image.

The use of high-resolution, geometrically correct, photogrammetric scanning techniques is either

(a) not essential; or

(b) essential.

4.2.3 #Digital image criteria

Choose an option. Monochrome images will have a smaller file size and by definition avoid colour balance problems. Colour images may assist in the interpretation of detail and will be essential for recording wall paintings, mosaics, tiles etc.

4.2.4 Film cameras

Metric or semi-metric cameras have been specifically manufactured or adapted for photogrammetric use. The lens will have little distortion and the focus will be fixed so that the focal length or principal distance can be measured precisely. Details of the lens distortion and the principal distance will be included in the calibration certificate. In order to avoid inaccuracies caused by film distortion the camera will have a mechanism for keeping the film flat while the photograph is taken. It will also have fiducial marks that appear in each photograph. Precise co-ordinates for these marks will be measured as part of the calibration. As part of the orientation process the positions of the marks in the image are measured and compared with values from the calibration certificate. Any discrepancies will highlight distortions of the image caused either by lack of film flatness, the film processing or scanning. These distortions can then be compensated for as part of the interior orientation.

4.2.5 Exposure of fiducial marks

If less than four fiducial marks are visible then the photography should be re-taken where practicable. This is because an affine transformation that is usually used for interior orientations will fit any three points to any other three points and therefore the fiducial marks will not reveal, or allow compensation for, film distortion.

4.2.3 Digital image criteria

Where digital camera imagery is to be used, this must be captured as 16 bit but may be reduced to 8 bit for processing. If the images are captured in RAW format these files must be supplied as well as TIFF versions. Monochrome imagery may be provided by reduction to grey scale in a standard image processing package. Where colour imagery is specified, as well as meeting the above criteria, the balancing of images for either daylight or artificial illumination must be achieved. A standard colour chart and/or grey scale is to appear in at least one of the images per subject area to provide guidance on colour balancing prior to output.

The images are to be either

(a) colour; or

(b) monochrome.

4.2.4 Film cameras

Where ‘metric’ and/or ‘semi-metric’ film cameras are used, these must have the following:

- an image format greater or equal to 60mm × 60mm
- a fixed focus lens with minimal distortion. This is to be calibrated to give a precise focal length, measured to within 0.01mm, and the precise distortion characteristics measured to enable compensation to occur during processing. A copy of the calibration certificate is to be supplied with the final survey materials. Details of proposed cameras and lenses are to be included in the method statement for each survey.
- a reseau plate with at least four fiducial marks visible per image.
- a film transport system that provides a suitable flatness for each exposure and will allow image restitution to the stated tolerances during later processing

4.2.5 Exposure of fiducial marks

Where practicable all available fiducial marks should be equally exposed and visible in each image. This is particularly important where the chosen camera does not have self-illuminating fiducial marks. Where fiducial marks have not been correctly exposed, the achieved accuracies of orientation are to be noted for each affected stereo-model during any later processing work. Where these may lead to orientation residuals being outside of the specified tolerances, the client is to be contacted to agree any necessary variation prior to processing the affected stereo-model.

4.2.6 #Film criteria

Choose an option. Monochrome film has the advantage of greater resolving power and sharpness and better archival qualities. Colour film may assist in the interpretation of detail and will be essential for recording wall paintings, mosaics, tiles etc. Colour transparency may speed up a project if an analytical plotter is to be used as it will not be necessary to make diapositives. This will be to the detriment of the archival value of the photography, however, as it will be the primary image that is being handled.

4.2.7 Production of positive transparencies (diapositives)

While it may be tempting to plot from negatives to save the time and expense of producing diapositives, this should be avoided for two reasons. Firstly, interpretation of detail is more difficult due to the unnatural negative view. Secondly, the negatives are bound to be damaged to a certain extent through the handling required to place them in and take them out of the plotter and therefore be of reduced archival quality.

4.2.8 #The use of small-format cameras

Smaller format cameras will mean that more photographs and more control points will be required to satisfy later sections so therefore delete (b) unless, for example, the subject is very small or lack of space dictates that a particular project requires the use of such cameras.

4.2.9 Metadata

The date and time of exposure is obviously a valuable addition to the archival quality of a photograph. For film photography a chalk board or letter board may be placed in the shot to show date and time etc.

4.2.6 Film criteria

Where film-based imagery is used, it must be taken with appropriate monochrome or colour film that:

- has a fine grain size for high-quality image definition with an ISO value of 125 or slower for monochrome and 160 or slower for colour;
- and is processed to an archival standard, as recommended by the manufacturer.

Where colour imagery is specified, all the above criteria must be met along with the appropriate balancing of film for either daylight or artificial illumination. A standard colour chart and/or grey scale is to be included in at least one of the images per subject to provide guidance on colour balancing prior to output.

The following type of film is to be used for the project:

(a) monochrome negative; or

(b) colour negative; or

(c) colour transparency.

4.2.7 Production of positive transparencies (diapositives)

If an analytical plotter is to be used contact positive images are to be made from film negatives, after initial development, for use in any subsequent photogrammetric processing. The primary negative is to be archived in an appropriate sleeve (see section 3.4.2). No photogrammetric processing is to be carried out from the primary negatives.

4.2.8 The use of small-format cameras

The use of small-format cameras – below 60mm × 60mm for film and sub 13 million pixel arrays for digital either

(a) is not allowed; or

(b) is allowed but full details of camera calibration, lens distortion or pixel resolution (digital only) must to be provided in the method statement.

4.2.9 Metadata

In order to provide proof of when the archive image was actually taken, the date and time of exposure is to be recorded within the metadata for each digital image. It is therefore essential that the date and time is set correctly in the camera.

4.3 Image acquisition for photogrammetry and orthophotography

The base to subject distance ratio (known as base to height ratio for aerial photography) is the ratio of the distance between two camera positions and their distance from the subject. If the ratio is too low or too high it will not be possible to view the photographs stereoscopically. An overlap of 60% between photographs ensures complete but economic coverage from a strip of photographs. Excessive variations in scale between stereo images will make them difficult to view stereoscopically.

4.3.1 Requirement for square-on imagery

If photographs are taken square-on to the subject it will be easier to use them for mapping and they are more likely to be suitable for other purposes such as rectification. It would not be economic, however, to take a photograph exactly square-on when, for example, a small tilt would avoid the need for a second strip of photography.

4.3.4 #Accepted scales of imagery

For digital imagery state the required ground sample distance (gsd). Gsd is the size in the real world of that part of the subject represented by one pixel of a digital image. For photogrammetry at the typical architectural scales the following values are recommended:

for 1:50 output scale, 2mm maximum gsd

for 1:20 output scale, 1mm maximum gsd

for 1:10 output scale, 0.5mm maximum gsd

For film state the required negative scale. This should be approximately 6× smaller than the output scale so the following values are recommended:

for 1:50 output scale, a minimum negative scale of 1:200

for 1:20 output scale, a minimum negative scale of 1:100

for 1:10 output scale, a minimum negative scale of 1:50

Values for different output scales may be extrapolated.

4.3.5 #High-level coverage

Delete the options not required. Photography of high elevations or even lower elevations with reduced stand-off distance can suffer from occlusions caused by the relief of the detail. This can lead to gaps in the plotted detail or orthophotograph. Extreme tilts of the camera can result in stereo-models that will not set-up or are difficult to plot from. To avoid these problems the camera can be raised up using access equipment such as a scaffold tower or hydraulic lift.

4.3 Image acquisition for photogrammetry and orthophotography

All areas outlined for survey in the project brief are to be covered by overlapping stereoscopic imagery. These images must be arranged to provide the following basic image geometry and camera alignments:

- camera base to subject distance ratio of no more than 1:4
- overlap between adjacent stereo images of at least 60%
- alignment of each image plane, with the principal plane of the subject, to be within ±3° of parallelism
- minimised vertical tilt of the camera, either upwards or downwards, to a maximum of 15°
- a variation in the scale between adjacent stereo-images of no more than 5%

4.3.1 Requirement for square-on imagery

To increase the archival value of the survey photography, where practicable, the stereo-images are to be taken approximately square-on to the subject in both the horizontal and vertical axes. Care must also be taken to achieve economic coverage.

4.3.2 Coverage of prominent architectural features

Where prominent architectural features are present, such as a large window or arched doorway, imagery must be taken that provides an orthogonal and not an oblique or tilted view of the feature. This is particularly important when the imagery is to be used to form a scaled image, such as an orthophotograph.

4.3.3 Use of oblique imagery

This is only to be used to infill areas potentially obscured on the standard orthogonal imagery. The imagery should not be convergent and the camera axes must not cross. Details of where any oblique imagery will be required are to be included in the method statement for each survey.

4.3.4 Accepted scales of imagery

Digital: Where digital imagery is used, whether from a digital camera or scanned film negatives, the ground sample distance (gsd) is to be ……mm.

Film: Where film diapositives are to be used or film negatives are to be scanned the photography must be taken with a negative scale of 1:….. .

4.3.5 High-level coverage

Where the subject to be surveyed is of a significant height, imagery must still be taken within the stated tolerances for camera tilt, image scale variation and negative scale as outlined above. The use of access equipment is

(a) not essential; or

(b) at the contractor's discretion; or

(c) essential.

4.4 Photogrammetric processing

There are two types of photogrammetric processing systems currently in use. These are analytical plotters and digital photogrammetric workstations. Analytical plotters are computer controlled optical-mechanical devices that use conventional film transparencies. Digital photogrammetric workstations are computers with a 3-D viewing system, a 3-D input device and obviously require digital images. For the production of line drawings both types of system require a skilled operator to trace round the detail in a 3-D view. In most situations it is more efficient to use a digital system especially now that directly captured digital images are more prevalent. Analytical plotters do have one advantage in that the stereo view is often clearer because the resolution of the image is the grain size of the film while with a digital system it is restricted to the resolution of the computer screen.

4.4.1 Accuracy of orientation

Photogrammetric orientation of a pair of stereo photographs is required before they can be used for accurate survey and consists of three processes. These are the interior, relative and absolute orientation (the latter two are often performed together and described as the exterior orientation). The interior orientation accounts for the geometry of the camera. The relative orientation recreates the positions and tilts of the camera relative to each other when the photographs were taken. The absolute orientation uses control points to position the stereo view in 3-D space so that scaled detail in the correct location can be recorded. Any discrepancies between the stereo view and the true co-ordinates of the control points are displayed as residuals. In order to achieve the required accuracy of processing the residuals will have to be equal to or less than the figures stated in section 4.4.2.

4.4.3 #Processing from large-scale imagery

If any part of the area for survey requires large-scale imagery insert a description or reference to the particular area(s) and the required gsd or negative scale.

4.4 Photogrammetric processing

All photogrammetric processing work is to be carried out using standard photogrammetric workstations utilising stereo-imagery. The choice of equipment – digital or analytical – and methodology is discretionary, but must be outlined in the method statement. See section 4.1.2 regarding the rejection of digitising techniques from overlapping imagery. Material generated must be within the stated tolerances and meet the specified standard for drawing detail and presentation. The data may be required in both digital form and as a hard copy (see section 3.5 for details).

4.4.1 Accuracy of orientation

All stereo images will be restituted, so that the residuals obtained during the orientation procedures generate survey data that is commensurate with the line width accuracy at final plot scale (see section 4.4.2). Where stereo-images have been successfully restituted, but do not meet these specified tolerances, the client is to be contacted to agree any necessary variations prior to processing continuing. The orientation results for all processed stereo models are to be recorded and provided, as a digital listing, with the final survey materials.

4.4.2 Accuracy of processing

Recorded points must be within the accuracy figures noted below, the standard for photogrammetric processing relates to the accuracy of final line width of the vector data generated. For standard-scale output using a 0.18mm line width these are:

for 1:50 output scale, 9mm in reality

for 1:20 output scale, 4mm in reality

for 1:10 output scale, 2mm in reality

4.4.3 Processing from large-scale imagery

Any ornate features, such as capitals, mouldings and other sculptural detail, may have to be surveyed using larger scale imagery than noted in the standard specification. The following areas (list areas here) require large-scale imagery with either

(a) a gsd of … ; and/or

(b) a negative scale of …

4.4.4 #Rate of data capture

Choose the option required and insert suitable values if necessary. The default values will be suitable in most cases (see section 2.1.2).

4.4.6 #Output scale

Insert the required output scale. The general standard for photogrammetric processing relates to line width accuracy so the output pixel size should be as follows for the typical architectural scales:

for 1:50 output scale, a maximum pixel size of 5mm in reality

for 1:20 output scale, a maximum pixel size of 3mm in reality

for 1:10 output scale, a maximum pixel size of 1mm in reality

Values for different output scales may be extrapolated.

4.4.4 Rate of data capture

Where regular un-eroded features are apparent both stream and point-by-point digitising methods may be used to accurately transcribe the shape of the feature being surveyed. For any irregular, eroded features the following criteria must be fulfilled:

- Stream digitising methods must be used with a maximum distance between points of either

  (a) 30mm; or

  (b) .....mm in reality.

- Points must be recorded be it manually or automatically at distinct corners and changes in direction of greater than either

  (a) 10°; or

  (b) .....°.

4.4.5 Plotting

All photogrammetric data is to be three-dimensionally recorded as CAD data. Such features as the splayed reveals to window openings, the curved elements of moulding profiles and returns to door openings must be correctly recorded in 3-D so as to allow oblique viewing of the final data set. Care is to be taken to ensure that no unnecessary overlap of lines in 3-D space occurs.

4.4.6 Output scale

The final out put scale is to be 1: ..... .

The output resolution is to be at least 600dpi and the pixel size is to be a maximum of …mm in reality.

4.5.1 #Level of detail

Choose the required level of detail.

Delete the item not required. The use of CAD repeats is unlikely to be appropriate for historic buildings as even detail that appears to be identical can have subtle differences.

4.5 Drawing content

4.5.1 Level of detail

The areas identified for survey will require photogrammetric processing to either

(a) the full level of detail; or

(b) the outline level of detail, as described below.

Full detail

All architectural detail is to be recorded including

- windows
- doors
- fireplaces
- jambs, cills, string courses, lintels
- the stonework immediately surrounding a feature
- window tracery and ferramenta (iron work)
- architectural fragments including corbels, architraves and mouldings
- roof and chimney outline
- any visible cracks in fabric
- quoins and individual voussoirs above window openings
- services and rainwater goods
- outline of brickwork, plaster and images upon fabric eg wall painting
- all visible ashlar, cut or dressed stone, and coursed rubble
- revealed core-work (outline of medium to large-sized stones).

(see Fig 4.1)

The outline of individual bricks and designs in stained glass windows are not normally required. Where the jointing between stonework is smaller than the required accuracy of the survey, and cannot be recorded on both sides, a single line is to be placed along the centre line of the joint.

Outline detail

Where an outline survey is specified, only the principal architectural detail is to be recorded. Unless specified, each individual stone or brick is not to be recorded.

The maximum output scale of survey dictates the required accuracy of photogrammetric processing. Therefore any feature(s) that measure greater or equal to the figures noted in section 4.4.2 must be recorded by a solid line, if visible in the stereo-model. Where a feature is not visible in the stereo-model, it must not be recorded.

The use of CAD repeats or cloning of features is either

(a) not permitted; or

(b) permitted.

(see Fig 4.2)

4.5.2 #Specific details to be noted

State the required level of recording for sculptural detail.

Choose whether individual roof tiles are required.

State the required level of recording for any vaulting details, timber panelling or metal work.

Insert any other required details or delete those not required.

4.5.2 Specific details to be noted

The outline of any stone block shall be taken as the arris where this is visible. Otherwise the junction between stone and mortar is to be recorded.

- Features in stonework such as putlog holes, structural cracks and rainwater services must to be recorded in full.
- Window reveals must be recorded in full (Fig 4.10; see section 4.5.6 for further details on presentation).
- The outline of any areas that cannot be surveyed using photographic based survey should be plotted as a dashed line encompassing the text 'obscured by …'.
  For example, when detail is hidden by vegetation, the text 'obscured by vegetation' should be inserted.
- The side faces of any buttresses that are more than one stone in depth are to be surveyed and presented as separate orthogonal drawings.
- The required level of recording of sculptural detail is …
- Individual roof tiles will either

  (a) not be required; or

  (b) be required.
- The required level of any vaulting details, timber panelling and metalwork is …
- Where the edge of an individual feature, such as a stone or brick, forms part of the outer edge of the elevation being surveyed, this must not be recorded separately as part of a major outline. Each object must be recorded as a closed feature with a separate line in between to represent any mortar infill.

  (see Fig 4.8)

  Other details …

4.5.3 Line styles

The standard line type for all processed architectural detail will be a continuous solid black line of 0.18mm in width. A dashed line is to be used to accurately define the shape where

- the edge of a feature is eroded/weathered beyond a range of 20mm;
- the edge of a feature is indistinct and the operator cannot guarantee the accuracy of the line work;
- the limits of an area of obscured detail (eg by vegetation are required).

(see Fig 4.9)

It is acceptable to use arcs, so long as they accurately define the shape of the feature to be surveyed.

4.5.4 #Curved features

Choose the required option. Unpeeling will allow the accurate scaling of dimensions and areas from a drawing but the detail will be displaced from its true 3-D position. An orthogonal view of a curved feature will suffer from fore-shortening but the detail will be in the correct position.

4.5.5 Closed features

Plotting stones etc as closed polylines means it is possible to apply hatching etc in the CAD drawing.

4.5.7 #Provision of sectional information

The photogrammetric process allows the production of horizontal (profile) and vertical (section) cut lines through the subject being surveyed. The standard level for horizontal profiles to be taken is 0.1m above window cill level although the precise location and purpose should be noted on an attachment. Unless they are to form part of an architectural section, these cut lines should be presented as a single, continuous solid line.

Indicate whether any sectional information is required and if so provide a diagram or description to indicate the location of cut lines.

4.5.8 #CAD layer names

The English Heritage convention may be used as a default or any other convention may be substituted. Please note the English Heritage convention separates detail by function rather than form. This is ideal for archaeological analysis but may not be suitable for architectural analysis.

4.5.4 Curved features

Curved features are to be recorded in true three dimensions, presented either

(a) unpeeled so as to provide a true-to-scale representation; or

(b) as an orthogonal view.

The method proposed for any required 'unpeeling' of data is to be outlined in the method statement.

4.5.5 Closed features

Detail that is a closed feature, such as a complete stone, is to be recorded with a closed 3-D polyline. Where a feature does not appear closed, such as part of an obscured stone, it is to appear as an unclosed 3-D polyline.

4.5.6 Recording of reveals

Where reveals detail is recorded, each face of the stone forming the arris is to be plotted. Problems of overlapping detail can occur when viewed 2-D. This is particularly apparent when the reveal is at right-angles to the main face. To avoid this, detail that is obscured by the main elevation is to be placed in a separate CAD layer, eg 0P-openingsA (Fig 4.10).

4.5.7 Provision of sectional information

Sectional information is either

(a) not required; or

(b) required for the cut lines shown on the attached diagram.

4.5.8 CAD layer names

The following is the English Heritage convention for the layering of architectural photogrammetric survey in CAD (Fig 4.9).

layer	*colour*	*description*
0P-major	white	major – This is to include all structural elements facing stone, ashlar etc, except for those specified below.
0P-core	red	core-work exposed by the removal of facing stone
0P-openings	blue	windows/doors/fireplaces – This is to include all jambs, cills, voussoirs, lintels and surrounding stonework.
0P-architectural	green	architectural fragments: corbels, architrave, mouldings, etc
0P-sculptural	cyan	sculptural detail: figures and carved detail
0P-services	magenta	modern service: drainpipes, lightning conductors, ducting, etc
0P-text	white	text/notes: for areas obscured, relating to architectural data, not border information
0P-control	white	control points: depicted as a cross with point number; layer to be frozen during hard copy output
0P-hidden	grey (254)	hidden detail
0P-etc		These may be used where a particular element does not fit into the previous layers. The layer name is to be prefixed 0P-.

4.5.9 #CAD layering – general notes

If a convention other than the English Heritage standard is used this section will need to be edited.

4.6 Orthophotographic processing

Please note this section specifies close range orthophotographic processing. For an aerial orthophotograph specification refer to 'Vertical Aerial Photography and Derived Digital Imagery' RICS 2001.

4.6.1 Accuracy of orientation

See notes to section 4.4.1.

4.6.2 #Digital elevation model

Choose the option required and insert a suitable value if necessary. Option (a) 100mm will be suitable for elevations with average relief, which are to be presented at 1:20 or 1:50 scale. Larger scales and more complicated relief may require a smaller point spacing.

4.5.9 CAD layering – general notes

Where architectural fragments or sculptural features form part of a window or door, etc, they are to appear within the layer for windows/doors (eg 0P-openings). The above layering convention is also to be applied when section or profile information is specified, depending upon the type of detail that the cut line actually passes through. Any areas of erosion or damage, that are recorded, should be placed within the same layer as the feature that they concern. If there is any doubt into which layer a feature should be placed, it should be put into 0P-major.

(see Fig 4.9)

4.6 Orthophotographic processing

All orthophotographic processing work is to be carried out using standard photogrammetric equipment utilising stereo-imagery. The choice of equipment, software, and method for providing the required survey are discretionary, however they must be outlined in the project method statement. The method proposed must be capable of generating the required materials to the stated tolerances and meet the specified standard for presentation.

4.6.1 Accuracy of orientation

All stereo images are to be restituted, so that the residuals obtained during the orientation procedures generate survey data that is commensurate with the line width accuracy at final plot scale (see section 4.4.2). Where stereo-images have been successfully restituted, but do not meet these specified tolerances, the client is to be contacted to agree any necessary variations prior to continuation of processing. The orientation results for all processed stereo models are to be recorded and provided in a digital listing with the final survey materials. There is no requirement for any printed listings.

4.6.2 Digital elevation model

The spacing of points in the digital elevation model (DEM), used for the generation of the orthophotograph, is to be not greater than either

(a) 100mm in reality; or

(b) …mm in reality.

Break lines should be included where necessary to assist in the orthophotograph generation. The processed DEM must accurately depict the 3-D surface surveyed and therefore automatically generated DEMs may require manual editing.

4.6.3 Mosaic generation

The orthophotograph mosaic is to be generated using 'feathering' techniques, so that the joins between images are not visible in the final output. Seam lines are to follow linear detail such as mortar joints. Colour balance must be consistent. Any distinct shadows in recessed areas are to be digitally removed.

4.6.4 #Output scale

Insert the required output scale. The general standard for orthophotographic processing relates to line width accuracy so the output pixel size should be as follows for the typical architectural scales:

for 1:50 output scale, a maximum pixel size of 5mm in reality

for 1:20 output scale, a maximum pixel size of 3mm in reality

for 1:10 output scale, a maximum pixel size of 1mm in reality

Values for different output scales may be extrapolated.

4.6.5 #Processing from large-scale imagery

If any part of the area for survey requires large-scale imagery insert a description or reference to the particular area(s) and the required gsd or negative scale.

4.6.6 #Presentation of orthophotography

Edit this section if, for example, a different CAD or GIS package is to be used.

4.6.4 Output scale

The final out put scale is to be 1: …

The output resolution is to be at least 600dpi and the pixel size is to be a maximum of …mm in reality.

4.6.5 Processing from large-scale imagery

Any ornate features, such as capitals, mouldings and other sculptural detail, may have to be surveyed using larger scale imagery than noted in the standard specification.

The following areas (list areas here) require large-scale imagery with either

(a) a gsd of … ; and/or

(b) a negative scale of … .

4.6.6 Presentation of orthophotography

The orthophotographic digital image files are to be supplied attached to an AutoCAD .DWG file, in the appropriate co-ordinate system (see section 3.1 Digital data) for further details.

4.7.1 #Image provision

It is unlikely that a contractor will want to use glass plate negatives, however, if they do this should only be allowed if the negatives are not required to be archived.

4.7.2 #Digital cameras and scanning

Many digital cameras now have arrays of 6 million pixels or greater, however, their lenses may well exhibit excessive distortion and therefore not be suitable for rectified photography. Higher grade digital cameras are able to use a wide range of high quality lenses that will be able to satisfy the conditions of this section.

Photographs taken in natural light are likely to have different exposure conditions. Scanner settings should be checked for each individual image and automatic colour balancing not relied on.

Choose an option. Option (b) may be helpful for very large-scale projects.

4.7 Rectified photography

4.7.1 Image provision

Details of the proposed cameras and lenses are to be provided with the method statement for each survey. The use of glass-plate negatives is either

(a) not allowed; or

(b) allowed.

4.7.2 Digital cameras and scanning

Where the use of either a digital camera or scanned images is proposed, the following criteria must be fulfilled:

- Digital cameras must have an array greater or equal to 6 million pixels.
- Digital cameras must have a lens, whether calibrated or not, that exhibits minimal distortion. That is the lens must not introduce any discernible distortion of horizontal and vertical lines in the subject to be surveyed and the resultant digital images must be capable of being processed to the tolerances stated in sections 4.8.1 and 4.9.1.
- If scanning of film negatives is proposed, this must be carried out to an optical resolution, without interpolation of at least 1000dpi, if using a standard scanner, or a pixel size no greater than 25 microns if using a dedicated photogrammetric scanner. The chosen equipment must be capable of scanning the image without introducing any significant distortion and the resultant digital images must be capable of being processed to the tolerances stated in sections 4.8.1 and 4.9.1. Details of the scanning equipment and proposed resolutions are to be provided in the method statement for each survey.
- If scanning of colour negatives is proposed, this must not introduce any changes to the colour balance of the original image.

The use of high-resolution, geometrically correct, photogrammetric scanning techniques is either

(a) not essential; or

(b) essential.

4.7.3 #Digital image criteria

Choose an option. Monochrome images will have a smaller file size and avoid colour balance problems. Colour images may assist in the interpretation of detail and will be essential for recording wall paintings, mosaics, tiles etc.

4.7.5 #Film criteria

Choose an option. Monochrome film has the advantage of greater resolving power and sharpness and better archival qualities. Colour film may assist in the interpretation of detail and will be essential for recording wall paintings, mosaics, tiles etc.

4.7.3 Digital image criteria

Where digital camera imagery is proposed, this must be captured at 16 bit but may be reduced to 8 bit for processing. If the images are captured in RAW format these files must be supplied as well as TIFF versions. If the proposed camera only produces JPEG files these must supplied with the least possible compression. Monochrome imagery may be provided by reduction to grey scale in a standard image processing package. Where colour imagery is specified, as well as meeting the above criteria, the balancing of images for either daylight or artificial illumination must be achieved. A standard colour chart and/or grey scale is to appear in at least one of the images per subject area to provide guidance on colour balancing prior to output.

The images are to be either

(a) colour; or

(b) monochrome.

4.7.4 Film cameras

Cameras, including 'metric' and 'semi-metric' that fulfil the following criteria may be used to generate the required imagery:

- an image format greater or equal to 60mm × 60mm
- a lens, whether calibrated or not, that exhibits minimal distortion. That is the lens must not introduce any discernible distortion of horizontal and vertical lines in the subject to be surveyed and the resultant photographs must be capable of being scanned and processed to the tolerances stated in sections 4.8.1 and 4.9.1.

4.7.5 Film criteria

Where film-based imagery is used, it must be taken with appropriate monochrome or colour film that

- has a fine grain size for high-quality image definition with an ISO value of 125 or slower for monochrome and 160 or slower for colour;
- is processed to an archival standard, as recommended by the manufacturer.

Where colour imagery is specified, as well as meeting the above criteria, the balancing of images for either daylight or artificial illumination must be achieved. A standard colour chart and/or grey scale is to appear in at least one of the images per subject area to provide guidance on colour balancing prior to output.

The following type of film is to be used for the project either

(a) monochrome negative; or

(b) colour negative.

4.7.6 #The use of small-format cameras

Smaller format cameras will mean that more photographs and more control points will be required to satisfy later sections so therefore delete (b) unless, for example, the subject is very small or lack of space dictates that a particular project requires the use of such cameras.

4.7.7 Metadata

The date and time of exposure is obviously a valuable addition to the archival quality of a photograph. For film photography a chalk board or letter board may be placed in the shot to show date and time etc.

4.8 Image acquisition for rectified photography

Although digital rectification packages can deal with fairly large tilts it is always advisable to take the photography as square-on as possible in the field. This is particularly important for features such as door and windows as any minor relief, such as moulding or reveals, will not be symmetrically recorded by a tilted photograph and as a result the final rectified photograph will look unnatural. Even lighting is particularly important when a number of photographs are to be montaged together. The join between two photographs will be difficult to hide if the exposure is uneven.

4.8.1 #Accepted scales of imagery

For digital imagery state the required ground sample distance (gsd). Gsd is the size in the real world of that part of the subject represented by one pixel of a digital image. For rectified photography at the typical architectural scales the following values are recommended:

- for 1:50 output scale, 5mm maximum gsd
- for 1:20 output scale, 2.5mm maximum gsd
- for 1:10 output scale, 1mm maximum gsd

For film state the required negative scale. This should be approximately 6× smaller than the output scale so the following values are recommended:

- for 1:50 output scale, a minimum negative scale of 1:200
- for 1:20 output scale, a minimum negative scale of 1:100
- for 1:10 output scale, a minimum negative scale of 1:50

Values for different output scales may be extrapolated.

4.7.6 The use of small-format cameras

The use of small-format cameras – below 60mm × 60mm for film and sub 6 million pixel arrays for digital either

(a) is not allowed; or

(b) is allowed but full details of camera calibration, lens distortion or pixel resolution (digital only) must to be provided in the method statement.

4.7.7 Metadata

In order to provide proof of when the archive image was actually taken, the date and time of exposure is to be recorded within the metadata for each digital image. It is therefore essential that the date and time is set correctly in the camera.

4.8 Image acquisition for rectified photography

All areas outlined for survey in the project brief are to be covered by suitable imagery. These images must be arranged to provide the following alignments and image quality:

- The alignment of each image plane, with the principal plane of the object, to within ±3 ° of parallelism. The alignment method is discretionary, but must be noted in the method statement provided for each survey.
- Where prominent architectural features are present, such as a large window or arched doorway, imagery must be taken that provides an orthogonal and not an oblique or tilted view of the feature.
- Imagery must be evenly lit with no strong shadows visible across the area covered.

4.8.1 Accepted scales of imagery

Digital: Where digital imagery is used, whether from a digital camera or scanned film negatives, the gsd is to be …mm.

Film: Where film negatives are to be scanned the photography must be taken with a negative scale of 1:…

4.8.2 #High-level coverage

Delete the options not required. Photography of high elevations or even lower elevations with reduced stand-off distance can suffer from occlusions caused by the relief of the detail. The gsd or negative scale may vary significantly across the image and therefore not satisfy section 4.8.1. Extreme tilts of the camera can result in photographs that fail to rectify in standard packages. To avoid these problems the camera can be raised up using access equipment such as a scaffold tower or hydraulic lift.

4.8.3 #Use of oblique imagery

Insert a figure of 45° or less. The use of oblique imagery should, however, be avoided wherever possible for the reasons stated above.

4.8.4 #Definition of principal plane

In almost all cases choose option (a).

4.8.5 #Control of rectified photography

Choose the required option. Option (a) co-ordinate controlled rectified imagery will be the most accurate and will be almost essential if a montage of a number of different images is required as there will need to be control points common to adjacent photographs. Option (b) scaled rectified imagery will be quicker, requires less equipment and therefore should be cheaper.

4.8.2 High-level coverage

Where the area to be surveyed is of a significant height, imagery must still be taken within the standard tolerances for scale of negative (see section 4.8.1).

The use of access equipment is

(a) not essential; or

(b) at the contractor's discretion; or

(c) essential.

4.8.3 Use of oblique imagery

This should only be used to infill areas potentially obscured on the standard orthogonal imagery. If used, the alignment of the image plane must be within 45° of parallelism with the principal plane of the subject. Details of where this technique is proposed should be included in the method statement for each survey.

The maximum tilt allowed will be …°.

4.8.4 Definition of principal plane

The principal plane is to be either

(a) the largest mono-planar surface of the area to be surveyed; or

(b) other (specify).

4.8.5 Control of rectified photography

Rectified photography is to be

(a) co-ordinate controlled rectified imagery; and/or

(b) scaled rectified imagery; or

(c) controlled by a method chosen at the contractor's discretion.

(see Figs 4.5 and 4.6)

Co-ordinate controlled rectified imagery requires a reliable and repeatable control to be achieved for each subject by establishing a metric-based co-ordinate system. Survey observations are to be taken to at least four survey targets or detail points if necessary, per image, to produce 3-D co-ordinated control points. The method for generating the co-ordinate control is discretionary, although this must achieve the survey accuracies specified in section 2.

Scaled rectified imagery requires the introduction of a scale measurement in the principal plane of the subject. The following methods for providing the scale are acceptable:

- one horizontal and one vertical measured distance between targets, placed in the principal plane in each image
- a scale bar typically divided into 100mm sections, placed in the principal plane and extending over at least half of the image area

4.9.2 #Output scale

Insert the required output scale. The general standard for rectified photography relates to line width accuracy so the output pixel size should be as follows for the typical architectural scales:

for 1:50 output scale, a maximum pixel size of 12.5mm in reality

for 1:20 output scale, a maximum pixel size of 5mm in reality

for 1:10 output scale, a maximum pixel size of 2.5mm in reality

Values for different output scales may be extrapolated.

4.9.3 #Presentation of rectified photography

Choose an option. Edit option (a) if a different CAD or GIS package is required.

If it is anticipated that dimensions or detail are to be digitised from the rectified photographs then (a) will be the best option.

4.9 Processing rectified photography

The final product is to be a digital image and it is anticipated that this will be achieved using one of a number of purpose designed digital rectification packages. Other methods are acceptable if it can be shown, in the method statement, that the specified tolerances can be achieved.

4.9.1 Accuracy of processing

The general standard for accuracy will be based on the ability to manually scale any measurable distance (eg the length of a scale bar or the distance between targets) that is visible in the principal plane of rectification to within ±0.5mm on the actual image. For the typical architectural scales of output the required accuracies for rectified processing are therefore at:

for 1:50 output scale, 25mm in reality

for 1:20 output scale, 10mm in reality

for 1:10 output scale, 5mm in reality

4.9.2 Output scale

The final out put scale is to be 1:…

The output resolution is to be at least 600dpi and the pixel size is to be a maximum of …mm in reality.

4.9.3 Presentation of rectified photography

All rectified photographs or montages are to be supplied as TIFF files. They are either

(a) to be attached to an AutoCAD .DWG file and correctly referenced to the control co-ordinate system; or

(b) if single rectified images they may be supplied as individual TIFF files but these must be to scale when printed at 100% image size.

(see Fig 4.7)

Fig 4.1 Photogrammetric survey 1:20 full detail.

Fig 4.2 Photogrammetric survey 1:20 outline detail.

Fig 4.3 Orthophotographic output.

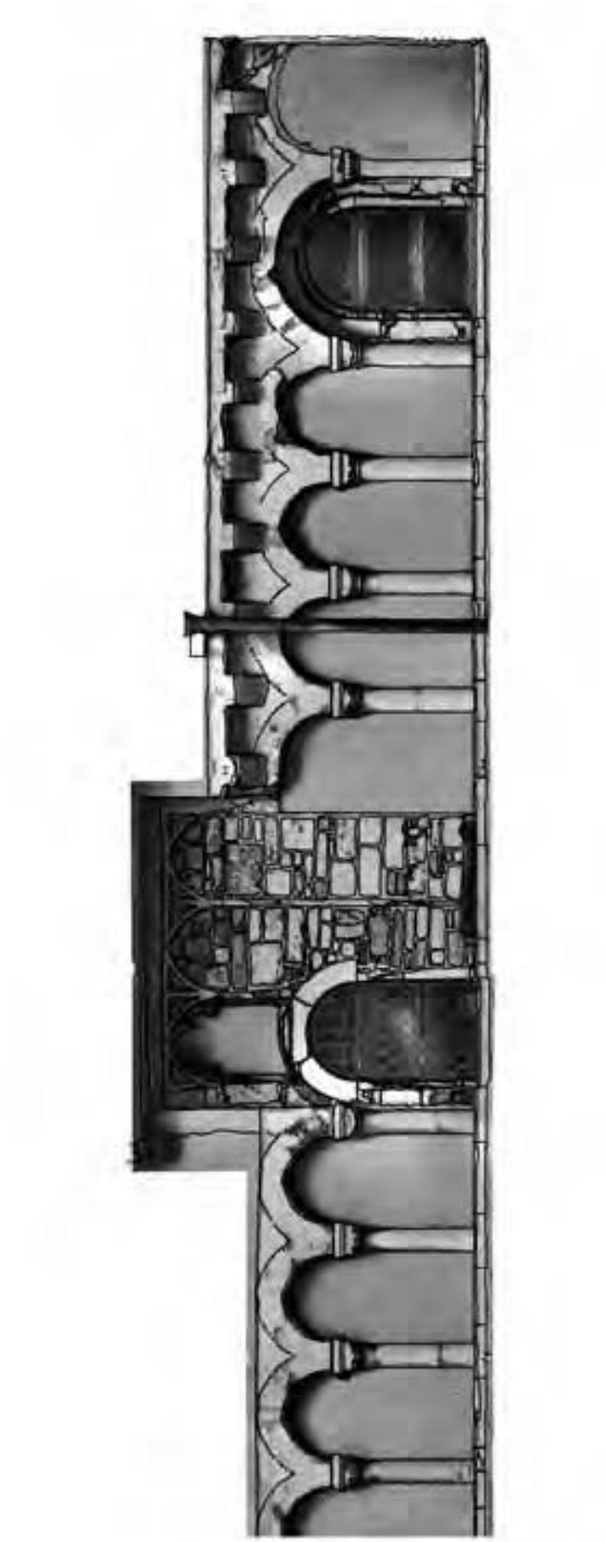


Fig 4.4 Orthophotographic survey with outline photogrammetry.

Fig 4.5 Single scaled rectified image.

Fig 4.6 Controlled rectified image.

Fig 4.7 Rectified digital montage.

Fig 4.8 Building edge detail, showing faced stonework and mortar

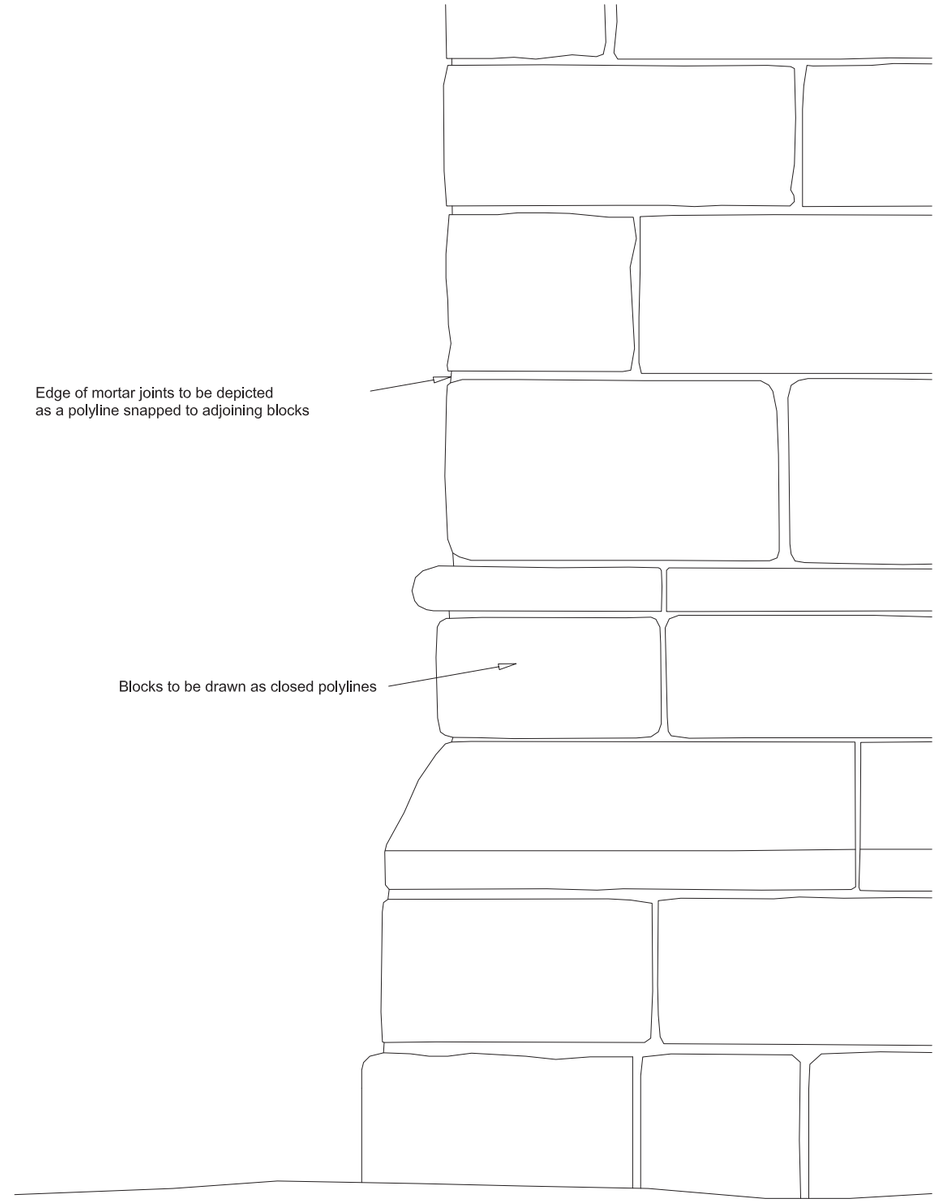


Fig 4.9 Use of layers and line types.

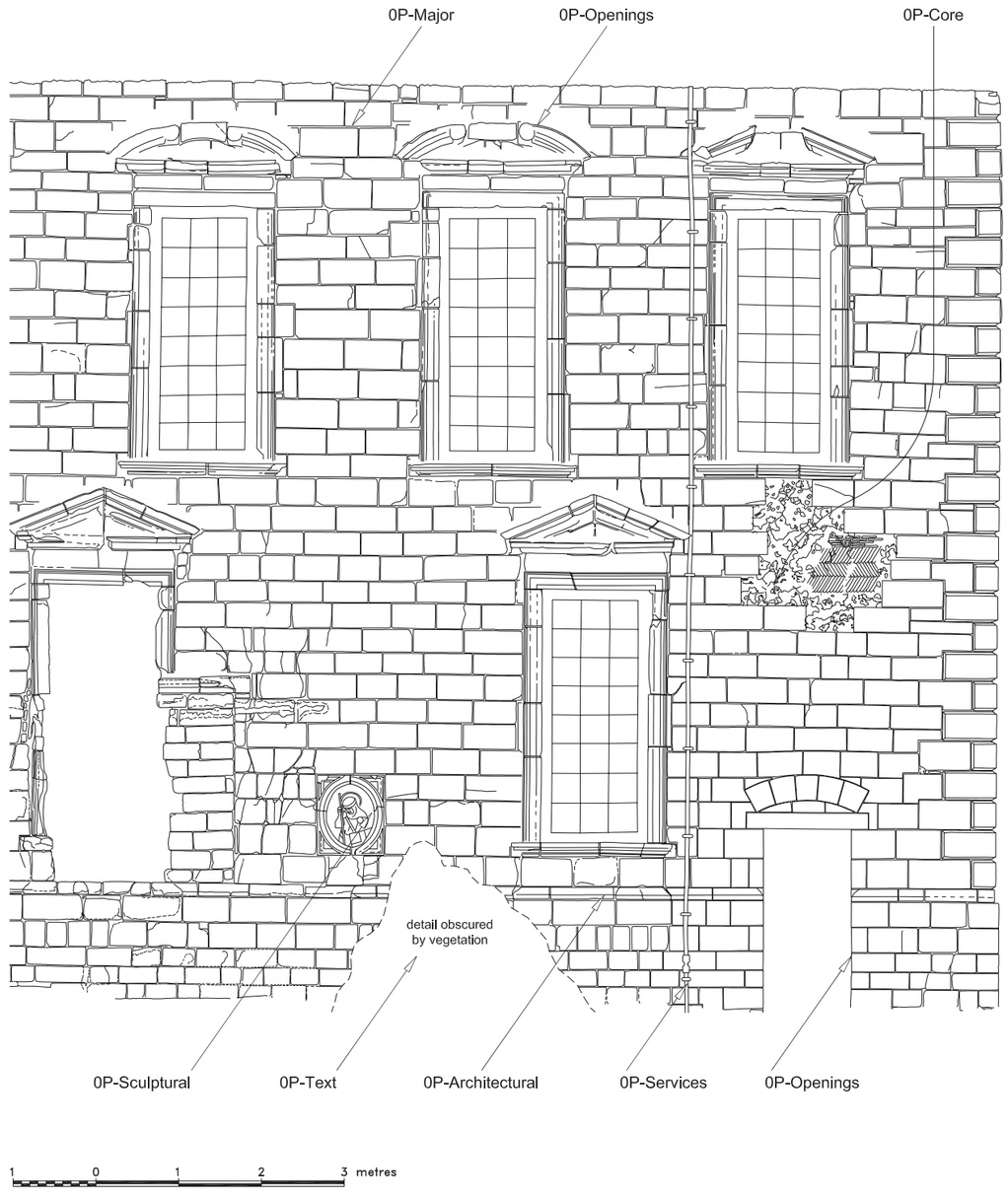
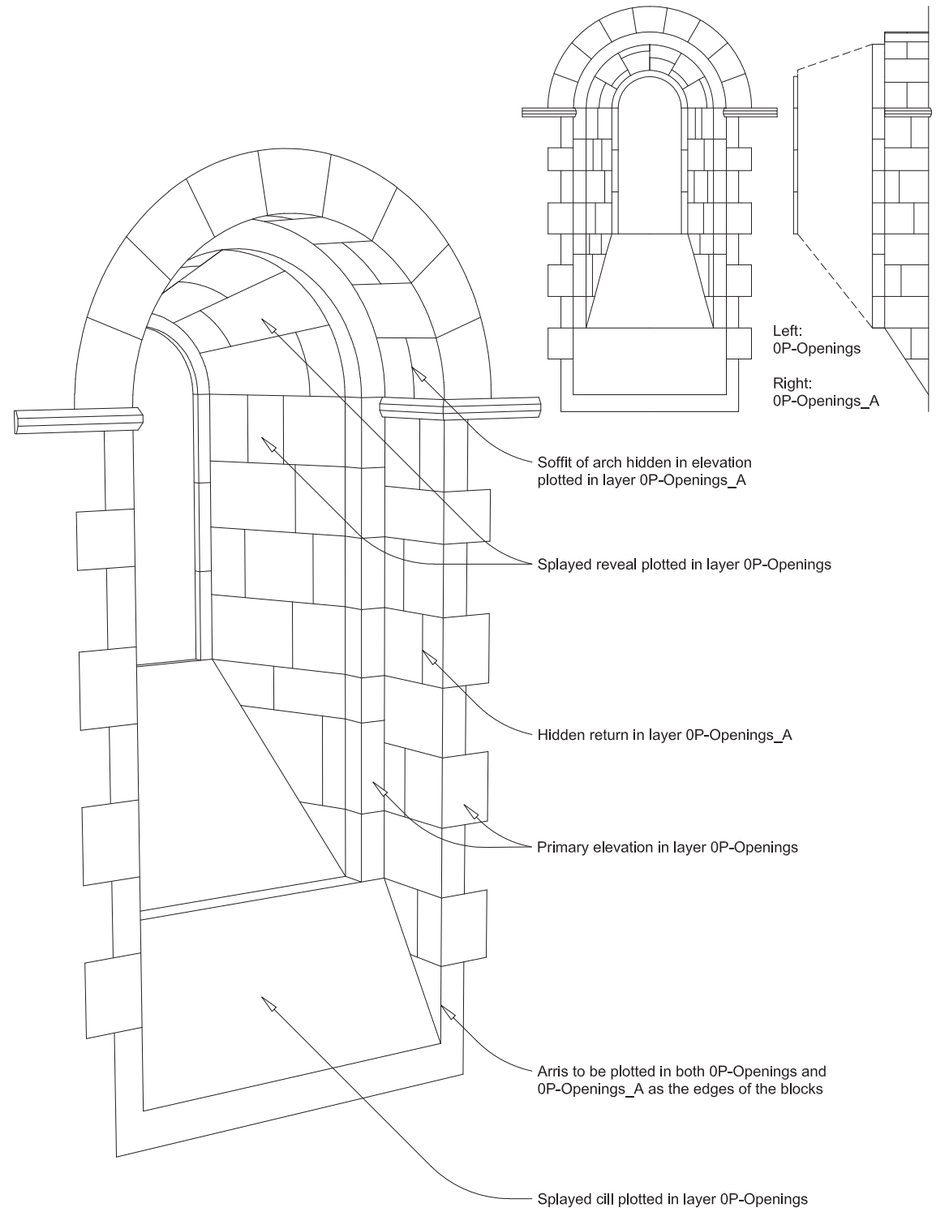


Fig 4.10 Presentation of reveal surfaces.



Section 5

Standard Specification for Measured Building Survey

5.2 Description of products

The required products must be correctly described so that there is clear agreement about terms such as ‘section’ and the completeness expected (full height etc), particularly if an indirect technique such as photogrammetry or laser scanning is proposed. Suppliers must not expect the client to accept unfinished work on the basis of constraints of the capture method.

A plan (Figs 5.1 and 5.2) is a convention for showing the horizontal extent of a building. A cut-line is required to show the walls of the building. The convention is for the cut-line to follow the height of a line between hip and shoulder height of a person standing. The cut-line is not simply a height at which the plane of projection is set, for it can vary. Clients are advised to closely specify a desired cut-line if there is ambiguity over the suitable height of the line (eg at changes in floor level or where buildings are built into a slope).

A section line can be taken anywhere through the building (Fig 5.3). The section line defines a plane of projection for the preparation of an elevational view. Section lines must be clearly defined in terms of position, extent and direction of view. They can be adjusted to include or exclude features (eg chimneys) but the line must remain parallel to the original plane. The exact position of the section lines needed to show the required aspects of the building when projected as a sectional elevation should be clearly delineated on sketch diagrams to accompany the project brief (see section 1.1.10).

Sections and sectional elevations are different (Fig 5.7). Determining the cut-line and the direction of view as well as the detail to be included is important. A simple profile can be referred to as a section but is often taken to mean a full height sectional elevation. It is essential that the terms are used correctly, as there is a great deal of work involved in preparing sectional elevations, which, once started, cannot be easily changed without expense, particularly the view or the position of the section line.

5.1 Measured building survey

5.1.1 Definition of measured building survey

For the purpose of this specification measured building survey is defined as the supply of metric survey data pertaining to buildings and presented as plans, sections, sectional elevations and elevations.

5.1.2 Metric requirements

The survey data must meet the metric performance requirements stipulated in section 2. The survey is required to be sufficiently precise so as to record the architectural form of the building and enable presentation in accordance with the conventions of architectural drawing (for example BS 8888:2004 Technical Product Documentation (TPD) Specification for defining, specifying and graphically representing products).

5.2 Description of products

The survey is to be supplied as a CAD drawing in the form of plans, sections, sectional elevations and elevations presented graphically (ie using lines and symbols). Where necessary the graphical data should be supplemented by text annotation (eg description of floor covering and material, height information). The correct use of line type, line weight and layers is essential in order to present the drawing elements in accordance with architectural convention. The building subject is to be presented using an orthogonal projection (ie the plan, section, sectional elevation or elevation is to be shown as a parallel projection onto a horizontal or vertical reference plane as described below).

5.2.1 Plan

A view of the structure as seen in a horizontal reference plane defined by the cut-line. The plan will show information above and below the reference plane unless this information is covered on another plan. The cut-line will reveal full architectural detail, deformation or displacement both at the height of cut and also above and below it. It should be made as informative as possible by cutting across door and window openings.

5.2.2 Section

A view of the internal space of the subject showing only those elements (including the thicknesses of walls) cut by a vertical reference plane.

5.2.3 Sectional elevation

A view of the internal space of the subject as seen from a plane defined by the cut-line or section line and showing all detail revealed by that view. Major structural components not visible (eg hidden from view or in front of the cut-line) may be required to be shown by use of a dashed line.

5.2.4 Elevation

A view of a facade or wall of the subject as an orthographic projection.

5.3 Drawing content

5.3.1 Detail required

The required scale of survey will determine both the level of detail and the expected precision. The level of detail refers to the density of information, while precision refers to the performance of the measured points used to delineate the detail. At a larger scale, such as 1:20, a plan, section or elevation will show more information than at a smaller scale, for example 1:50 or 1:100.

Detail comprises the visible features delineated within a plan, section or elevation such as openings, straight joints, roof scars, the jointing of masonry, the outline of fittings and fixtures or the outline of materials used. Sectional detail is to include eaves, cills, lintels, sashes etc.

1:50 scale

- The smallest plottable detail is 0.2mm (at 1:50 scale this equates to a 10mm × 10mm object), so a degree of generalisation is required.
- Large linear objects, such as skirting or cornices, must be shown as a light line inside the wall or cut-line.
- Annotation indicating floor material and direction of floorboards is to be included. A single line can be used to show joints in timber or for floor coverings.
- Openings in plan may be generalised, but must show an indication of the type of detail by careful use of an approved symbol for sash, mullion, door swing and lining.
- Overhead detail, such as beams, vaults, stair flights, reveals etc, must be shown as a dashed line.

1:20 scale

All detail and annotations that would appear at 1:50 will also be present at 1:20. In addition, all visible architectural features must be shown including:

- mouldings and sculptural detail from actual size source material (such as a profile trace or measured drawing);
- all stone by stone detail and galleting for elevations;
- floor detail such as the plan of stone flags or floor tiles for plans;
- timber components with pegs, peg holes and open or re-used joints plotted using a separate line to describe each component;
- eroded edges as seen in the required view to show the condition of the fabric;
- the deformation of wall surfaces at the cut-line and foot of wall line; and
- openings in full detail as apparent from the plane of reference.

5.3.2 #Curved features

Choose an option. A curved facade may be projected as 'un-peeled' to show all of the facade true to scale on the plot. If the facade is required to be seen as 'square on' the edges will suffer from foreshortening.

5.3.3 # Depiction of cut-line (plan and section)

The position and direction of view of the section line must always be shown on a plan or key plan – choose an option.

Building footprint

The building footprint or ground or floor line is the line at the foot of the wall. Plans of vertical walls that have a constant width over their full height will not show this line unless it is specifically requested. Where a wall has a batter or sits on a plinth the line will be visible and should appear on the plan.

Choose an option for depiction of the building footprint.

5.3.2 Curved features

Curved or conical facades will need special provision if all aspects of the facade should be recorded as an elevation (see also section 4.5.4)

Curved features should be presented either

(a) unpeeled so as to provide a true-to-scale representation; or

(b) as an orthogonal view.

The method proposed for any required 'unpeeling' of data must be outlined in the method statement.

5.3.3 Depiction of cut-line (plan and section)

Plan

The cut-line(s) must be shown with a line weight of a thickness determined by the output or plot scale. If possible the line should be thickened on the inside of the measured line such that the wall dimensions are not obscured.

Sections and sectional elevations

The cut-lines of any sections or sectional elevations should be clearly shown on either

(a) the accompanying plan; or

(b) a key plan.

The line must include arrows showing the direction(s) of view (Fig 5.3).

Building footprint

The contact lines between the building and the ground (also known as the ground line, when visible in elevation) must to be shown with a lighter line than the cut-line. The visibility of the line will depend on the wall, its inclination and the required scale.

The building foot print is to be

(a) shown; or

(b) omitted; or

(c) recorded in 3-D in a frozen layer.

5.3.4 Use of symbols

Symbols can be used as tabulated below.

item	*scale*	*size on plot*	*symbol*
door swing	1:20	full extent of swing	shown as an arc
	1:50	open at 90° or 45°	
levels	1:20 and 1:50	2mm cross	small cross with value to top right to two decimal places
step direction		text 2mm in height	arrow pointing up, labelled 'up'
glazing detail		a 0.25m line	single line on centre of window frame; frame beads omitted
windows and doors	1:100	repetition of a single measured type permitted	

5.3.8 #Use of text

Choose the preferred font.

5.3.9 #Overhead detail on plans

Choose an option. It is recommended that overhead detail is included as its omission will limit the usefulness of the final product.

5.3.5 Point density and line quality

Point density and line quality is to be in accordance with the performance specified in section 2.

5.3.6 Use of 'best profile'

The depiction of architectural forms requires special attention to the detail of functional openings such as cills, door opening, splays, mullions, plinths etc. Mouldings must be shown as completely as possible, with the 'best profile' shown. Where a profile of a damaged or eroded moulding can be derived with certainty it should be shown 'as complete' with the cut-line profile shown as a dashed line.

5.3.7 Assumed detail

Assumed detail should be submitted only if it meets the performance requirements of the survey product. If detail is absent from a drawing then the space is to be annotated with an explanation (eg 'no access', 'obscured at time of survey' etc).

5.3.8 Use of text

Text is only to be used if the information needed cannot be displayed as a graphic component of the drawing. Use of text is restricted to:

- annotation of direction of steps;
- description of material and services using appropriate abbreviations;
- values of spot heights;
- notification of restrictions to survey (see section 5.3.7);
- as required by section 3.

The text height is to be 2mm at the plot size.

The text style is to be either

(a) AutoCAD RomanD; or

(b) other (specify).

5.3.9 Overhead detail on plans

Large-scale surveys will require the depiction of the principal features of overhead structures such as vaults, beams, gantries, ceiling details, high level windows, roof lights, pulleys, murder holes etc. The annotation 'at high level' or (at HL) can be used to indicate detail above the plan height if it is not clear from the plotted lines alone.

Vaults, at 1:50 and 1:20 scale, should be shown by a plot of the rib lines, with imposts and bosses in outline. A single dashed line indicating the centre line of the rib may be used at 1:100 scale.

Overhead detail is to be

(a) recorded in 3-D and plotted at true height; or

(b) plotted in 2-D congruent with all other plan detail; or

(c) omitted (not recommended).

5.3.11 #Treatment of staircases on plans

Staircases must be shown. The amount of detail will vary according to the required scale. All staircases will require the use of a break line to show the intersection of the stair with the cut-line for the plan (Fig 5.5). Indicate the required options for levels and annotation.

5.3.12 #Services

Choose the required details or add/delete from the list as necessary.

5.3.10 Floor detail on plans

Plans at 1:20 and 1:50 scale are required to show the following floor details.

- changes in floor treatment;
- changes in floor level;
- steps: the line of tread noses (continuous) and risers (dashed, if undercut);
- flagstones etc, depending on scale;
- and fixings to walls and floor as seen on the cut-line (hinges, sockets, niches etc) should be shown in a line thickness greater than that used to depict all other detail.

5.3.11 Treatment of staircases on plans

The required convention for the depiction of stairs is to show the plan as seen from the cut-line and to use a break line to show the interruption of the plan, (Fig 5.5). Where stairs include, detail such half landings between floors that would not otherwise appear on a drawing, an inset plan is to be used. Overhead detail is to be shown as required by section 5.3.9.

Levels on steps and stairs should be shown either

(a) on each landing (ie at the top and bottom of each flight); or

(b) on all treads.

Stairs are either

(a) to be annotated with numbers to each tread; or

(b) not to be annotated.

5.3.12 Services

Large components such as radiators, exposed pipe-work, shafts, ducts etc must be shown in full detail. Smaller components may be indicated by standard symbol and/or annotation. The following services details must be shown and annotated with service type:

- large fittings only;
- pipe-work;
- duct-work;
- and electrical fittings (in elevations only).

Electrical wiring and fittings are not usually required to be shown on plans unless specified in the brief.

5.3.13 #Levels

Choose a preferred method for the indication of door and window heights.

5.3.14 #Roof survey

Choose an option for any roof survey (Fig 5.6).

5.3.13 Levels

Levels must be shown relative to the vertical datum as specified in section 2.

Levels must be located at the following locations where applicable:

- thresholds;
- either side of door openings;
- centre of each room;
- in each corner of each room;
- interior cills;
- exterior cills on centre of cill boards;
- lintel soffit.

The heights of window and door opening shall be either

(a) as indicated by lintel soffit and cill/threshold levels; or

(b) shown as an opening height

Floor to ceiling heights are required for each room should be shown enclosed in an ellipse.

5.3.14 Roof survey

Roof survey drawings can be presented in one of two states. Either with the roof cover (slates, tiles, lead etc) on or with the roof cover off. A survey may be required to show rafters and trusses or trusses only.

A roof plan is required showing

(a) ‘cover on’; or

(b) ‘cover off’; or

(c) ‘cover off trusses only’.

In all cases the roof must be shown as a true plan ie looking down.

5.4 Line types

The general requirement for the presentation of the survey is described in section 3.
The following describes requirement specific to the supply of measured building survey.

line	*line type*	*line weight/pen thickness*		
		1:20 scale	*1:50 scale*	*1:100 scale*
lines describing the edges of openings, changes of plane or skyline	continuous	0.18mm	0.25mm	0.18mm
cut-line	continuous	0.35mm	0.5mm	0.35mm
lines used to plot detail, if detail overlaps an edge, only the heavier line weight is to be used	continuous	0.13mm	0.13mm	0.13mm
overhead detail	dashed/hidden 2mm line with 1mm spacing		0.13mm	
plinth lines in plan	continuous, inner and outer	0.13mm and 0.18mm	0.13mm and 0.25mm	0.13mm
below plan detail – outside wall line	continuous	0.18mm	0.13mm	
below plan detail – inside wall line	dashed/hidden		0.13mm	
in front of section line	dashed/hidden	0.25mm	0.18mm	
inside cut-line of section	dashed/hidden		0.13mm	

APPENDIX 5.1

CAD Layer names for measured building survey

This is not an exhaustive list. New layers may be created so long as they are prefixed with 0A-.

APPENDIX 5.1

CAD Layer names for measured building survey

layer	*colour*	*line type*	*line weight* (mm)*	*description*
0A-cutline	cyan	continuous	0.5	the cut or plan line
0A-cutline	magenta	continuous	0.25	
0A-detail_50	black	continuous	0.13	detail lines for presentation at 1:50 scale
0A-detail_20	black	continuous	0.13	detail lines for presentation at 1:20 scale
0A-text	black	continuous	0.13	
0A-level		continuous	0.13	
0A-level text		continuous	0.13	
0A-svs_electric		continuous	0.13	
0A-svs_water		continuous	0.13	
0A-svs_gas		continuous	0.13	
0A-svs_ foul		continuous	0.13	
0A-svs_other		continuous	0.13	
0A-inst_cntl	black	continuous	0.13	control positions – to be frozen on presentation
0A-raw points	yellow	continuous	0.13	unedited 3-D data
0A-network _diagram	red	continuous	0.13	control diagrams – to be frozen on presentation
0A-digi		continuous	0.13	digitised from other sources
0A-title	cyan	continuous	0.35	
0A-grid		continuous	0.13	grid points to be frozen on presentation
0A-overhead	black	dashed	0.13	
0A-hidden	black	dashed	0.13	
additional layers for roof surveys				
0A-rafter		continuous	0.13	
0A-wallplate		continuous	0.13	
0A-chimney		continuous	0.35	
0A-purlin		continuous	0.13	
0A-joist		continuous	0.13	
0A-truss		continuous	0.25	

*except where specified as scale dependent in section 5.4

layer	*colour*	*line type*	*line weight* (mm)*	*description*
additional layers for vault surveys				
0A-rib		dashed †	0.13	for the rib lines; to be expanded according to rib type if required
0A-corbel		dashed	0.25	on plans, if at high level, shown as an outline
0A-shaft		dashed	0.35	on plans, usually shown as a cut-line
0A-cap		dashed	0.13	capital, impost or abacus
0A-boss		dashed	0.13	bosses may be shown as an outline

† dashed on plans, continuous for elevation

ENGLISH HERITAGE

APPENDIX 5.2

Abbreviations for measured building survey annotation

This is not an exhaustive list.

APPENDIX 5.2

Abbreviations for measured building survey annotation

Abbreviations must be listed on the index sheet or in the title panel. New abbreviations may be created but must be consistent within a survey or surveys. Where abbreviation leads to ambiguity the full text is to be used.

word	*abbreviation*	*word*	*abbreviation*
General			
centre line	CL	survey station	Stn, Sta
height/high	H	site bench mark	SBM
high level	HL	soffit	Soff
invert level	IL	surface level	SfceL
Ordnance Survey bench mark	OSBM	temporary bench mark	TBM
Building components			
arch height	AH	recessed door mat	RDM
beam Height	BH	skirting board	Skrtg
ceiling	C	springing line	SL
cill	S	stair	Str
cupboard	Cup	wall	W
fire place	FP	window head height	WH
floor	Flr		
Services			
cover level	CL	rain water pipe	RWP
down pipe	DP	roding eye	RE
drain	Dr	stop valve	SV
drive shaft	D shft	vent pipe	VP
electricity	Elec	void	Vd
inspection cover	IC	water closet	WC
man hole	MH	waste pipe	WP
radiator	Rad	wash hand basin	WHB
rainwater hopper	RWH		
Materials			
aluminium	Al	concrete	Conc
asphalt	Ap	lath and plaster	L&P
bitumen	Bit	lead	Pb
brick	Bk	reinforced concrete	RC
cast iron	CI	stone	St

Fig 5.1 Plan showing use of line weights and inclusion of overhead detail; inset, the treatment of overhead detail in plan.

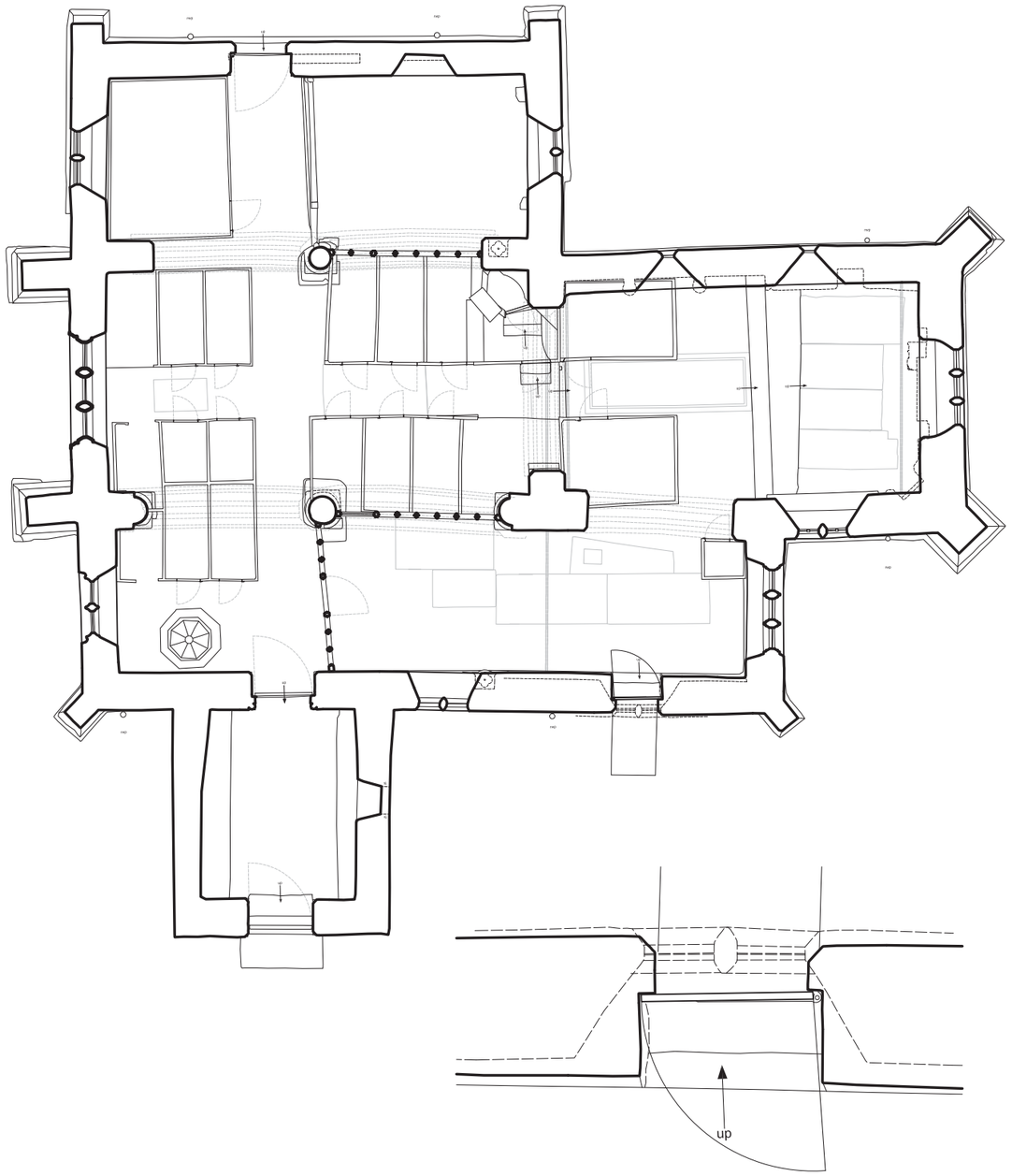


Fig 5.2 Example of the use of symbol and text on a plan at 1:50 scale.

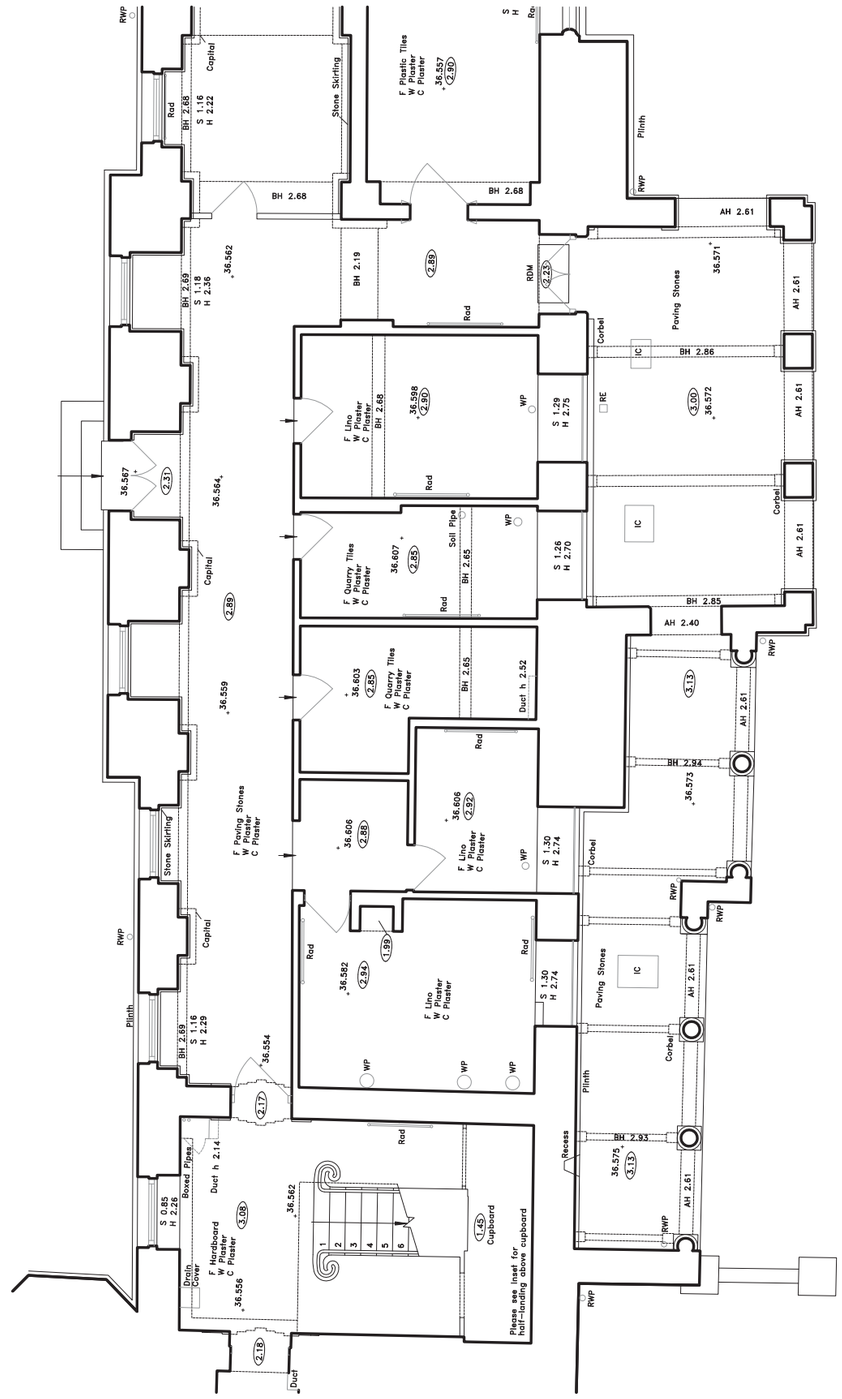


Fig 5.3 Section line as shown on plan.

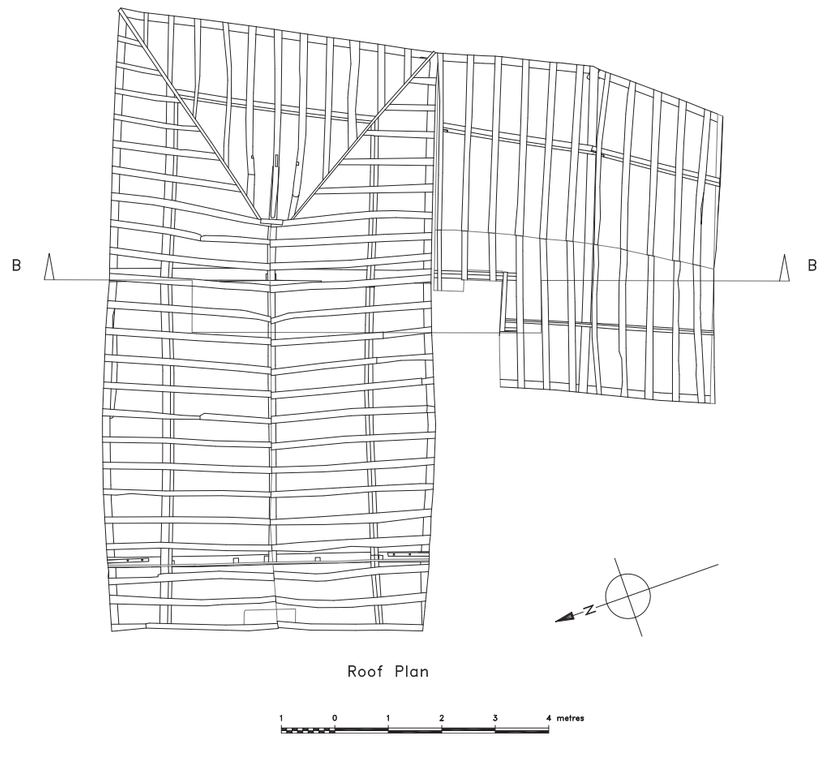


Fig 5.4 Examples of overhead detail: top, a vaulted ceiling prepared for 1:20 scale reproduction; bottom, overhead beams on a 1:50 plan.

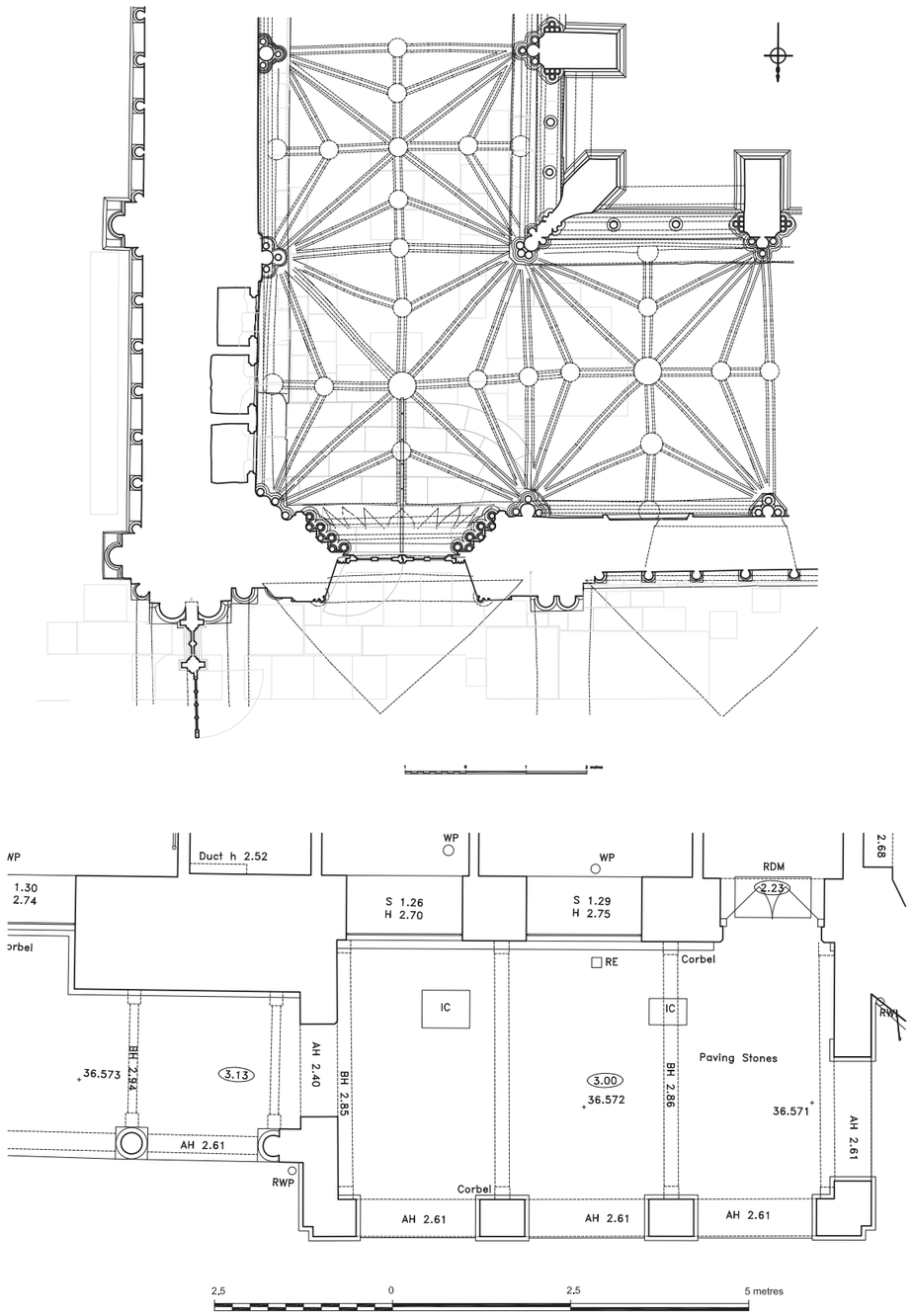


Fig 5.5 Treatment of staircases on plans.

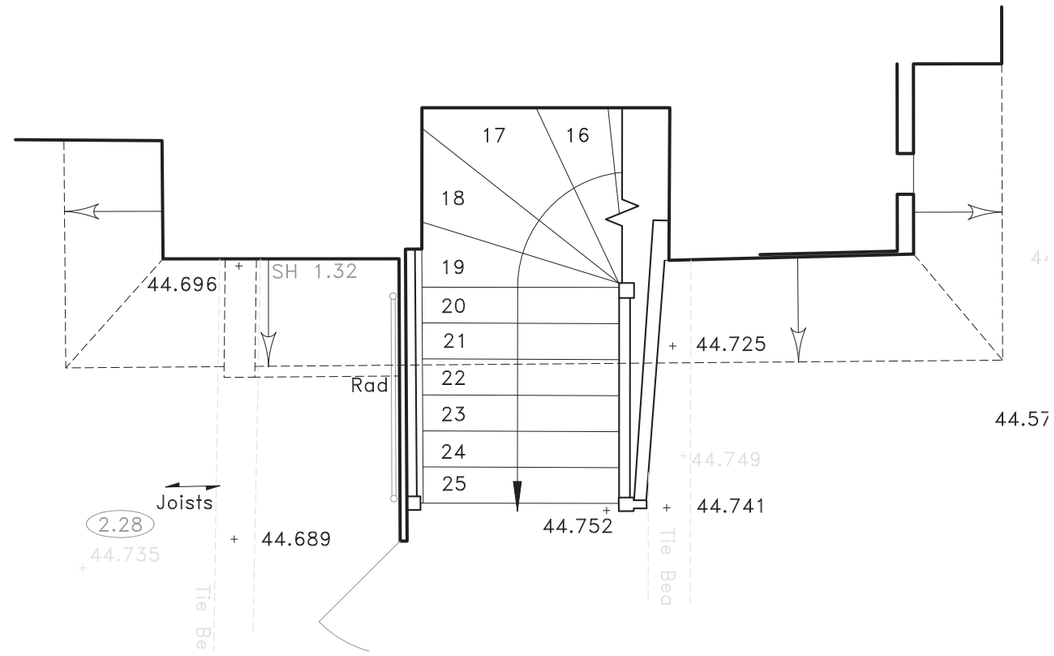
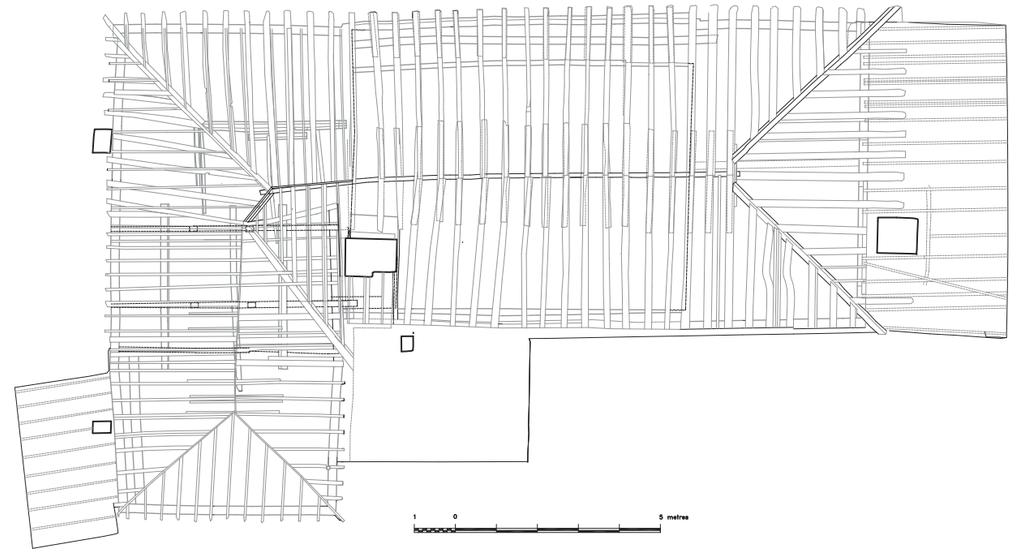
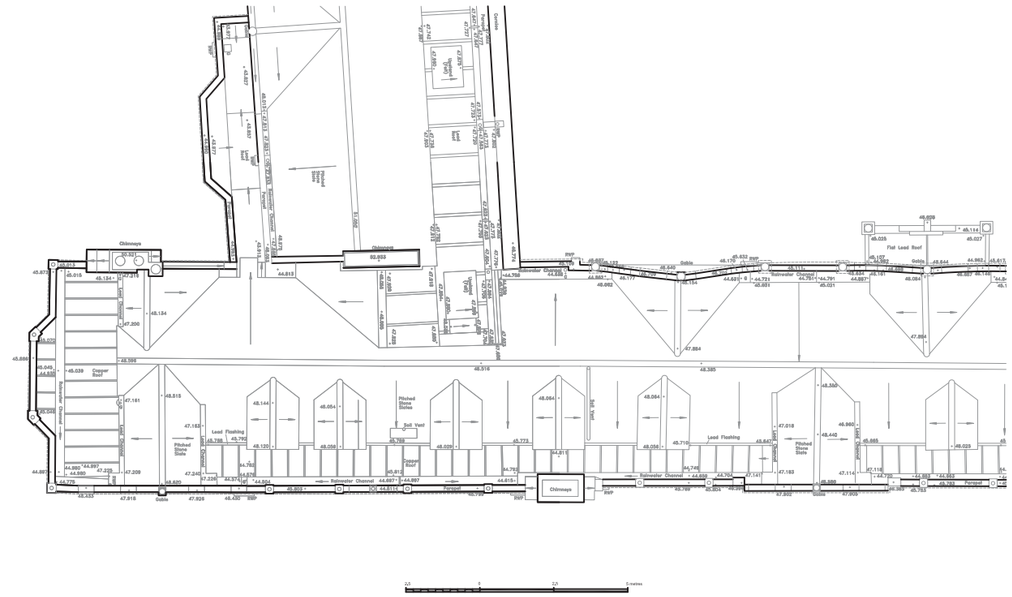
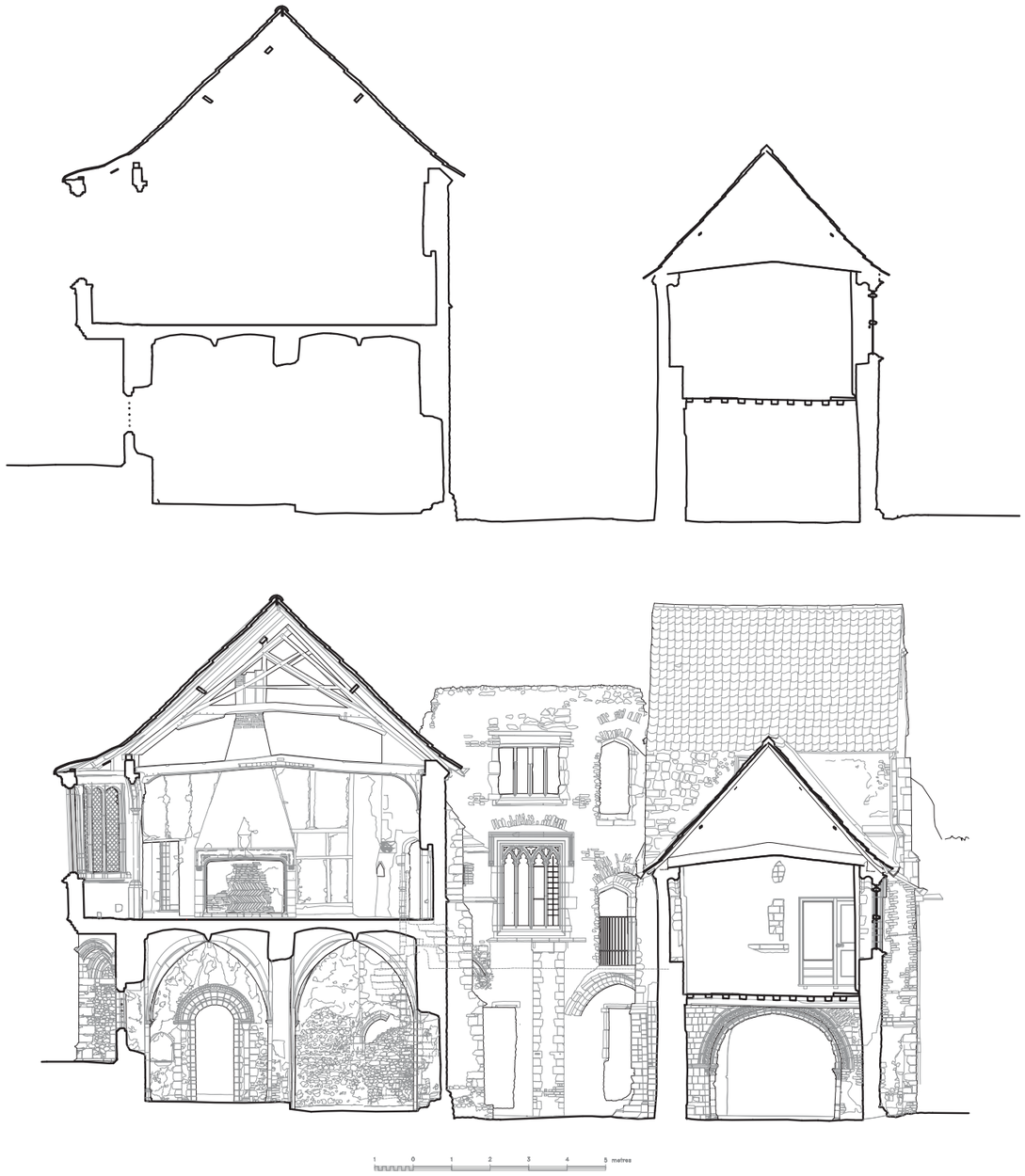


Fig 5.6 Roof plans: top, plan with cover off; bottom, roof plan with cover on (extract).







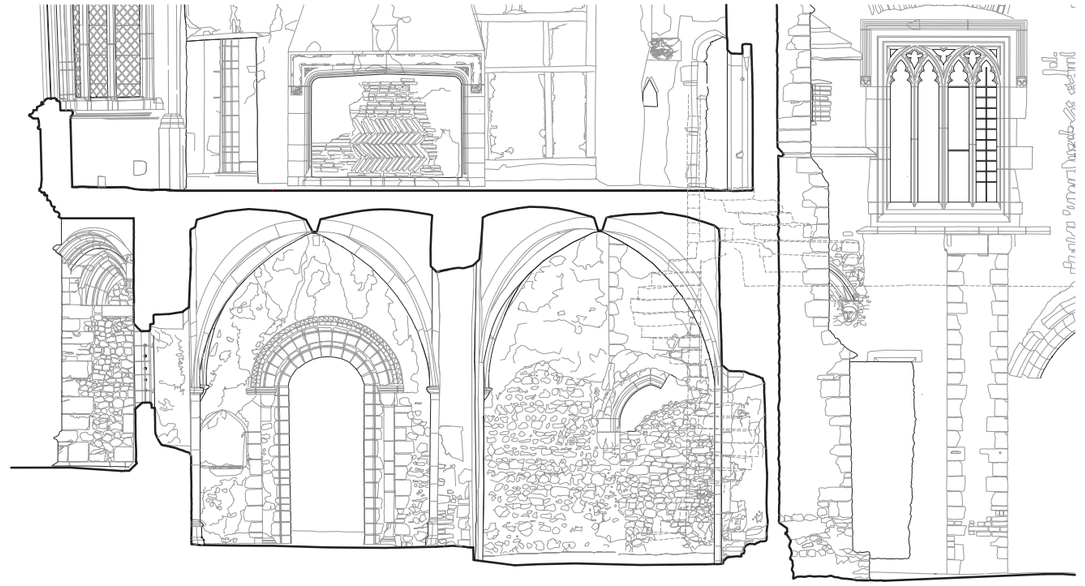


Fig 5.7 Section and sectional elevation, top left; profile or section, bottom left; sectional elevation, bottom; sectional elevation with hidden detail shown by dashed line.

Section 6

Standard Specification for Topographic Survey

6.1 #Definition of topographic survey

Choose an option. A 3-D survey will be more expensive but may prove much more useful than a 2-D product.

6.1.1 Definition of terms

Plan

For extensive surveys, a projection and scale factor may be applied (see section 2.2.4). These should be described in the survey documentation.

Detail

ie everything that is not control, contours, spot heights or hachures

Hard detail

This should be annotated with heights to two decimal places.

Soft detail

This should be annotated with heights to two decimal places.

Symbol

These should include quantitative information such as height or material. Scalable symbols are to be used for trees and hachures.

Annotation

For guidance on the position style and size of text see section 6.3.5.

6.1 Definition of topographic survey

For the purposes of this document topographic survey is defined as the controlled measurement of natural and artificial landscape features. It is to be presented as a either

(a) two-dimensional (2-D); or

(b) three-dimensional (3-D)

data set reading as a plan. Profiles and a digital terrain model (DTM) may also be required (see section 6.2).

6.1.1 Definition of terms

For the purpose of producing large scale topographic survey, the following definitions apply.

Plan

This is a vertical orthographic projection onto a horizontal reference plane. The plan may incorporate information above and below the reference plane; buildings shown will normally be cut on a different horizontal plane to that used for the main plan. The view is to be presented both as plotted or drawn 'hard copy' such that there is no discrepancy beyond permitted standard error (see section 2) and as a CAD file containing the same data as the plot.

Profile

A horizontal orthographic projection onto a vertical reference plane. Profiles will show the surface or cross section of the ground, including the thickness of any walls. The end points and line taken by the profile(s) should be clearly marked on a key plan. The vertical exaggeration for such views shall be ×1 unless otherwise stated.

Detail

The visible features, excluding the surface of the terrain, shown on the plan. It may be considered either 'hard' or 'soft'.

- Hard detail is detail defined with a clearly visible edge.
- Soft detail has an undefined edge or surface.

Symbol

An abstract shape used to identify an object in lieu of a scale drawing of the object. Symbols may be either point or linear.

Annotation

Any text used to describe surveyed features; excludes text used in the sheet title. Annotation may be abbreviated, provided that the abbreviation is explained by use of a key on the drawing sheet or CAD file.

6.2 #The survey product

Choose the required products but also describe them fully in section 1.1.10 of the project brief.

This document assumes the methods employed will usually be global positioning system (GPS), electromagnetic distance measurement (EDM) and hand measurement. Data may, however, also be derived by photogrammetric plotting from vertical aerial photography or using lidar.

6.2.1 #Scale

Choose the required scale(s)

'Overscale' survey

For example where a group of buildings or trees require an enhanced level of definition on the plan, at a scale of, say, 1:100.

6.2 The survey product

Topographic survey may be undertaken using any appropriate technique. The metric performance of the technique must meet the requirements of the specification for a data set (including all mapped detail, control and presentation) commensurate with the required scale as described in section 2. The basic requirement is for clear delineation of detail.

The product is to comprise one or more of the following:

(a) plans

(b) sections or profiles

(c) DTM

To prepare a topographic survey it may be necessary to integrate data sets from disparate sources. In order to achieve this reliably and precisely the survey is required to be in a digital CAD format (section 3).

The method statement must make reference to the survey techniques proposed, unless the project brief specifies a particular technique. The precise details of the products required will be also stated.

6.2.1 Scale

Topographic survey is required at a scale of either

(a) 1:200; and/or

(b) 1:500; or

(c) as specified in the project brief (section 1.1.10).

If the survey is to be presented at more than one scale different sizes of text are to be layered in CAD so that they may be segregated to allow for legibility at both scales.

It may be necessary to carry out survey at a larger scale than that commensurate with the plot scale. Reference will be made in the project brief as to the area and nature of 'overscale' survey required. At 1:500 scale, a degree of generalisation from the 1:200 level is acceptable. The smallest plottable object at map scale is 100 mm by 100 mm and therefore symbols should be used to describe visible features of less than 100mm × 100mm.

For all hard detail the accuracy of planimetric information shall be such that the plan position of any point shall be correct to within +/-20mm rmse when checked from the nearest permanent control station when surveyed for presentation at scales between 1:100 and 1:200. At 1:500 scale, any point of hard detail shall be correct to within +/-30mm rmse.

6.2.2 #Planimetric information

Delete any that are not required.

6.2.3 #Obstructed ground

Select the option required. Detail or contours that cannot be surveyed without clearing will be treated accordingly. In many cases it will be more economical for the client to arrange clearance.

6.2.2 Planimetric information

The following general categories of information shall be surveyed:

- roofed buildings/structures (Fig 6.1)
- roofless/ruined structures
- temporary/mobile buildings
- visible boundary features: walls, fences and hedges
- roads, trackways, footways and paths
- street furniture
- statutory authorities' plant and service covers where visible
- changes of surface
- isolated trees/wooded areas/limits of vegetation
- pitches/recreation
- private gardens or grounds (off-site areas)
- water features
- earthworks
- industrial features
- railway features (with arranged access)
- above ground services
- underground services
- other (specify)

All of the above are to be presented using the specified cartographic conventions (see below), or by replication of large scale detail at reduced scale as a legible and definitive plot (referred to in this section as 'mapping', 'the plan' or 'plans', 'the survey', 'survey' and 'product') such that the form and function of a landscape or structure can be delineated clearly. The plans should have a fixed control network and measurable repeatability of precision commensurate with the required scale (section 2.1.2).

6.2.3 Obstructed ground

Details or contours that cannot be represented to the specified accuracy without extensive clearing shall be

(a) surveyed approximately and annotated accordingly; or

(b) surveyed, following clearance by the client; or

(c) surveyed, following clearance by the surveyor.

6.3.1 #Landform, earthworks and surface terrain

Delete any that are not required.

6.3.2 #Contouring and DTMs

Plans up to 1:200

Select the option required.

Plans at 1:500

Select the option required.

Index contours

Indicate the index contour frequency required.

6.3 Cartographic convention

6.3.1 Landform, earthworks and surface terrain

Landform, earthworks or surface terrain are to be indicated by:

- surveyed contour
- form line
- text
- spot height
- hachure

6.3.2 Contouring and DTMs

Contours are required to represent the surface characteristics of the terrain. They are to be shown with contour values reading up the slope at a density sufficient to identify all contours without ambiguity. Where contour values are inserted the contour lines must be broken to ensure legibility. The contours must be shown cut by vertical or near vertical buildings, including the batter of masonry fortifications built into earthworks. Contour lines must be appropriately smoothed after interpolation to avoid lines with sharp changes in direction (Fig 6.7).

Contours derived from a DTM must not reveal the geometric model used to construct the surface. Care must be taken to ensure that the presence of detectable edges is only a result of such edges being part of the landscape. Breaklines shall be used to ensure that the DTM accurately describes the landform to be depicted by identifying changes of slope at, for example, the tops and bottoms of ditches and banks. When earthworks are mapped, attention must be paid to the surface and its intersection with vertical and near-vertical objects such as gun emplacements, battered walls, chimneys etc, so that a plan of the building components can be seen clear of the contours used to describe the earthworks or landform surrounding them. For the required accuracy of contours (see section 2.5.3).

Plans at 1:100 and 1:200 scale are to be contoured at a vertical interval of either

(a) 0.25m; or

(b) other (specify).

Plans at 1:500 scale are to be contoured at a vertical interval of either

(a) 0.5m; or

(b) other (specify).

Thicker index contours are to be shown at multiples of ……..m.

Hachures may be used to supplement contoured information and to describe sub-contour detail (Fig 6.5).

6.3.3 Location of spot heights

In flat areas spot heights will be located at 6m to 20m intervals for 1:200 scale and at15m to 50m intervals for 1:500 scale.

Sufficient levels for the DTM shall be surveyed such that the ground configuration, including all discontinuities, is represented on the survey plan.

The maximum spacings for DTM points are:

scale	*ground spacing*	*distance on plan*
1:100	5m	50mm
1:200	10m	50mm
1:500	10m	20mm

Where a DTM is the final product the density of levels shall be such that the surface of the model is constructed within 0.1m of the true surface when verified by check measurement. The density of levels shall be at least 1m for surfaces with earthworks or 5 m for open ground.

6.3.3 Location of spot heights

Spot heights shall be shown in the following positions, except where the ground is obscured by vegetation or other obstructions:

- at salient positions such as top, bottom, and along the centreline and mid-point of slopes, ditches, embankments and earthworks
- at the top and bottom of features described by hachure to support the form lines
- at significant changes of gradient, along the centre and edges of road, tracks and water courses, at between 50mm and 100mm at map scale
- in flat areas (where the horizontal distance between contours generally exceeds 30mm at map scale) at intervals between 30mm and 100mm at map scale
- at the cill tops and thresholds of buildings, ruins and building fragments
- at the base of walls showing height of ground at the corners, buttresses and change of direction of walls; to include corresponding positions either side of a free standing wall
- wall tops on ruined walls, to indicate major changes in wall height and maximum height; large and irregular ruined walls may not require levels other than a general indication of height
- at regular intervals along dwarf walls, showing the height of ground at the wall base and wall top
- at changes of surface treatment (eg the edges of grassed areas and hard standing, paths, walkways etc)
- at the surface of drainage inspection covers, the invert level of drainage pipes, on the edge of rain water gullies and along rainwater channels
- at the edges and high points of large fragments of buildings (fragments of 1m × 1m size or greater on any edge at actual size)
- at the top and bottom (and if practicable on each tread) of flights of steps
- at the base of the bole of large trees

6.3.3 #Location of spot heights

Point descriptor

Select the option required.

6.3.4 #Depiction of trees and vegetation

CAD layering

See Appendix 6.1 for CAD layering convention.

General points – bole

The base of the bole at ground level is to be shown if there is a significant lean from the vertical.

General points – canopy

The CAD layer containing the trimmed envelope is to be the default visible (plotted) layer, with the layer containing the individual spreads available but not visible in the CAD drawing files.

The required control and precision of vertical data is described in section 2 of this document.

The standard point descriptor must be either

(a) a cross ; or

(b) other (specify).

of no more than 2mm × 2mm at plot size, the intersection of which shall represent the given co-ordinate value. The symbol is to be aligned with the sheet edge. The point descriptor shall be used for the depiction, with appropriate annotation, of spot heights and reference points.

Ground survey spot levels shall be correct to ±10mm rmse on hard surfaces and elsewhere up to ±50mm rmse except on ploughed or otherwise broken surfaces.

6.3.4 Depiction of trees and vegetation

Vegetation is to be indicated by a standard scaled symbol and text description of species by common name.

Trees are to be plotted as up to four components; the base, bole, canopy/spread and envelope. Trees are considered to be identifiable as such if 5m or greater in height, unless of a species known as a shrub (such as laurel) lacking an identifiable bole.

If less than 5m high trees should be depicted as vegetation. Trees, including the bole, are to be shown to scale. Any displacement of the tree canopy from the bole should be shown. Single small trees in unobstructed terrain should be shown even if they may not be of a size that normally qualifies for depiction. Small trees of less than 5m in height are to be layered in CAD separately to aid landscape management.

General points

The bole is to be plotted at 1.5m above ground level and to include multiple grouped boles. They are to be a scaled and hatched shape that appears solid on the plotted drawing sheet. Hatching used must be consistent for all bole sizes.

The spread of the canopy is to be shown as a standard scaled symbol (Figs 6.2 and 6.3). At 1:200 scale and greater, the canopies are to be contained within the digital file such that both the individual spread per tree is shown in one CAD layer and the envelope of a group of trees is shown in another (see Appendix 6.1). At 1:500 scale, depiction of the envelope only is sufficient. Where a small tree has an extensive canopy spread over other vegetation, the canopy should be mapped as a dashed line.

6.3.4 #Depiction of trees and vegetation

Tree annotation

Select the options required.

Tree number

Usually located on a metal tag fixed to the trunk at approximately head height.

6.3.5 #Text style and positioning

Major objects

For example buildings, bastions, named areas etc.

Select the font required.

Trees are to be annotated with the following information:

- the girth
- the tree number where visible
- species by common name
- height to the nearest 0.5m

For vegetation, hedges are to be depicted using a linear symbol. They shall be surveyed so that the centre line, width and descriptive annotation are clearly shown on the plan.

The extent and type of other vegetation is to be shown, annotated in a similar manner to that used for hedges (Fig 6.4).

6.3.5 Text style and positioning

For annotation, levels, index contours and descriptions of form or surface treatment the height of text should not exceed 2mm at plot scale. For major objects the text shall be 5mm in height at plot scale.

The font used is to be either

(a) AutoCAD RomanD; or

(b) other (specify).

For drawing sheet title text see section 3.3.1.

Text is to be positioned on the drawing so that it is

- aligned with the sheet edge if possible;
- aligned with large linear objects;
- as close as possible to the object described;
- not overlapping or breaking plotted lines;

and

- preferably to the upper right of the object described.

If the upper right default position causes text to be in conflict with detail or other text, it is to be placed elsewhere in the following order of preference:

1 upper left
2 lower left
3 lower right
4 rotate at default position to avoid clash

6.3.6 Line types

(a) General considerations

The cut-line of a building or feature should be of a heavier weight than lines used for other detail.

A dot and peck line type should be used to indicate any or all of the line types in the table if there is a conflict of lines and for boundaries if required to avoid confusion.

A dotted line may be used for clarity if there are a large number of dashed lines on the drawing sheet.

In AutoCAD, LTGEN is to be set to on.

(b) Dashed lines

The line type should be controlled so that lines are 0.5mm long with a 0.5mm gap at the plot scale.

(c) Dotted lines

A dotted line should be a 0.18mm or 0.25mm diameter dot at a 2mm to 5mm interval, depending on the map scale plotted.

(d) Dot and peck lines

The dot and peck line should comprise a line 1mm in length separated by a 0.5mm gap from a dot of 0.18mm, with a 0.18mm line width.

6.3.6 Line types

line	*line type*	*line weight/pen thickness*	
		up to 1:200 scale	*1:500 scale*
lines used to plot hard detail	continuous	0.18mm	0.13mm
wall tops	continuous	0.18mm	0.13mm
building footprint	continuous	0.5mm	0.35mm
dwarf walls under 300mm high	continuous, dashed where edge uncertain	0.18mm	0.13mm
internal features in roofless buildings	continuous	0.18mm	0.13mm
contours	continuous	0.18mm	0.13mm
index contours	continuous	0.25mm	0.25mm
line of surface on profiles	continuous	0.5mm	0.35mm
overhead detail	dashed	0.18mm	0.13mm
delineate the outline of areas of different ground treatment or material	dashed	0.18mm	0.13mm
indicate the line of a wall visible as a sub-contour feature	dashed	0.18mm	0.13mm
to show an underground feature such as the path of a traced water pipe	dashed	0.18mm	0.13mm
to show a pathway where there is no kerb or channel	dashed	0.18mm	0.13mm
in support of contour or hachure, to describe, eg top and bottom of a slope	dashed	0.18mm	0.13mm
roof overhangs or buttresses, walls leaning outside wall base	dashed	0.18mm	0.13mm
roof overhangs or buttresses, walls leaning inside wall base	dashed	0.25mm	0.25mm

6.3.8 #Depiction of buildings and walls

Cut-line

Select the option required.

Additional detail

Select the option required.

Scales of 1:100 or larger – floor detail

For example the plan of stone flags or floor tiles.

6.3.7 Direction of steps

Where space on the drawing allows, an arrow pointing up a flight of steps should be used to support level information. The symbol should extend the full length of the flight.

6.3.8 Depiction of buildings and walls

For roofed structures, the cut-line is to be at

(a) cill height; or

(b) ground level; or

(c) other (specify);

and should show returns for doors and windows on the outside only.

Roofless or ruined structures must have their internal layout (such as walls or columns) shown.

Free-standing walls must be shown at a nominal plan height, with lines closed to show openings, where possible. Additional detail below the plan height (cills, thresholds and floor treatments etc) will either

(a) be shown; or

(b) not be required.

At 1:200 scale detail such as plinths may be omitted if the projection from the wall line is less than 2mm at plot scale.

Where a wall is leaning over significantly from the line of its base, it will be necessary to show the true plan position of both the top (or nominal plan height) and bottom of the wall.

Spot levels must be shown on cills, thresholds and floors.

Annotation indicating floor, wall and roof material as well as building height is to be included.

On plans at scales of 1:100 or larger, floor detail will be required if visible.

Large linear objects such as roof overhangs or buttresses are to be shown.

6.3.9 #Above-ground utilities and boundaries

Select the option(s) required.

6.4 (A) Record information

Existing information taken from record plans covering underground services is often incomplete and of doubtful accuracy. It should usually be regarded only as an indication and cannot be guaranteed.

6.4 (B, C) Underground utility services

Drainage covers should not be lifted without the permission of the owning authority. Many councils do not permit their inspection covers to be lifted but will provide some information for a standard fee.

6.4 (D) Electronic tracing

This is a more reliable method of locating buried services. On heavily built-up sites 85% completeness is probably all that can be expected. Plan accuracies of ±150mm may be achieved but this will be dependant on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.

6.3.9 Above-ground utilities and boundaries

Services, roads, tracks, watercourses, fences, boundaries etc. are to be delineated by use of:

(a) surveyed lines

and/or

(b) symbol

and/or

(c) text

Fence lines are to be indicated by the plotted plan position of posts; the position and width of gates is to be to scale. At 1:500 scale or smaller, building openings, gates and the position of fence posts in plan may be generalised, ie depicted by a symbol or line type.

Ditches are to be shown by a dashed line showing the top of bank. Bottom of bank is to be supported by a spot level at changes of height for each surveyed line.

Overhead services such as telephone or electricity cables are to be shown with a distinctive line type and annotated with the service description and height above Ordnance datum.

6.4 Underground services

An accurate base plan is essential for the plotting of underground utility services. If such a plan does not exist it will be necessary to produce one (Fig 6.6).

Underground services surveys will be undertaken using one or more of the following methods:

A **Consulting underground service records**
(To be taken from statutory or other authorities' record drawings and plotted to agree as closely as possible with surveyed surface features.)

B **Direct visual inspection**
(Accessible inspection chamber covers should be lifted where permissible and services positively identified.)

C **Direct visual inspection supplemented by consulting service record drawings**
(Accessible inspection chamber covers should be lifted where permissible and services positively identified. Routes of services between access points to be taken from record drawings and plotted to agree as closely as possible with surveyed surface features and trench scars where obvious.)

D **Full investigation, including electronic tracing**
(Services to be fully investigated by visual survey supplemented by electronic or other tracing of inaccessible routes.)

6.4.1 #Extent of survey required

Tick in the table the type of survey required.

6.4.2 #Services information

Where section 6.4.1 includes survey by (B), (C) or (D), select the required method for recording the information.

6.4.1 Extent of survey required

Services listed below shall be surveyed by the method indicated (see section 6.4 for description of methods). All work should be carried out with due regard to the Health and Safety guidelines for working within confined spaces.

A	*B*	*C*	*D*	*service*
				surface water drainage
				foul drainage
				water
				gas
				electricity
				telecommunications
				other services
				other underground features (specify)

6.4.2 Services information

Information derived from survey methods (B), (C) and (D) shall be supplied as either

(a) invert levels, pipe diameters and annotations on drawings or digital files; or

(b) inspection chamber description sheets.

The date of inspection/survey must be included.

6.4.3 Derived information

Where information is derived from statutory authorities' record drawings, a schedule shall be provided giving full details (eg drawing number, scale, date etc). All information taken from records shall be clearly identified as such on the survey drawings.

6.4.4 Report

A report shall be submitted indicating any anomalies between surveyed data and records, detailing likely accuracies achieved and commenting on services not located for any reason (eg unliftable or hidden covers). All identified features should be highlighted in this report.

APPENDIX 6.1

CAD Layer names for topographic survey

This is not an exhaustive list. New layers may be created so long as they are prefixed with 0T-.

APPENDIX 6.1

CAD Layer names for topographic survey

CAD layer	*colour*	*line weight (mm)*	*description of content*
0T-035	cyan	0.35	the line of cut for plans – If possible the line should be thickened on the inside of the measured line such that the wall dimensions are not obscured.
0T-025	red	0.25	lines indicating information remote from the line of cut
	orange	0.18	
0T-cut	white	0.5	the line of cut for sections and profiles
0T-dashed	white	0.25	lines indicating overhead detail on plan or hidden detail below the line of cut
0T-dot	white		to be used to describe 'indicative' information, eg the position of lost building components
0T-txt	orange	0.25	all text except title, logo title panel control text, tree data and text associated with height – Text associated with the grid should be on layer 0T-gridtxt. Text should be positioned to avoid overwriting detail when the layer is on with all other layers.
0T-digi1			to be used to separate digitised data from primary survey and to be expanded to digi2, digi3 etc, to accommodate line type; colour should agree with line type and pen thickness
0T-ht	yellow	0.25 or 0.18	Spot levels to two decimal places with associated text rotated so that it is legible with all layers on. Where the level or any other text crosses other lines a break should not be used to ensure clarity.
0T-tree	green	0.25	tree bole hatched solid
0T-treetxt	green	0.25	tree – descriptive text
0T-treeM	green	0.18	tree less than 5m in height
0T-treeA	green	0.18	canopy spread by individual tree
0T-treeB	green	0.18	canopy spread trimmed to envelope
0T-hdge	36	0.18	hedge line at ground level
0T-hgdeOL	34	0.18	outline limit of hedge spread
0T-veg1	96	0.18	limit of vegetation, to be subdivided if needed
0T-grid	white	0.25	Indicate the grid using annotated margin marks and associated text (as per txt layer). Length of line not to exceed 5mm at plot scale. Grid intersections should be shown by an 8mm cross.
0T-gridtxt	white	0.25	all text associated with the grid; annotation to be aligned with grid line

CAD layer	*colour*	*line weight (mm)*	*description of content*
0T-cntl	white	0.25	all control data with the exception of traverse lines (on layer 0A-trav) and text other than station symbol and target descriptors; datum lines indicated as a 5mm horizontal line on either side of the plotted subject with annotation in text 3mm high; plumb lines to be indicated in the same manner; station symbol to be a triangle with centre mark 3mm high
0T-cntltxt	white	0.25	schedule of co-ordinates for control stations; to be to 3dp with a description of the marker used; may be included on data sheet for project or as separate file
0T-trav	white	0.25	traverse lines with annotation of reduced angles, distances and station co-ordinates (if other than WORLD co-ordinate system is used)
0T-level	white	0.25	level point descriptor
0T-lvltxt	white	0.25	text for levels
0T-contour	green	0.18 or 0.13	contours
0T-contour-index	red	0.25	index contours; to be broken to accept text; text to be positioned so that the top of the text faces up slope
0T-htg	magenta	0.25	ground line, line at the base of a batter or where height of ground becomes part of the building plan
0T-corhl	white	0.25	lines used to describe wall tops inside the line of cut (ie the view of the wall looking from above)
0T-services–elec	red	0.18	electrical services – to be expanded as required
0T-services–fire	red	0.18	fire control services
0T-services–gas	blue	0.18	gas services
0T-services –water	121	0.18	water supply
0T-services–drain–foul	34	0.18	drainage – foul; show direction of flow
0T-services–drain–rw	175	0.18	drainage – rainwater; show direction of flow
0T- services–tele	orange	0.18	telephone lines; poles to be show;, lines to be shown as an overhead detail with a dashed line

APPENDIX 6.2

Abbreviations for topographic survey annotation

This is not an exhaustive list.

All abbreviations used must be positioned as specified in section 6.3.5.

APPENDIX 6.2

Abbreviations for topographic survey annotation

Abbreviations must be listed on the index sheet or in the title panel. New abbreviations may be created but must be consistent within a survey or surveys. Where abbreviation leads to ambiguity the full text is to be used.

word	*abbreviation*	*word*	*abbreviation*
aggregate	Agg	invert	Inv
air brick	AB	invert level	IL
approximate	approx	inspection chamber	IC
asbestos	Asb	interception trap	IT
asphalt	Ap	lamp column	LC
bench Mark	OSBM	overhead (telephone cables, electric cables)	O/H
bitumen	Bitn	petrol interceptor	PI
brickwork	Bwk or B	radius	Rd (state units)
cast iron	CI	rain water pipe	RWP
centre line	C	reinforced concrete	RC
cement	Cem	rising main	RM
clearing eye	CE	rain water outlet	RWO
corrugated	Corr	rodding eye	RE
cover level	CL	round	Rd
diameter (to be used rather than width)	Dia (state units)	stop valve	SV
drinking fountain	DF	soil and vent pipe	SVP
earth closet	EC	stand pipe	St.P
fire hydrant	FH	street gully	SG
grease trap	GT	vent pipe	VP
ground level	GL	volume	Vol (state units)
gully	G	waste pipe	WP
ground level	GL	water closet	WC
height	Ht	width	W (state units)
internal	Int	yard gully	YG

Fig 6.1 Occupied buildings and associated detail.

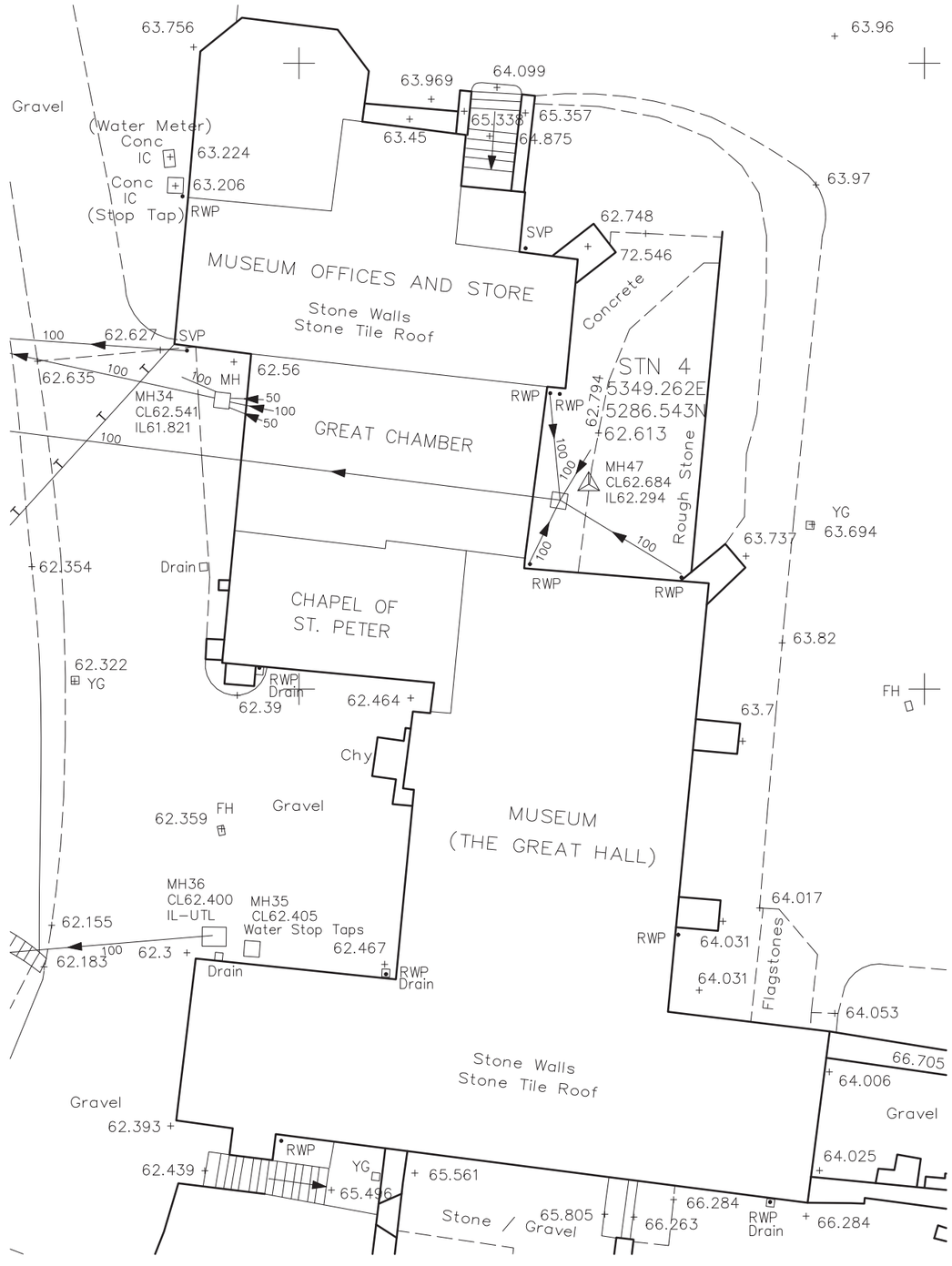


Fig 6.2 Depiction of trees, canopies untrimmed.

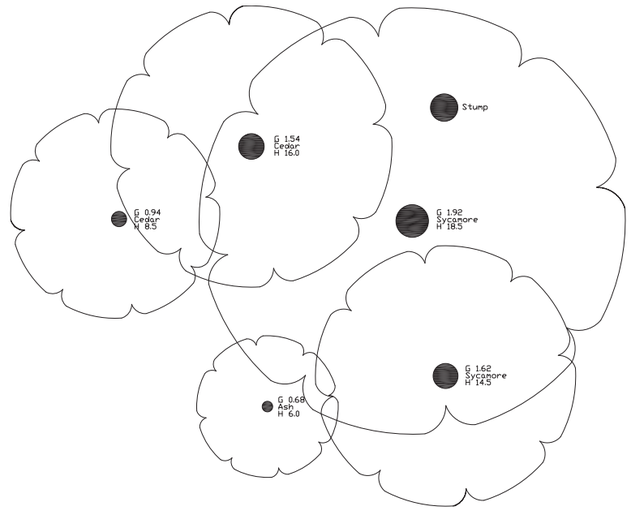


Fig 6.3 Depiction of trees, canopies trimmed.

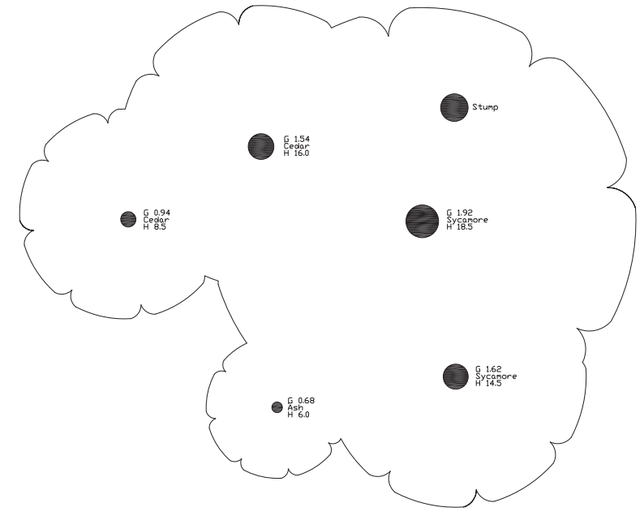


Fig 6.4 Hedges (including centreline) and vegetation.

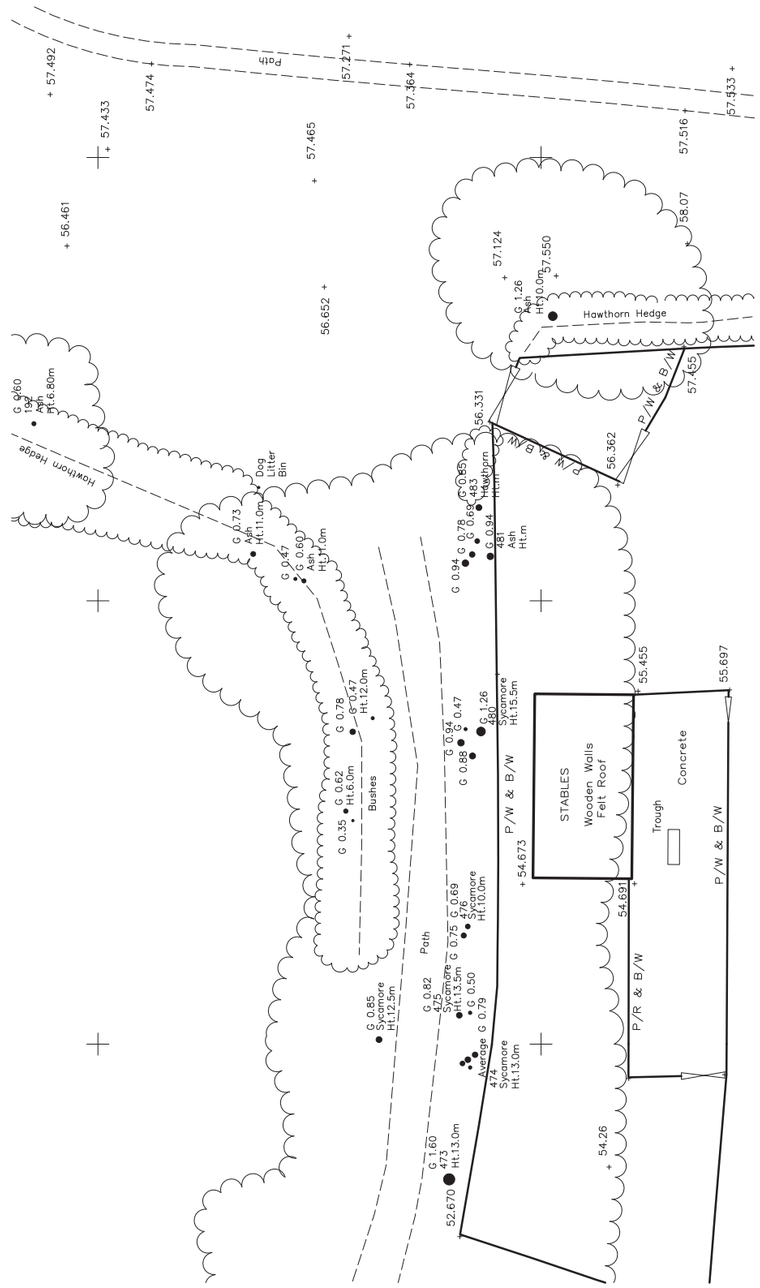


Fig 6.5 Use of hachures to supplement information from contours.

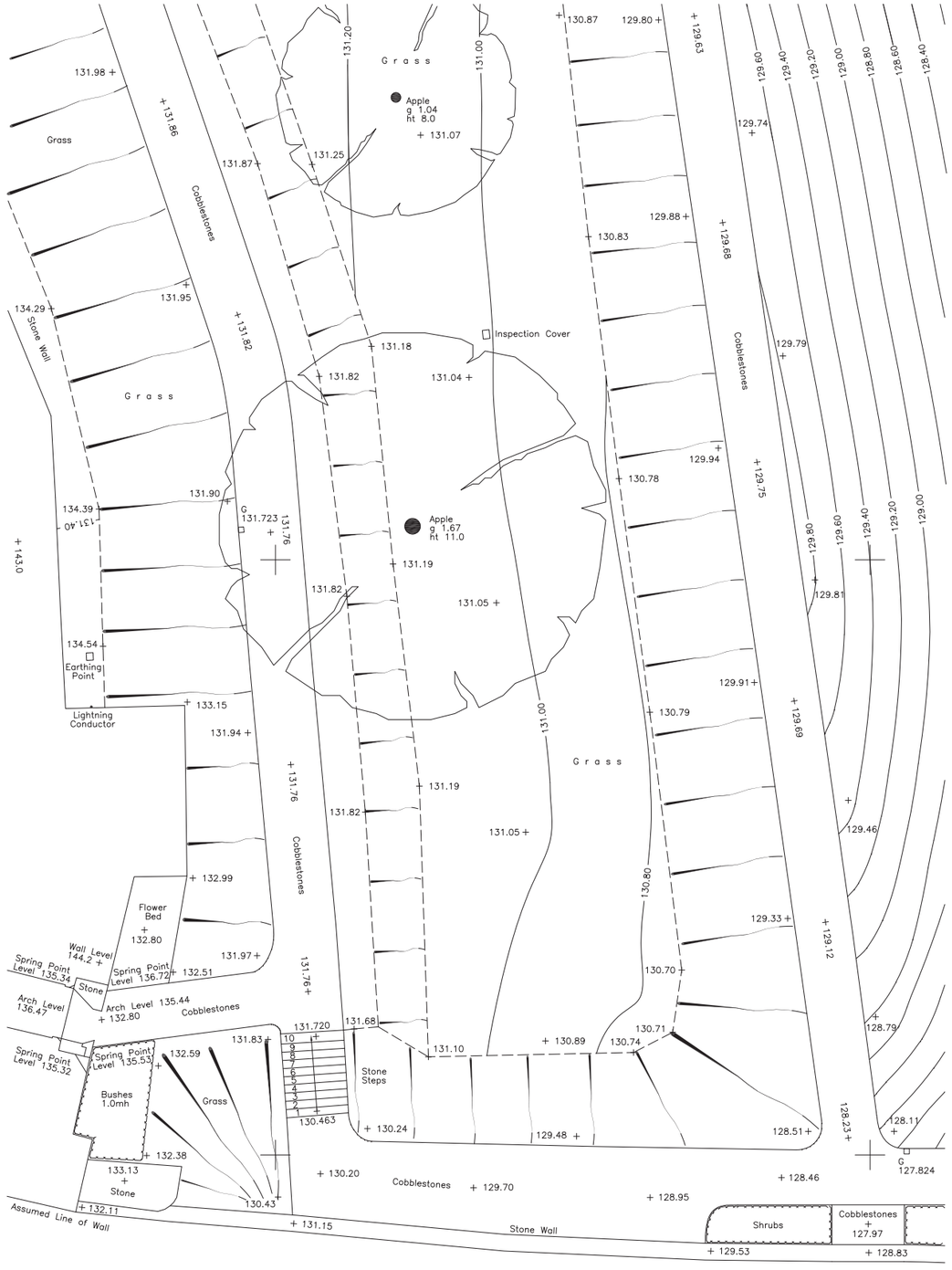


Fig 6.6 Depiction of underground services.

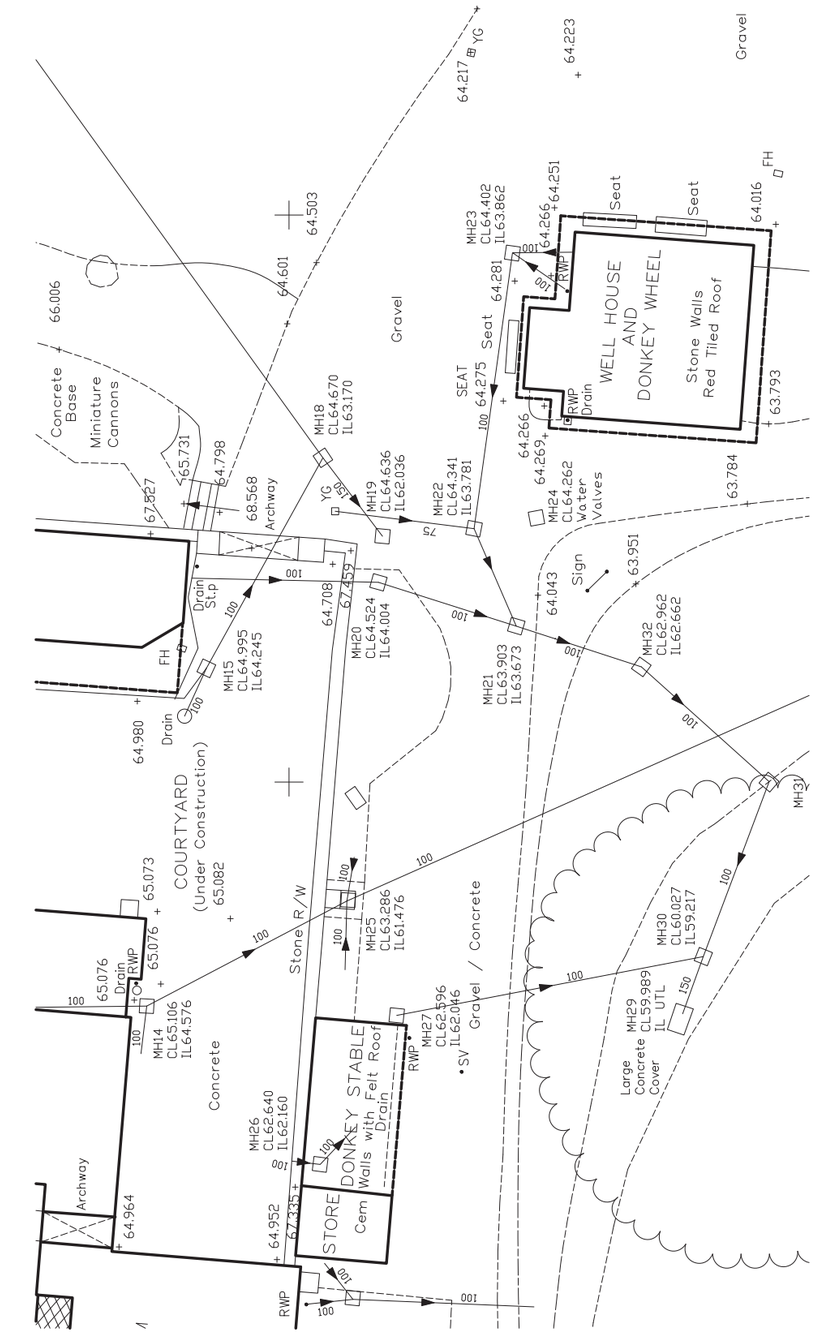
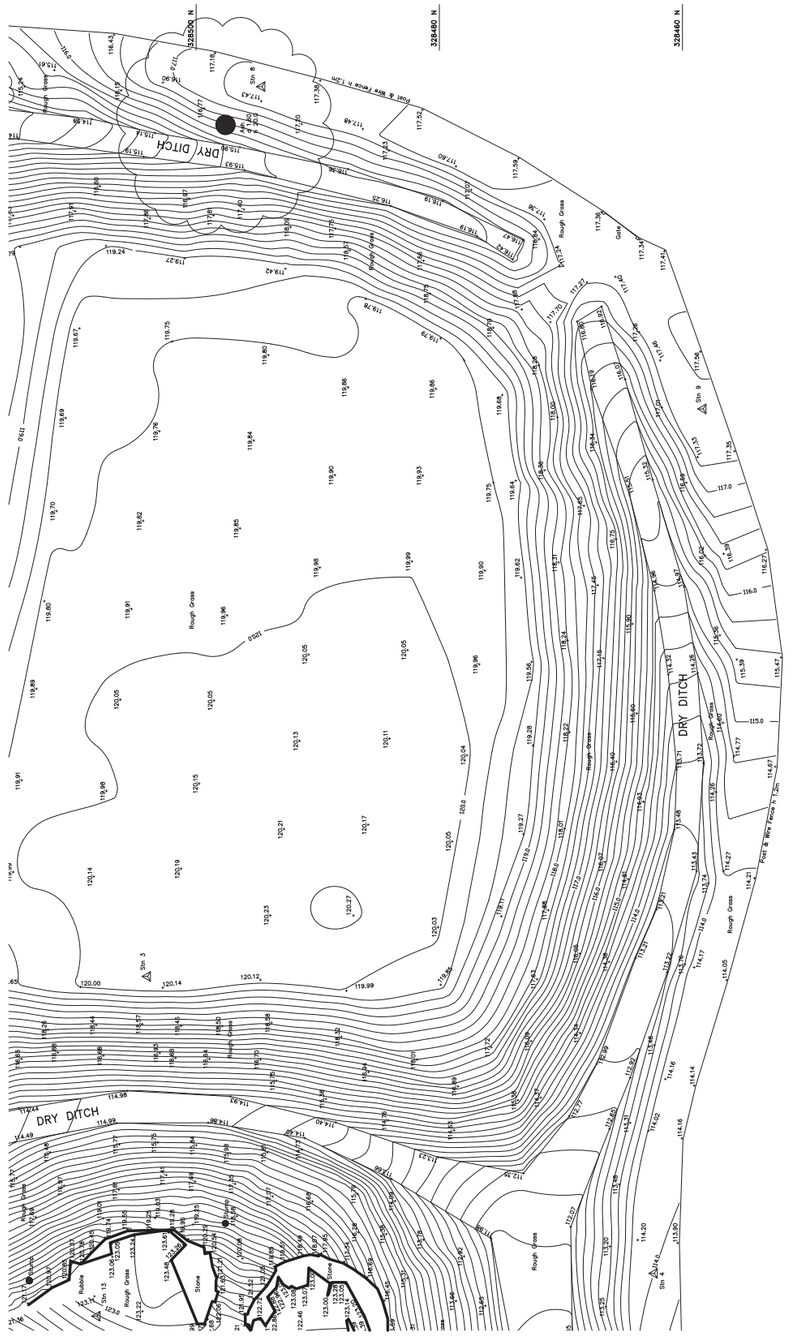


Fig 6.7 Use of DTM and breaklines to generate contours.



Section 7

Standard Specification for the Collection and Archiving of Terrestrial Laser Scan Data

7.1 Definitions of terms

7.1.1 Terrestrial laser scanning

The term laser scanner refers to a range of instruments that operate on differing principles, in different environments and with different levels of accuracy. The three main types that can be used for terrestrial laser scanning are:

- triangulation based
- time of flight
- phase comparison

The first is more suited to artefacts and sculpture, while the second two are generally used for building sized objects.

7.1.2 Point cloud

Point clouds are suitable for use on a wide variety of subjects including small objects, details of architectural design, building facades and whole sites. Point clouds do not, however, automatically lend themselves to the generation of survey products traditionally seen in cultural heritage applications. Instead they are often more suitable for collection of surface information or use in surveys to provide 3-D spatial orientation, or where other measurement techniques are unusable (for example where there is a lack of surface texture, which makes the use of photogrammetry inappropriate). Point clouds should not be seen as a replacement for existing techniques and the appropriateness of the technique chosen should always be considered.

7.1.3 Point density

The average distance between XYZ co-ordinates in a point cloud. This is commonly represented in two forms, spatial and angular.

The average 3-D distance between points at a specified distance (assumed to be taken from/to the centre of the footprint) – eg 30mm × 30mm (at 50m).

The angular step of the two axes – eg 0.25° × 0.25°.

The average 3-D distance between points on the subject is likely to be clearer to a non-technical user.

7.1 Definitions of terms

7.1.1 Terrestrial laser scanning

For the purposes of this document terrestrial laser scanning is defined as the use of a ground based device that employs a laser to measure the three-dimensional co-ordinates of a given region of the surface of an object automatically, in a systematic order and at a high rate in (near) real time.

7.1.2 Point cloud

This comprises a collection of XYZ co-ordinates in a common co-ordinate system that portrays to the viewer an understanding of the spatial distribution of a subject or site. It may also include additional information such as an intensity or red, green, blue (RGB) values. Generally a point cloud contains a relatively large number of co-ordinates in comparison with the volume the cloud occupies, rather than a few widely distributed points.

7.1.3 Point density

This is the average distance between XYZ co-ordinates in a point cloud represented in a spatial or angular manner. Where a spatial value is given this must be supported by the distance from the scanner to the subject. The quoted point density for any scan should always be given as the minimum density of points for data on the subject, not including, peripheral data (ie data outside the area of interest).

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7.2 Data collection

7.2.1 Pre-survey deliverables

A number of standard deliverables are required before a survey is performed. This is to ensure clarity in the requirements of the survey.

7.2.2 #Certification requirements

There are no standard practises for the certification of terrestrial laser scanners.

7.2.3 Health and safety

Please see Appendix 7.1 for further details.

7.2 Data collection

7.2.1 Pre-survey deliverables

Prior to survey a method statement as defined in section 1.3.2 is required. In the case of terrestrial laser scanning the method statement is also to include technical specifications of the scanning system(s) to be used the proposed point density the location and extent of potential data voids and a proposal for their amelioration.

7.2.2 Certification requirements

The method statement is to be accompanied by either

(a) a calibration certificate for the laser scanning system; or

(b) details of tests, performed within the last 12 months, which show that the scanner has achieved the required geometric precision and geometric accuracy.

7.2.3 Health and safety

Readers are referred to IEC 60825:1 (2001) for the full precautions on the user of lasers. However, explicitly only an appropriately trained individual may operate a laser scanner on site. Signs warning visitors that lasers are in use must also be displayed.

Systems that use Class 3B or Class 4 lasers are not acceptable for use on English Heritage sites.

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7.2.4 #Point density and measurement precision

Define the required point density.

The density of point measurement is intrinsic to the geometric and narrative accuracy of any derived data. An appropriate point density is therefore required. The density of measurement should also be chosen with reference to the accuracy of individual point measurements. For example, scanning at a density well below the accuracy of the measurement will result in a high level of noise in the resulting point cloud.

As a general rule the point density should be at least half the size of the smallest feature that is required to be discernible in the scan. The smaller the distance between points the more likely it is that the feature will be recorded. This will, however, be at the expense of larger file sizes.

In order to minimise the creation of scanning artefacts within the scanning process, point densities should be equal in both scanning axes. Uneven point densities for example may lead to the lack of definition of horizontal or vertical features.

For most instruments point density during the scanning process depends on the range to an object. It is, therefore, not normally possible to maintain a constant point density over an entire subject during the scanning process. It is most likely, however, that a particular area will be of interest, such as a façade, or building detail and that a regular density of points is preferable. The point density specified by the client or selected by the contractor should be understood as the maximum value for the subject in question.

7.2.5 #Overview and detail scans

A combination of overview and detail scans provides both a clear description of the general area in question in addition to providing detailed information of selected parts of a site or object. It is likely that scanning surveys will combine a mixture of scans. Define the areas and point densities required.

7.2.6 #Overlapping scans

Overlapping scans are generally required to ensure that a full record of an object is collected. Overlapping data can also provide users with confirmation that the registration process has been successful. It is possible to filter overlapping scan data in order to reduce the point density in the final registered point cloud and hence reduce file sizes and demands on software systems during processing. Generally, this is not recommended so as to ensure that a full archive of the subject is collected.

7.2.4 Point density and measurement precision

All reference to point density is to be given as the average 3-D distance between points at a defined range.

The point density and precision required is to be either

(a) as defined below for the scale specified in the project brief

scale	*effective point density*	*precision of measurement*
1:10	1.0mm	+/- 1.0mm
1:20	2.5mm	+/- 2.5mm
1:50	5.0mm	+/- 5.0mm
1:100	15.0mm	+/- 15.0mm

or

(b) based on a minimum feature size of …mm (specify).

That is the minimum size of feature required to be discernable in the point cloud is …..mm in depth and …..mm in width and height.

The beam width of the measurement beam must not be greater than double the effective point density.

7.2.5 Overview and detail scans

Overview scans are either

(a) required for the following areas ….. at point density of …..mm (specify); or

(b) not required.

Detail scans are either

(a) required for the following areas … at point density of …mm (specify); or

(b) not required.

7.2.6 Overlapping scans

It will either

(a) not be acceptable; or

(b) be acceptable;

to filter areas of overlapping scan data, so as to reduce the point density in the final registered point cloud.

7.2.7 Data voids

As data collected during the survey of cultural heritage sites will form part of the archive record of that site it is important that the data collected is complete. Data voids should, therefore, be minimised during the scanning process through the selection of appropriate scanning positions (overlapping where necessary) and minimising temporary obstructions to the scanner during operation (such as those caused by vehicles and pedestrians). Data voids due to occlusions to the line of sight can normally only be eliminated by using multiple scans. Data voids due to temporary obstructions such as pedestrians or vehicles should be limited by appropriate positioning of the scanner or restriction of access.

7.2.8 High level coverage

Laser scanning relies on a line of sight to a target and, therefore, where a subject of a significant height is to be surveyed access to higher areas may be a problem. Also, as laser scanning is not an instantaneous measurement process methods used to gain access to higher areas must provide a platform stable enough to support the scanning instrument for the duration of the scan.

7.2.9 Weather

Weather may have an impact on the quality of data collected. For example, scanning in heavy rain may lead to data voids due to falling raindrops or erroneous data points due to returns from airborne raindrops or erroneous range measurement due to refraction of the measurement beam.

7.2.10 #Survey control and co-ordinate systems

If a site co-ordinate system already exists then supply details. Where a previous co-ordinate system does not exist a new system will need to be established. In order to ease the processing of the point cloud in CAD packages the Z-axis should be defined as the vertical axis.

7.2.7 Data voids

Data voids are to be kept to an absolute minimum. Voids caused by temporary obstructions such as cars and pedestrians will not be acceptable, unless it is impossible to restrict access, in which case this is to be highlighted in the method statement. Voids caused by occlusion are to be minimised by using multiple scans or access equipment. If significant problems with occlusion are anticipated then this is to be highlighted in the method statement.

7.2.8 High level coverage

Methods used to achieve high level coverage must be described in the method statement and outlined in the final survey report.

7.2.9 Weather

If working outdoors, the weather conditions during the survey should be recorded. Scanning/image capture must not be performed in adverse weather conditions where the quality of observed data could be affected.

7.2.10 Survey control and co-ordinate systems

The methods and networks used for providing survey control are discretionary. However, details of the method and equipment proposed must be included in the method statement. Where a survey co-ordinate system already exists the necessary information will be supplied to allow the re-occupation of previously installed points. This will include a full listing of 3-D co-ordinates and witness diagrams.

Where a previous survey co-ordinate system does not exist a new system will need to be established as specified in section 2.2.4. Individual survey control points are to be provided to a geometric precision/accuracy of twice the geometric precision/accuracy required by individual measurements.

7.2.11 Targets and control points

Targets located in a defined co-ordinate system will usually be used to transform scan data to a common system.

The design of targets can vary between different laser scanning systems but generally should allow the positioning of the target by an appropriate survey method. Target design may be based on the measurement of reflectance or shape.

The use of targeted points, positioned using a survey instrument, such as a total station, provides additional checks on the geometric quality of the scan data.

Targets placed in the scan scene could lead to data voids.

In addition to artificially signalised points, natural points of detail may also be used for control points. However, scan artefacts may occur at distinct geometric edges on a surface where, due to the footprint of the laser, erroneous points are recorded. Although this is minimised through the use of lasers with a small measurement footprint this effect may still occur.

The use of points of natural detail should therefore, generally be avoided, although where unavoidable the use of distinct features may be suitable providing the point density of the scan is sufficient to maintain the requirements of the registration process.

7.2.11 Targets and control points

Targets must not be so positioned, or be so large, that they obscure important details of the subject. A description of the targets to be used must be given in the method statement and the location and naming of targets is to be clearly given on the site sketches that accompany the survey report.

The use of natural detail points should be avoided, but where necessary the use of distinct features is acceptable providing the point density of the scan is sufficient to maintain the registration requirements in section 7.3.2 of this document. The use of features at distinct corners or edges is not permitted. Where natural detail points are to be used this must be noted in the method statement. See also sections 1.6.2 and 2.2.9.

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7.3 Provision of point cloud data

7.3.1 #Standard deliverables

The listed standard deliverables will generally be required for archive purposes. Edit the list if necessary and insert the number of copies required.

7.3 Provision of point cloud data

7.3.1 Standard deliverables

The following standard deliverables are required (see section 7.4 for a full description of the appropriate media, formats and required metadata). The standard deliverables in digital form are:

- project metadata
- raw scan data (for archive)
- scan metadata
- control information
- registration information for all raw scans to the site co-ordinate system
- registered scan data (for archive)

a survey report, supplied as a .pdf file, is also required, containing diagrams showing the position of scanning stations and control points

- details of the traverse/control network used, three-dimensional co-ordinates of all control points and residuals for the computed XYZ control
- the precision of any parameters derived in the registration process for each scan along with the residuals of the registration
- a summary outlining the completeness of the point cloud and all known data voids
- any site sketches/additional field notes made during field work

The following number ..... (specify) of copies of all digital and hardcopy data/documentation are required on delivery.

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7.3.2 #Registration

Specify the registration method.

Although a single scan may be sufficient to fully record certain scenes, multiple scans are likely to be required, especially when dealing with a large site or structure. It is likely to be necessary to transform the collected point clouds to the local site co-ordinate system. The process of registration can be performed using one of or a combination of the following methods:

1 Targets can be used to transform the data onto common co-ordinate systems.

2 Surface matching algorithms can be used to transform data onto common co-ordinate systems. The use of surface matching algorithms alone would normally involve the use of an arbitrary co-ordinate system.

3 Data collection can be performed from a station with known co-ordinates and a known orientation.

Generally, each method will provide an indication of the quality of the registration process. In the case of using targeted points the quality of the registration process is best indicated by the residuals of the transformation process and the estimated precisions for each transformation parameter. In the case of surface matching alone the quality of the registration would be indicated by the residuals of the surface matching algorithms, along with the estimated precisions of the transformation parameters. It is unlikely that surface matching algorithms alone would be suitable for metric survey applications so some targeted points will always be required. Data collection from a known station and known orientation will be reliant upon the precision to which the control information is known.

7.3.2 Registration

Individual scans used to achieve the required coverage must be registered together. The residuals of the registration process must be shown to be equal to or better than the geometric precision required by the end deliverable. Registration should

(a) be done solely via a resection calculation from controlled targets – each scan must contain a minimum of four appropriately distributed XYZ control points/targets; and the residuals of the registration process and the geometric precision of the estimated parameters should be noted in the survey report.

or

(b) be performed using surface matching techniques – the data must include at least n + 3 appropriately distributed XYZ control points/targets, where n is the number of scans made; the residuals of the registration process and the precisions of the estimated parameters should be noted in the survey report; and the geometric accuracy of the fit should be noted in the survey report;

or

(c) be done using a known station positions and orientations – the data must include at least three appropriately distributed XYZ control points; and the residuals of the registration process and the precisions of the estimated parameters should be noted in the survey report;

or

(d) be done using a method(s) of the contractor's choosing.

Irregular features in the scan data caused by cracks or features on the subject that could be misinterpreted as errors in the registration must be augmented with illustrative photography and noted in the final survey report.

7.3.3 #Intensity/colour information

The majority of systems provide intensity information, in addition to an XYZ position. Some systems provide a colour value for each point. Specify whether such data is required.

7.3.4 #Additional image data

Additional image data should be collected to provide an overview of the subject being scanned, in addition to providing imagery for narrative purposes. This imagery should be of a high resolution and clearly portray the subject in question.

This additional data will help to identify scan artefacts caused by, for example, poor framing of the scanner. Include requirements for delivery of imagery in section 3.

7.3.3 Intensity/colour information

Intensity/colour information can be recorded on a per point basis at each scan position where the instrumentation allows. Intensity/colour information either

(a) is required; or

(b) is not required.

7.3.4 Additional image data

Additional image data to show the location of the scanner and the subject being scanned is required for narrative purposes. This imagery is to be of a high resolution and must clearly portray the subject in question. It is to be delivered as specified in section 3.

7.4 Storage and archive of point cloud data

7.4.1 #Data format

To assist in the future management of scan data all data is required to be delivered in a pre-specified format with emphasis on the transferability of data between software systems. The raw scan data (the data collected by the scanner before pre-processing) should ideally be delivered in the ASPRS LAS format. Until the LAS format is revised to include registration information relating to terrestrial laser scanning, contractors should where available, use the Heritage3D LAS implementation, which includes records for registration information. Where this is not possible the scanner proprietary format or ASCII is to be used.

7.4.2 #File naming convention

Filenames should be logical and be located in an appropriate directory structure.

Only use alphanumeric characters (a–z, 0–9), the hyphen (-) and the underscore (_) in naming files. Both upper and lower case characters and numbers can be used in a filename. Don't use spaces or full stops (.) within filenames. Full stops should only be present where the filename is separated from the file extension (eg .doc or .pdf). Spaces can usually be replaced with the underscore (_) character.

Contractors should use a consistent scheme and case when naming files. A descriptive filename should be used that helps explain the contents of the file, for example 12102004_trench_1.tif could be a digital photograph of trench 1 taken on 12/10/2004. A non-descriptive file name might be a unique identification number allocated to an image within an accompanying image catalogue database. Non-descriptive filenames are acceptable but their content must be adequately described in accompanying metadata.

7.4 Storage and archive of point cloud data

7.4.1 Data format

The data is to be delivered in the following format

(a) ASCII; or

(b) scanner proprietary format; or

(c) both ASCII and scanner proprietary format; or

(d) other (specify).

Contactors must ensure that all of the standard file header information is included.

7.4.2 File naming convention

Files are to be named either

(a) following the convention described below (specify); or

(b) the contractor may propose their own convention but must observe the rules set out below.

Use only alphanumeric characters (a–z, 0–9), the hyphen (-) and the underscore (_).

Both upper and lower case characters and numbers may be used.

Spaces and full stops (.) must not be used within filenames.

A full stop must only be used to separate the filename from the extension.

Descriptive filenames may be used.

Non-descriptive filenames are acceptable but their content must be adequately described in accompanying metadata.

The contractor must provide a 'readme' file to document the contents, structure and naming of the delivered data.

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7.4.3 Scan metadata

Example

parameter	*example*
file name of the raw data:	TYP03L02.xyz
scanning system used (with serial number):	Cyrax 2500 #055
monument name:	Tynemouth Priory
survey number (if known):	NA
total number of points:	857 446
date of capture:	29/05/2003
company name:	University of Newcastle
monument number (if known):	NA
scan number (unique scan number for this survey):	2
point spacing on the object:	0.015 m (@ 30 m)
weather during survey:	sunny and calm

7.4.4 Project metadata

Example

parameter	*example*
filename(s) of the raw data used in the registration	TYP03L01.txt (1 – in index plan) TYP03L02.txt (2 – in index plan) TYP03L03.txt (3 – in index plan) TYP03L04.txt (4 – in index plan) TYP03L05.txt (5 – in index plan) TYP03L06.txt (6 – in index plan)
data of capture (month and year)	May 2003
scanning system(s) used (with serial number(s))	Cyrax 2500 #055
company name	University of Newcastle
monument name	Tynemouth Priory
monument number (if known)	NA
survey number (if known)	NA
number of individual scans	6
scan numbers of all scans	1–6
total number of points	8270541
description of registration method	all scans registered to local site grid using targeted points and resection calculation
filename of control data	TYP03H.xyz
weather during survey	sunny and calm
an index plan showing the data collected with individual scan points named	see below

7.4.3 Scan metadata

Metadata (information relating to the captured information) is required with all raw scan data and scanning projects. Metadata is to be provided in both hardcopy and digital form. It must include:

- file name of the raw data
- date of capture
- scanning system used – with manufacturer's serial number
- company name
- monument name
- monument number (if known)
- survey number (if known)
- scan number (unique scan number for this survey)
- total number of points
- point density on the object (with reference range)
- a record of the weather conditions during scanning (external scanning only)

7.4.4 Project metadata

A single project metadata file is required with the project. This must include the following:

- filename(s) of the raw data used in the registration
- data of capture (month and year)
- scanning system(s) used – with manufacturer's serial number(s)
- company name
- monument name
- monument number (if known)
- survey number (if known)
- number of individual scans
- scan numbers of all scans
- total number of points
- filename of the control data
- description of registration method
  (eg "All scans registered to local site grid using targeted points.")
- an index plan showing the data collected with individual scan points named
- weather during survey (external scans only)
- any scanner specific information

7.4.5 Registration information

Registration information is the parameters used to transform raw scan data into a site co-ordinate system. To allow the re-transformation of raw scans at a later date preservation of such information is an extremely important quality control requirement.

7.4.6 Control information

As registration will generally be based upon targets/control stations positioned using other survey techniques, information relating to that control is, therefore, required.

7.4.7 #File sizes

Edit if smaller file sizes are preferred.

7.4.8 #Media

Edit if a specific medium is required.

7.4.5 Registration information

The following is to be supplied as registration information:

- translations in the X, Y and Z axes necessary to transform the scan origin to the scan position
- rotations around the X, Y and Z axes. This should be carried out in the order X, Y and Z

7.4.6 Control information

The following information should be supplied as control information:

Point ID, X, Y, Z, comment (optional)

7.4.7 File sizes

Individual file sizes are to be limited to the capacity of a standard single DVD-ROM (4.7GB). If capacity allows, multiple scans can be placed on a single DVD-ROM.

7.4.8 Media

Unless otherwise stated, all data is to be provided on CD-ROM, DVD-ROM (not RW), hard disk or, by prior arrangement, electronic transfer (ftp). Any text referencing is to be provided on a suitable label applied to the top surface of the CD/DVD-ROM. On no account must any text be written directly onto the surface of the CD/DVD-ROM.

7.4.9 Retention of survey documentation

See section 1.7.2 for general requirements.

APPENDIX 7.1

Health and safety considerations

The European Standard 'Safety of Laser Products – Part 1: Equipment classification, requirements and users guide' (IEC 60825-1: 2001) provides information on lasers and describes precautions on the use of laser products. Users should refer directly to this document when preparing health and safety assessments. However, a brief summary is provided below.

Dangers

Lasers used in survey applications may have risks associated with eye damage. The European Standard (IEC 60825-1: 2001) provides seven classes of lasers.

Class 1 lasers are safe under reasonably foreseeable conditions of operation, including the use of optical instruments for intrabeam viewing.

Class 1M lasers are safe under reasonably foreseeable conditions of operation, but may be hazardous if optics are employed within the beam.

Class 2 lasers normally evoke a blink reflex that protects the eye, this reaction is expected to provide adequate protection under reasonably foreseeable conditions, including the use of optical instruments for intrabeam viewing.

Class 2M lasers normally evoke a blink reflex that protects the eye, this reaction is expected to provide adequate protection under reasonably foreseeable conditions. However, viewing of the output may be more hazardous if the user employs optics within the beam.

Class 3R lasers are potentially hazardous where direct intrabeam viewing is involved, although the risk is lower than that for Class 3B lasers.

Class 3B lasers are normally hazardous when direct intrabeam exposure occurs, although viewing diffuse reflections is normally safe. This class of laser is generally not suited for survey applications.

Class 4 lasers will cause eye or skin damage if viewed directly. Lasers of this class are also capable of producing hazardous reflections. This class of laser is not suited for survey applications.

Users of laser scanning systems should always be aware of the class of their instrument. In particular the user should ensure the correct classification system is being used (eg IEC 60825-1: 2001 and not BS EN 60825-1: 1994 or other standard that differ slightly in classification).

Precautions

The European Standard IEC EN 60825-1: 2001 provides a number of safety precautions that should be observed during use of laser scanning surveys. For lasers up to Class 3R (those normally used in survey applications) and where applicable to laser scanning for metric survey these precautions are briefly outlined below.

For a full description the user is referred directly to the European Standard, however, generally:

- Care should be taken to prevent the unintentional specular reflection of radiation.
- Open laser beam paths should be located above or below eye level where practical.
- Only persons who have received training to an appropriate level should be placed in control of laser systems. The training, which may be given by the manufacturer or supplier of the system, the laser safety officer or an approved external organisation should include, but is not limited to: familiarization of operating procedures; the proper use of hazard control procedures, warning signs etc; the need for personal protection; accident reporting procedures and bioeffects of the laser upon the eye and skin.
- Particular care should be taken through the use of magnifiers or telescopes around laser devices that may pose a risk when intrabeam viewing is used.
- The instrument should only be used in accordance with the manufacturer's instructions.

For lasers that emit energy outside the wavelength range of 400nm to 700nm special considerations are often required. For example

Where using a Class 3R laser a laser safety officer should be appointed.

Beam paths should be as short as possible and avoid crossing walkways and access routes.

Particular precautions and procedures are outlined in the IEC standard for Class 1M, Class 2M and Class 3R laser products used in surveying, alignment and levelling. Those with relevance to laser scanning are:

- Only qualified and trained persons should be assigned to install, adjust and operate the laser equipment.
- Areas where these lasers are used should be posted with an appropriate laser warning sign.
- Precautions should be taken to ensure that persons do not look into the beam (prolonged intrabeam viewing can be hazardous). Direct viewing of the beam through optical instruments (theodolites, etc) may also be hazardous.
- Precautions should be taken to ensure that the laser beam is not unintentionally directed at mirror-like (specular) surfaces.
- When not in use the laser should be stored in a location where unauthorized personnel cannot gain access.

Other considerations

In addition to the risks associated with lasers, users should be aware that due to the size and weight of some systems there is a risk of injury to visitors, especially children, if systems are left unaccompanied.

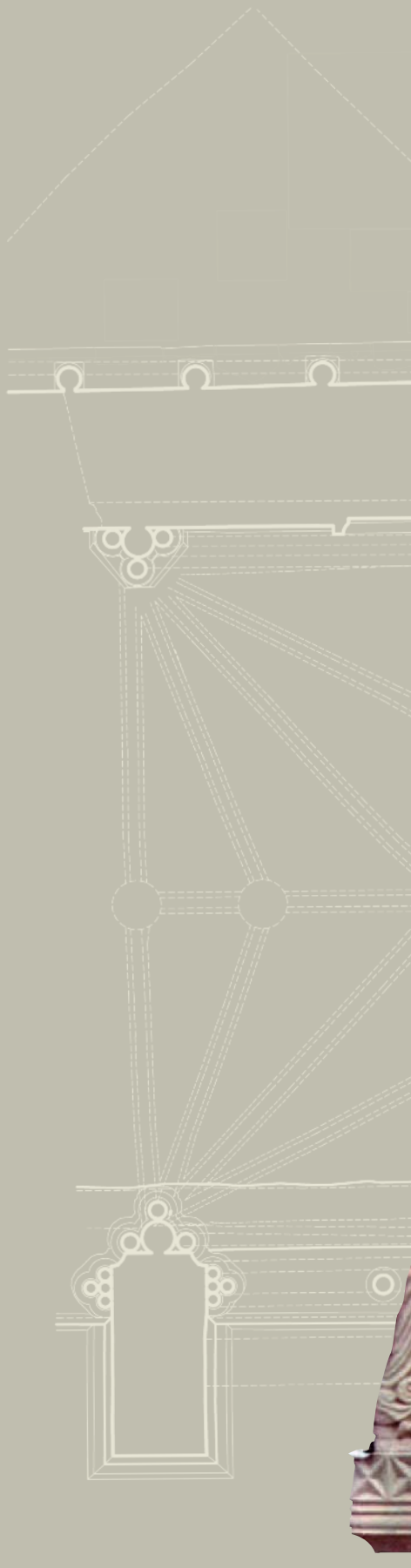
The effect of laser scanning on features such as lichens and delicate fabrics is not well understood. Consideration should be given to the use of lasers in the vicinity of such features.

Metric Survey Specifications for Cultural Heritage

Metric survey forms an essential component of the conservation cycle, as well as providing a valuable source of base mapping for analytical projects. Whether supplying metric survey data to buildings curators, conservators, architects or archaeologists, surveyors need to know what makes survey work for cultural heritage. A proven specification is a valuable tool for use in achieving this goal.

Getting the right survey for the right job is important to the heritage conservation community, and this specification will act as a guide to both the user and the supplier of metric survey data. It contains a description of the services expected and, where possible, the performance indicators that can be used to ensure the successful management of metric survey projects.

This document is a revised and updated second edition of *Metric Survey Specifications for English Heritage* – the standard specification that English Heritage has successfully used to procure metric survey for the last nine years. The new title reflects a more generic approach that, it is hoped, will make the specifications even easier to apply across the cultural heritage profession. This new edition also covers the collection of terrestrial laser-scan data that, as the technology matures, are becoming increasingly applicable to the survey of historic buildings and landscapes.



Product code 51481

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