PAS 128:2014

Specification for underground utility detection, verification and location

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Contents

Foreword

This PAS was sponsored by the Institution of Civil Engineers (ICE). The development of this PAS was facilitated by BSI Standards Limited and it was published under licence from The British Standards Institution. It came into effect on 30 June 2014.

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- The Geological Society
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- Transport for London

The PAS process enables a specification to be rapidly developed in order to fulfil an immediate need in industry. A PAS may be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

Hazard warnings

WARNING 1. This PAS calls for the use of procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

WARNING 2. For all excavations, assume that underground utilities are present and act accordingly.

Attention is drawn to laws, rules and regulations applicable to vacuum excavating or hand digging near or atop dangerous utilities such as electric, gas, fuel or petroleum.

WARNING 3. This PAS refers to physical entry into confined spaces, which is not to be attempted without suitably trained operatives and safety equipment.

Attention is drawn to HSE's publication, *Confined space – A brief guide to working safely* (INDG258) [1].

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in italic type, and does not constitute a normative element. The word "should" is used to express recommendations, the word "may" is used to express permissibility and the word "can" is used to express possibility, e.g. a consequence of an action or an event.

Spelling conforms to The Shorter Oxford English Dictionary. If a word has more than one spelling, the first spelling in the dictionary is used.

Use of this document

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a PAS cannot confer immunity from legal obligations.

0 Introduction

0.1 Background

As the demand on the nation's infrastructure continues to grow due to new developments, and the need to replace and/or maintain our existing utilities increases, it is essential we have accurate information on the existence and location of our underground utilities.

The accurate detection, identification, verification and location of utility assets have always been difficult tasks, subject to interpretation and inaccuracies. Not having sufficient or reliable information leads to:

- risk to the safety of workers and to the public;
- abortive and unnecessary work;
- damage to third party assets;
- inefficient design solutions.

Accurate utility data could also afford the opportunity for as yet unrealized benefits, such as the use of remote robotic techniques to maintain asset networks in busy highways in future to reduce the need for intrusive maintenance practices (road excavations). Similarly, accurate mapping of utility networks could improve asset modelling capabilities with more determined outcomes.

In the UK, there are no agreed or published standards either for the detection, verification and location of underground utilities or for the collection and recording of these data.

***NOTE** Given the wide use and varying connotations associated with the word "survey", the word "location" has been used throughout this PAS to define the act of geospatially referencing utility assets or topographical features.*

The purpose of this PAS is to set out clear and unambiguous provisions to those engaged in the detection, verification and location of active, abandoned, redundant or unknown utilities.

This PAS aims to provide:

- clarity in the service provided and methods employed;
- consistency in the approach to data capture;
- classification of the results and the confidence that can be associated with them;
- standardization of the format of deliverables; and
- accountability for the work undertaken.

It is expected that with time, education and experience in the application of this PAS, this will lead to more effective planning and safer execution of street works, civil works, ground works and utility-based activities.

In creating this PAS, the development of other similar work, such as guidelines and standards undertaken in the USA, Canada and Australia, have been taken into consideration.

Different survey types and methods provide different accuracy and certainty around results. For example, verification provides more accurate results than desktop utility records search. It is recognized that an increase in accuracy and certainty inevitably means an increase in effort, cost and time to deliver those results.

0.2 The survey type

This PAS takes a hierarchical approach to the survey types used in recognition that different clients at different stages of an asset life cycle will require different levels of detail and confidence in the data provided. This PAS defines four types of survey:

- desktop utility records search (survey type D) – where underground utilities are identified through the collation and analysis of existing paper/online utility records;
- site reconnaissance (survey type C) – where existing records are supported and validated by the visual inspection of physical evidence observed during a site visit;
- detection (survey type B) – where underground utilities are detected and located by geophysical techniques;
- verification (survey type A) – where underground utilities are observed and located at a manhole or inspection chamber, or are excavated and exposed.

These represent the different levels of effort required in obtaining information on the location of utilities, whereby the desktop utility records search requires the least effort and verification the most.

A survey type D is a prerequisite for survey types C, B and A. Survey types A to C are independent of each other. For example, a detection survey can conform to this PAS without the need to conduct a survey type C or A.

0.3 Detection methods

This PAS defines a hierarchy of detection methods to be used to detect underground utilities in terms of the minimum equipment types to be used, the minimum techniques to be applied and the survey search resolution and relates this to the maximum quality levels achievable that can be attained using a particular detection method (see Table 2). The detection methods are usually selected taking into account density of services of the survey area and whether post-processing is undertaken or not. Several detection methods may be applied to one survey area.

By ensuring the practitioner indicates in their method statement the methodologies they intend to use and thus the level of work their price is based on, this enables the client to assess and compare tenders on an equal basis. More importantly it defines for the practitioner the minimum standard expected for detection associated with each typical application.

These detection methods follow the philosophy of The Survey Association's (TSA's) levels of survey for levels 4 to 6 as given in *The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey* [NR1].

TSA level 3 – EML only survey – is deliberately not accounted for and not included as a detection method because this PAS is looking to raise the standard of detection so that in all cases a minimum of two detection techniques – ground penetrating radar (GPR) and electromagnetic location (EML) – are used.

0.4 Quality levels

The quality level is a classification applied to each segment of utility surveyed based on survey type undertaken, location accuracy achieved, whether post-processing was undertaken and level of supporting data obtained in determining the quality level (see Table 1). It reflects the confidence the practitioner has that they have achieved this quality level. For the survey type B, detection, where there are four quality levels, the aim of the practitioner is to attain a QL-B1 not aim for a QL-B4. A "P" suffix is added to QL-B1 to QL-B3 to distinguish where post-processing has been undertaken (see Note 1 to Clause **8**).

0.5 Absolute geospatial location of underground utilities

To improve accuracies and how data are exchanged and integrated, this PAS encourages the absolute geospatial location of utilities referenced to three dimensions using a national coordinate grid system and datum. In Great Britain this is the Ordnance Survey's National Grid (OSGB36) and Ordnance Datum Newlyn (ODN) coordinates. In Northern Ireland this is the Irish Grid (IG) as used by Ordnance Survey Northern Ireland.

NOTE *The Ordnance Survey of Ireland and Ordnance Survey Northern Ireland have implemented a new coordinate system for Ireland called Irish Transverse Mercator, or ITM, which will initially run in parallel with the existing Irish grid system.*

1 Scope

This PAS specifies requirements for the detection, verification and location of existing and new underground utilities.

It applies to the detection, verification and location of active, abandoned, redundant or unknown underground utilities and the location of their associated surface features (e.g. manhole covers and utility markers). It applies regardless of where these utilities are located (e.g. in urban or rural areas, in the street, or on private sites such as hospitals or airfields). It applies to utilities buried no deeper than three metres.

This PAS sets out the accuracy to which the data are captured, the quality expected of these data and a means by which to assess and indicate the confidence that can be placed in such data.

More specifically it covers:

a) project planning and scoping process;
b) classification system for quality levels based on survey type, location accuracy, inclusion of post-processing and level of supporting data;
c) desktop utility records search;
d) detection;
e) verification;
f) location;
g) deliverables.

It does not cover:

1) emergency utility works as defined by legislation [2] or where there is imminent risk to life, limb or environment;
2) underground basements, underground tunnels (including railways, road tunnels, and underground pedestrian walkways), plant rooms and non-utility based features;
3) above surface utility infrastructure (such as overhead power or telecommunication lines).

This PAS is for use by practitioners (usually a surveyor, geophysicist or subsurface utility engineer). It also might be of interest to clients (such as engineers, constructors, project managers and utility owners), who are responsible for recording information about underground utilities.

Where ground investigation, borehole, trial pit works and other construction works are proposed, a current utility mapping survey conforming to this PAS can be used as an indicator of the presence or absence of underground utilities before conducting further ground investigation prior to breaking ground.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards

PAS 1192-2:2013, *Specification for information management for the capital/delivery phase of construction projects using building information modelling*

Other publications

[NR1] THE SURVEY ASSOCIATION. *The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey.* TSA: Newark-on-Trent, 2011.

[NR2] RICS. *Guidelines for the use of GNSS in land surveying and mapping.* RICS Business Services Limited: London, 2010.

3 Terms and definitions and abbreviations

3.1 Terms and definitions

For the purposes of this PAS, the following terms and definitions apply.

3.1.1 absolute accuracy

degree to which the position of an object on a map conforms to its true or accepted location on the earth in a specified reference (coordinate) system

3.1.2 absolute coordinates

easting, northing and height that define the absolute geospatial location in a specified reference (coordinate) system

3.1.3 attribute data

structured data relating to specific descriptive characteristics associated with the underground utility

3.1.4 building information modelling (BIM)

process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information

[SOURCE: PAS 1192-2:2013, **3.7**]

3.1.5 building information modelling execution plan (BEP)

plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out

[SOURCE: PAS 1192-2:2013, **3.6**]

3.1.6 client

person or organization who has commissioned the underground utility survey

3.1.7 deliverable

underground utility detection, verification and location survey outputs provided to the client by the practitioner

3.1.8 detection

use of geophysical and other techniques and methods to establish the presence of an underground utility that can be either marked on the ground for later location or post-processed to determine location

3.1.9 employer's information requirements (EIR)

pre-tender document setting out the information to be delivered, and the standards and processes to be adopted by the supplier as part of the project delivery process

[SOURCE: PAS 1192-2:2013, **3.21**]

3.1.10 geospatial

relating to or denoting data which are associated with a particular location at or near the earth's surface

3.1.11 interpretation

analysis and identification of signals and images in the data that are representative of buried features, and the correlation of these signals and images to map linear segments representative of one or more underground utilities

3.1.12 location

process of geospatially recording the position of an underground utility

3.1.13 location accuracy

accuracy to which an object on a map conforms to its true positions on the earth's surface

3.1.14 mapping

process of graphically representing the spatial relationships of entities within a defined area

3.1.15 metadata

data about data

[SOURCE: BS EN ISO 19115-2:2010, **4.21**]

3.1.16 null level

level that infers no real value has been observed

NOTE *For example, -999.0.*

3.1.17 post-processing

post-acquisition enhancement and interpretation of raw data to help identify responses indicative of the presence of underground utilities

3.1.18 practitioner

person(s) carrying out the specified utility survey

NOTE A practitioner is usually a surveyor, geophysicist or subsurface utility engineer.

3.1.19 quality level

classification applied to a utility segment post survey based on survey type, location accuracy achieved, whether post-processing was undertaken and level of supporting data obtained

3.1.20 relative accuracy

measure of location accuracy on a map between one data point and other, nearby data points

NOTE Relative accuracy compares the scaled distance between objects on a map with the same measured distance on the ground.

3.1.21 safe digging practice

process of carrying out intrusive investigations which avoids both damage to the utility and harm to the operator, contractor, public or property

NOTE This may be careful hand excavation or a safer mechanical method such as a high pressure water or air lance used in conjunction with vacuum spoil removal. For further information, see HSE's Avoiding danger from underground services *(HSG47) [3].*

3.1.22 segment

part or section of an underground utility in terms of linear length or point to which a quality level applies

3.1.23 site reconnaissance

visual inspection of the survey area (as defined by the survey boundary) to ascertain facts and information about relevant topographic features and evidence pertaining to underground utilities

3.1.24 survey area

area defining the extent of works

3.1.25 utility owner

person or organization responsible for maintaining the utility asset and/or utility network

NOTE A utility owner could be, for example, a statutory undertaker, company or private individual.

3.1.26 utility record

information relating to the underground utility infrastructure

NOTE Utility records can include, for example, drawings (including "as-builts"), maps, spreadsheets, schematics, photographs, reports.

3.1.27 underground utility ("utility")

item or network of pipes and/or cables located beneath the surface level

NOTE 1 Underground utility is referred to as "utility" throughout this PAS.

NOTE 2 It includes exposed or submerged utilities.

3.1.28 verification

act of reviewing and inspecting, by existing access chambers or direct physical access using safe digging practice, in order to determine the absolute geospatial location and detailed attributes of the exposed underground utility

3.2 Abbreviations

BEP	building information modelling execution plan
BIM	building information modelling
CAD	computer-aided design also known as computer-aided drafting
EIR	employer's information requirements
EML	electromagnetic location
GIS	geographic information system
GNSS	global navigation satellite system
GPR	ground probing radar also known as ground penetrating radar
RFID tag	radio-frequency identification tag
RTK	real-time kinematic

4 Project planning

NOTE Utility surveys should be approached holistically both in the planning and execution; it is a synthesis of the results of a number of technologies and methodologies deployed on the site. Utility surveys should be planned by the client in conjunction/consultation with a trained, skilled and experienced practitioner. The project requirements should be clearly specified in tender and/or contract documentation. For guidance on specifying a utility survey, see TSA's The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey *[NR1].*

Survey techniques and methodologies vary considerably, with each having their own advantages and disadvantages. The more intensive utility surveys have the potential to produce results that are more accurate but at an increased cost.

When responding to a client's specification, the practitioner should address whether the client has taken into account some or all of the following considerations in the scope of work at the earliest possible opportunity.

a) Has a desktop utility records search been undertaken within the last 90 days?

b) Are the results to be marked onto the ground?

c) Are the results to be fully mapped in CAD/GIS/BIM?

d) Are the results to be marked onto the ground as well as being fully mapped in CAD/GIS/BIM?

e) What consideration should be given to any CAD/GIS/BIM outputs? Is the existing base mapping at a scale suitable for the proposed project or is there a need to commission a new survey?

f) Do you have the legal rights or permission for the use of any existing base mapping?

g) Has the survey area been clearly defined?

h) Are there any areas of particular concern that the client should be highlighting (e.g. any risks associated with not knowing the accurate location of utility infrastructure)?

i) Are there any sections within the survey area where key information is needed and where the highest intensity of survey is to be undertaken?

j) Are there any health and safety issues, hazards or risks associated with this site (e.g. working on highways including road category/speed limits, ongoing construction activities, confined space entry requirements, industrial premises where there is a potential presence of asbestos)?

k) Is there other material relevant to the project (e.g. geological information)?

l) Has the suitability of the survey area for geophysical investigation been assessed?

m) What utility attributes need to be included in the deliverables?

n) What level of detail is to be recorded against accessed manholes, inspection chambers and pits, etc.?

o) Is post-processing of the data required?

4.1 Documentation

4.1.1 General

A method statement, programme of works, risk assessment and safety plan for the survey shall be submitted to the client before commencing work on-site.

4.1.2 Method statement

NOTE 1 Some clients might have their own templates for generic method statements which should be addressed in drafting the method statement.

NOTE 2 In planning the survey, the practitioner should consider the likely depth, size, duty and material of construction of the buried utilities within the survey area to ensure a survey is delivered that meets the client's requirements. An appraisal of the expected utilities and their complexity should be made by considering the type of site.

NOTE 3 Gaining access to utility assets such as manholes and inspection chambers and obtaining permission to do so is a contractual arrangement specific to a particular project.

A method statement shall be produced and submitted to the client and shall include as a minimum:

a) the survey type(s) to be deployed as specified in Table 1, including the estimated survey extent for each survey type;

b) for survey type B, detection methods to be deployed as specified in Table 2, including the estimated survey extent for each method;

c) comment on these survey type(s) and, for survey type B, detection methods, with regard to satisfying the client's requirements;

d) comment on the expected achievable quality level;

e) names and experience of the project team;

NOTE 4 Experience includes training, qualifications, previous project experience and evidence of competencies.

f) how traffic, pedestrians, parked vehicles, bus stops, skips, animals and other surface obstructions are to be managed to maximize the area available for survey and to ensure the safe execution of the works.

NOTE 5 Access to private land is to be negotiated and if work is required in the highway, any permissions will need to be sought from the appropriate highway authority(ies).

NOTE 6 Before undertaking any excavation, evidence should be obtained that the following are in place:

a) permits;

b) licences;

c) footpath/road closure notices.

NOTE 7 It is usually the client who is responsible for procuring relevant permits, licences, footpath/road closure notices. Attention is drawn to the New Roads and Street Works Act 1991 (NRSWA) [2] and the Traffic Management Act 2004 [4].

NOTE 8 Night time or weekend working should normally be agreed with the client to ensure safe and considerate impacts on the local environment and community.

4.1.3 Programme of works

A programme of works shall be drawn up detailing the time allowed for the fieldwork, initial reporting, client consultation, any agreed further fieldwork and submission of the deliverables.

NOTE The programme of works can take a variety of forms (schedule of work, spreadsheet, list of dates, etc.) appropriate to the project.

4.1.4 Risk assessment and safety plan

A site-specific risk assessment and safety plan or safe system of works shall be compiled.

NOTE The risk assessment involves:

- *an examination of the work and workplace to identify what could cause harm to people (a hazard). This should be developed by a site visit and/or current information supplied by the client;*
- *an assessment of the chance, high or low, that somebody could be harmed by the hazards identified, together with an indication of how serious the harm could be (the risk).*

The safety plan involves taking the results of the risk assessment and developing a plan showing the precautions needed to mitigate the risks and how these precautions will be communicated and implemented.

4.2 Utility records

4.2.1 For a survey type C, B or A, utility records shall be obtained through a desktop utility records search in accordance with Clause **6**.

4.2.2 The desktop utility records search deliverable shall not be older than 90 days prior to conducting a survey type C, B or A.

4.3 Base mapping

Where existing base mapping has been obtained (in any format, e.g. drawing, electronic such as 3D-CAD/GIS/BIM models), its accuracy, currency and scale shall be assessed for its intended purpose.

*NOTE 1 This subclause covers requirements for assessing base mapping as part of the planning process. Requirements for on-site checks are specified in **10.4.1**.*

NOTE 2 If there are any obvious omissions, inaccuracies or doubts about any inherited data, or if any data are considered unsuitable, the practitioner should inform the client that a new topographic survey will need to be undertaken.

NOTE 3 Where Ordnance Survey data is being used, the practitioner should obtain details of an Ordnance Survey licence from the client to include on drawings.

4.4 Other buried features and obstructions

***NOTE** This PAS does not cover the identification and mapping of other buried features or obstructions. If the client requires additional site investigation work this should be carried out in accordance with BS 5930.*

If buried feature or obstructions are discovered whilst undertaking the works, they shall be reported in accordance with **11.6**.

4.5 Geology of the site

***NOTE 1** Any detection or verification methodologies to be used should take into account the geological bedrock, natural and artificial superficial deposits and geological structures beneath the site when known.*

***NOTE 2** When selecting the geophysical technique, the resolution as well as depth of penetration expected in the prevailing geological bedrock should be taken into account along with the variability within the geological subsurface which might exert a strong influence.*

***NOTE 3** When selecting the method of verification, the composition and physical properties of the geology should be taken into account.*

4.6 Meetings and site visits

A post-fieldwork meeting shall be held to review the results in terms of the information delivered and any remaining areas of uncertainty, and to discuss whether additional fieldwork is required.

***NOTE 1** The meeting may be a face-to-face meeting or a virtual meeting (telephone, video-conferencing, online).*

***NOTE 2** In addition to the post-fieldwork meeting, other meetings, site visits, client visits and progress reports might be required to inform the client on progress and resolve problems as they arise.*

5 Quality level

5.1 Survey types

The survey type(s) shall be selected from the following:

a) survey type D – desktop utility records search;

b) survey type C – site reconnaissance;

c) survey type B – detection;

d) survey type A – verification.

***NOTE 1** A survey type D is a prerequisite for survey types C, B and A (see **4.2.1**). Survey types A to C are independent of each other. For example, a detection survey can conform to this PAS without the need to conduct a survey type C or A.*

***NOTE 2** The practitioner should establish with the client the survey type(s) required and where these are to be performed on the survey area.*

***NOTE 3** A client might specify multiple survey types over the survey area. For example, the client might require a survey type D for the whole site, a survey type B in the road carriageways and a survey type A only at a specific location where a potential design element has a possible conflict in a congested area.*

***NOTE 4** The practitioner should establish with the client the detection methodology required and document this in the method statement (see **4.1.2**).*

***NOTE 5** Figure 1 illustrates the typical processes involved in delivering the different survey types and the assessment of the deliverables to determine whether further work is required.*

5.2 Quality level

The quality level achieved shall be applied to each segment of utility surveyed in accordance with Table 1.

***NOTE** Survey type D can only be classified as QL-D in the deliverables. Survey type C can have utility segments that are classified as QL-C or QL-D in the deliverables. Survey type B can have utility segments that are classified as QL-B1, QL-B1P, QL-B2, QL-B2P, QL-B3, QL-B3P or QL-B4 in the deliverables. Survey type A can have utility segments that are classified as QL-A in the deliverables if utility(ies) are exposed/inspected and measured.*

Figure 1 – PAS 128 process flowchart (informative)

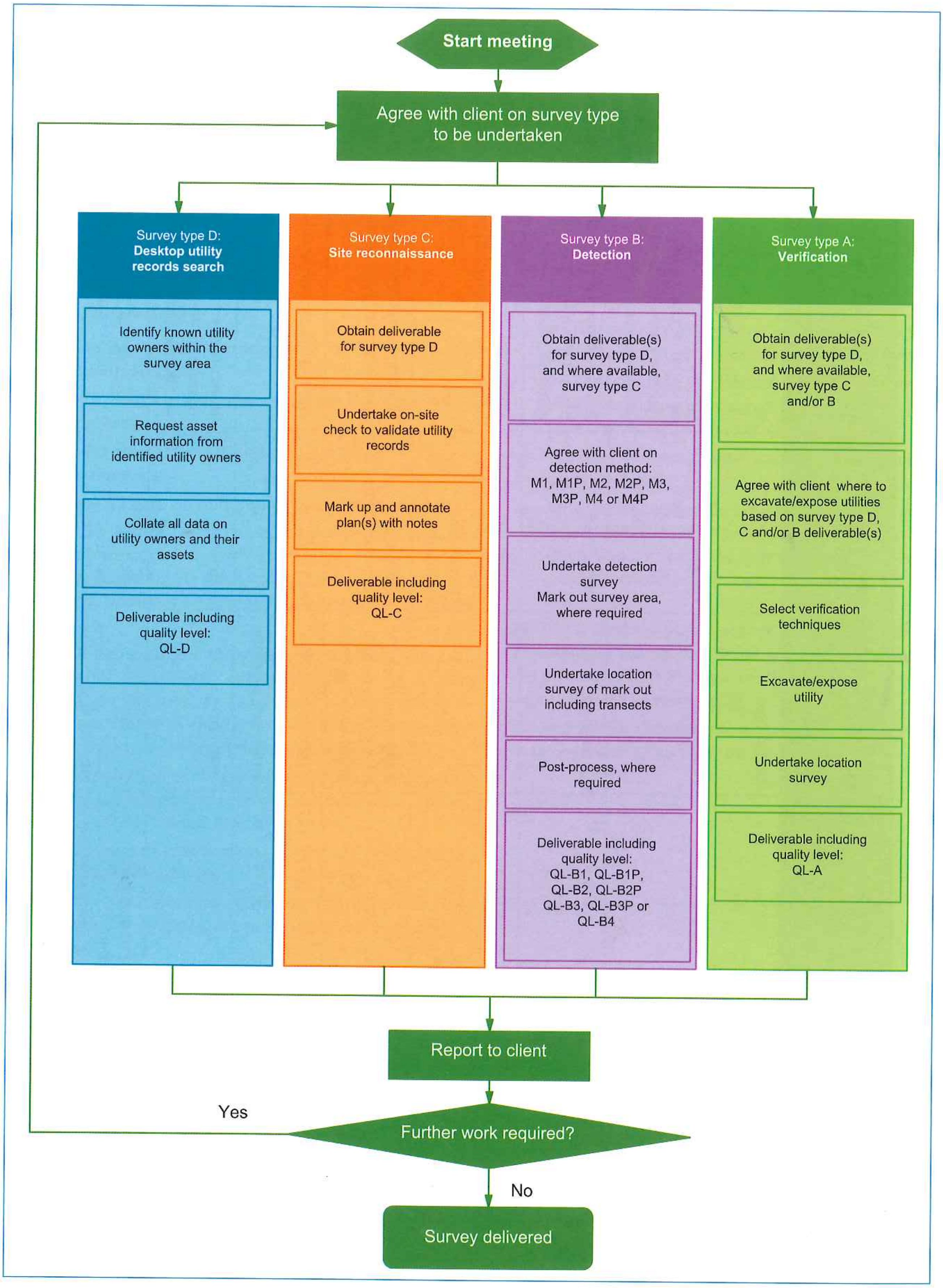


Table 1 – Quality level of survey outputs (normative)

Survey type (Establish with client prior to survey)		Quality level (Practitioner to determine post survey)	Post-processing	Location accuracy		Supporting data
				Horizontal [1]	Vertical [2]	
D	Desktop utility records search	QL-D	—	Undefined	Undefined	—
C	Site reconnaissance	QL-C	—	Undefined	Undefined	A segment of utility whose location is demonstrated by visual reference to street furniture, topographical features or evidence of previous street works (reinstatement scar).
B	Detection [3]	QL–B4	No	Undefined	Undefined	A utility segment which is suspected to exist but has not been detected and is therefore shown as an assumed route.
		QL-B3	No	±500 mm	Undefined (No reliable depth measurement possible)	Horizontal location only of the utility detected by one of the geophysical techniques used.
		QL-B3P	Yes			
		QL-B2	No	±250 mm or ±40% of detected depth whichever is greater	±40% of detected depth	Horizontal and vertical location of the utility detected by one of the geophysical techniques used. [4]
		QL–B2P	Yes			
		QL-B1	No	±150 mm or ±15% of detected depth whichever is greater	±15% of detected depth	Horizontal and vertical location of the utility detected by multiple [5] geophysical techniques used.
		QL–B1P	Yes			
A	Verification	QL-A	—	±50 mm	±25 mm	Horizontal and vertical location of the top and/or bottom of the utility. Additional attribution is recorded as specified in **9.2.5**.

1) Horizontal location is to the centreline of the utility.
2) Vertical location is to the top of the utility.
3) For detection, it is a requirement that a minimum of GPR and EML techniques are used (see **8.2.1.1.2**).
4) Electronic depth readings using EML equipment are not normally sufficient to achieve a QL-B2 or higher.
5) Some utilities can only be detected by one of the existing detection techniques. As a consequence, such utilities cannot be classified as a QL-B1.

6 Desktop utility records search (survey type D)

6.1 General

6.1.1 Survey type D shall use desktop search techniques to identify existing utility data within the survey area.

6.1.2 The quality level achieved shall be documented as QL-D in accordance with Table 1.

6.2 Methodology

6.2.1 A desktop utility records search shall be produced by the following process:

a) identify known utility owners within the specified survey area;

b) request asset information from identified utility owners;

c) collate all data on utility owners and their assets.

NOTE 1 The identification of utility owners and the request for asset information should be extended to land adjacent to the survey area, as this might offer an informative understanding of where utility feeds derive.

NOTE 2 When a project takes place on a private site, such as a hospital, industrial or military establishment, a utility owner might not have statutory records covering the survey area. Historical utility data should be obtained from the relevant estate's department, where available.

NOTE 3 A practitioner should allow adequate time within their schedule of work to receive the responses from utility owners. A 20-day period is recommended.

NOTE 4 Sources of information can include, for example, internet-based inquiry sites.

NOTE 5 The practitioner should consider asking the utility owner whether RFIDs have been used within the survey area.

NOTE 6 A desktop utility records search deliverable can be provided as a compilation and consolidation of all record data into a digital representation within a CAD/GIS/BIM model file structured to the client's requirements.

6.2.2 The information gathered shall include as a minimum:

a) company details of the practitioner carrying out survey type D;

b) client details;

c) a plan showing the boundary for the requested survey area;

d) a list of utility owners to whom a request was sent;

e) a list showing utility owner responses and actions taken to obtain response from non-responders;

f) any information received from the utility owner by way of plans, maps, diagrams or text and covering letter along with any asset guidance notes;

g) the date of issue of any maps supplied by the utility owners;

h) an advisory/cautionary note in **BOLD** explaining how this information was constructed, its limitations regarding accuracy and that no on-site survey/ geophysical detecting techniques have been used.

NOTE 1 A desktop utility records search deliverable older than 90 days should be classed as historical and used with caution. Attention is drawn to the New Roads and Street Works Act 1991 (NRSWA) [2].

NOTE 2 Where data have been supplied in imperial measurements this should be noted.

7 Site reconnaissance (survey type C)

7.1 General

7.1.1 Survey type C shall comprise a site reconnaissance to identify physical features that support the existence of utilities within the survey area.

7.1.2 Where the utility records can be matched to surface features, the quality level achieved shall be documented as QL-C in accordance with Table 1.

NOTE *Where only one surface feature is identified relating to a specific utility, then the QL-C given for that segment will comprise a point on the utility. Where two or more surface features reference a specific utility, then the QL-C given for that segment will comprise a length on the utility.*

7.1.3 Where the utility records cannot be matched to surface features, the quality level achieved shall be documented as QL-D in accordance with Table 1.

7.2 Methodology

7.2.1 Site reconnaissance shall comprise on-site checks to validate the utility records and to assess if there are any conflicts that need to be resolved.

NOTE *These might be records and drawings provided by utility owners obtained via a type D survey or might comprise historic drawings, records and digital data from other sources.*

7.2.2 On-site checks shall document:

a) the presence, type and markings of utility-related surface features (see **7.2.3**);

b) measurements between known surface features on the ground compared with those depicted on the plan;

c) differences between the map/drawing or digital features supplied and those extant on the ground.

NOTE *Documentation of on-site checks may include, but are not limited to, the mark-up and annotation of existing plans, the inclusion of supporting photographic evidence and/or a written report.*

7.2.3 Surface features to be included in the on-site checks shall include as a minimum:

a) manhole and inspection chamber covers;

b) valve covers;

c) utility markers;

d) control and distribution pillars and columns, LV power, street lighting, traffic lights; and

e) historic excavation scar lines.

8 Detection (survey type B)

NOTE 1 *The remote detection of underground utilities uses geophysical techniques. As the survey area is scanned, signals are received and analysed for anomalous responses. If the positions of these anomalies form linear strings they can be interpreted as features, such as utilities.*

Some geophysical equipment only permits real-time data to be displayed without the facility for recording the data for post-processing and interpretation. This means that the operator has to interpret the signals whilst in the field and has to mark the results onto the ground surface being surveyed, i.e. no post-processing.

Some geophysical equipment is capable of recording the data and some is capable of real-time mark up. The ability to post-process data can often help in understanding areas of complex utility networks so improving the confidence in the interpretation of the data. There is also the advantage of acquiring a record of what work was carried out in the field.

This PAS specifies two techniques as a minimum to be used in detecting utilities:

a) EML, Electro Magnetic Locating: Detection of buried utilities via a hand-held receiver using electromagnetic and radio frequency signals that are present in metallic utilities as a result of current flow or re-transmitted low frequency radio signals (passive EML). Signals can also be induced from a transmitter at ground surface, by direct connection from a signal generator or from a sonde or tracing wire introduced into a pipe or duct (active EML). Most EML systems do not have the capability of recording what was detected on-site so it relies on the detected position and depth being marked on the ground surface as the survey progresses. This has the advantage of providing quick results but does not allow post-processing and retrospective interpretation of the data to be undertaken and has the disadvantage that no digital record is made.

b) GPR, Ground Penetrating Radar (sometimes referred to as ground probing radar): The use of radar waves from a surface transmitter that can penetrate through ground materials and are reflected back to the instrument by a change of ground material or other buried objects: In its simplest form, GPR has systems which have only real-time capability. As with EML, no digital record is captured. GPR systems where the data are recorded are usually surveyed in grids and then post-processed and interpreted off-site. This increases the confidence in the data. Accurate survey grids are established so that detected features found during post-processing and interpretation can be retrospectively located on the interpretative drawings. A digital record is generated with these systems.

Geophysical data by itself does not allow identification of the utility detected. The identification of the utility is achieved through a combination of on-site interpretation from both GPR and EML surveys together with on-site reconnaissance and correlation with utility records.

It is recognized that post-processing generally improves the interpretation of GPR data by resolving weak and intermittent signals or analysing multiple targets in order to gain a better understanding of areas of complex or more obscure utility networks. In addition there is the added advantage of acquiring a digital record of what work was carried out in the field.

The practitioner should advise whether post-processing is necessary based on their understanding of the survey area and the requirements specified by the client. The client may choose whether or not to specify post-processing. The use of post-processing is reflected in the method statement and also in the quality level determined and assigned to the results.

For further information on on-site interpretation and post-processing see TSA's The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey *[NR1].*

NOTE 2 The accuracy with which depth assessment can be made depends on the technique being used and depth of utility (see Note 3). However, other factors, such as ground conditions, proximity of other utilities, material and method of construction, have an influence on the quality of depth data. Some techniques, such as ground conductivity, allow no depth assessment to be made; others might only provide indicative depth estimates.

NOTE 3 The accuracy with which horizontal and vertical position of the utility can be estimated depends on the depth of burial of the utility so that accuracies are expressed, in part, as a percentage of depth. The deeper the target utility the less accurately both the horizontal and vertical position can be assessed. This PAS applies to utilities buried no deeper than three metres.

NOTE 4 No detection technique can detect every type of underground utility in every location.

8.1 General

NOTE Table 2 specifies the minimum requirements for each method. Table 3 provides guidance on other techniques available.

8.1.1 Survey type B shall use geophysical techniques to detect and identify utilities within the survey area.

8.1.2 The quality level achieved shall be documented as QL-B1, QL-B2, QL-B3 or QL-B4 in accordance with Table 1.

8.1.3 If post-processing has been used to improve the confidence of the data, then each quality level shall be suffixed with the letter "P", i.e. QL-B1P, QL-B2P and QL-B3P.

8.1.4 Where post-processing is selected as part of the detection methodology, all data which can be post-processed, shall be post-processed.

NOTE Post-processing may be instructed within defined discrete sections of the survey area.

8.2 Methodology

8.2.1 Detection techniques

8.2.1.1 General

8.2.1.1.1 The detection techniques shall be deployed in accordance with Table 2.

8.2.1.1.2 A minimum of GPR and EML techniques shall be used in detecting utilities.

NOTE Three or more techniques should be used, where it provides benefits in the detection capability, coverage, efficiency and/or accuracy.

8.2.1.1.3 The GPR, EML and any other geophysical equipment shall be operated in accordance with the manufacturer's instruction procedures, calibration and any equipment process or limitations.

NOTE For information on the control, and application of GPR, see ETSI EG 202 730 V1.1.1 (2009-09) *[5].*

8.2.1.1.4 The following shall be recorded as a minimum as evidence of work carried out:

a) site name and location;
b) time and date of the site interpretation;
c) detection techniques used including the model and serial number of equipment;
d) weather conditions;
e) the names of the operator(s);
f) calibration method and calibration data obtained;
g) modes of detection for each geophysical survey instrument used;
h) photographs of the site (e.g. of on-site mark out, obstructions);
i) notes on site limitations (e.g. overgrown);
j) utility records available at time of the survey;
k) a polygon representing where any search sweep has been undertaken;
l) where post-processing is employed:
   1) the geo-reference to the start and end of each search transect;
   2) the data from all search transects;
m) where post-processing is not employed, the coordinate at any point where a utility has been detected and marked on the ground.

   NOTE Where detection techniques allow recording of geophysical data, practitioners are encouraged to keep a record as evidence of detections and work undertaken. This allows the geophysical data to be reviewed by either client or practitioner at a later date.

8.2.1.1.5 Any linear feature identified in the data whilst on-site shall be either followed to a node where the identity of the utility can be established or, where this is not practical, labelled as "unknown utility" in accordance with **11.4**.

NOTE 1 This might involve tracing beyond the survey area.

NOTE 2 When detecting utilities over large areas (such as brown field sites), where the density of utilities is expected to be low, a perimeter search can be carried out in accordance with M2, Table 2 and the utilities traced across the site or to their termination.

8.2.1.1.6 Where post-processing has been employed, the results of the data interpretation shall be presented on drawings.

NOTE The client might also request that on-site mark out is undertaken retrospectively.

8.2.1.1.7 Where post-processing has not been employed, the data shall be marked out on-site in accordance with **8.2.2.**

8.2.1.2 Ground penetrating radar (GPR)

8.2.1.2.1 GPR shall be deployed in accordance with Table 2.

8.2.1.2.2 For a high density array (100 mm or closer antenna separation), the following requirements shall be met.

a) The collection regime for the main array shall be maintained throughout the survey area ensuring that any gap between swaths is no larger than the transect spacing specified in Table 2.

b) Survey speed shall be selected such that it allows scans to be collected where the centres do not exceed the antenna separation.

c) Positioning of the array shall be continuously monitored and recorded using either GNSS or total station and at an absolute accuracy of ≤100 mm.

d) Where a large (typically vehicle-towed) high density array cannot achieve full coverage over the whole survey area due to limited access, a handcart high density array or a single channel system shall be used for these infill areas.

8.2.1.3 Electromagnetic locator (EML)

8.2.1.3.1 EML shall be deployed in accordance with Table 2.

8.2.1.3.2 Passive EML shall be deployed over the whole survey area. Where an active EML method can be used, it shall be used.

NOTE 1 Active EML involves the application of line tracers and/or sondes at the location of manholes and inspection chambers.

NOTE 2 Where it is not possible to lift a manhole cover because it is stuck or obstructed, or access is not permitted by the asset owner, this should be reported to the client at the earliest opportunity with a request for the cover to be made accessible or lifted, preferably whilst the practitioner(s) are still on-site. It is good practice not to attempt to lift damaged covers but to report the damage to the client for instructions.

WARNING. This PAS refers to physical entry into confined spaces, which is not to be attempted without suitably trained operatives and safety equipment.

Attention is drawn to HSE's publication, *Confined space – A brief guide to working safely* (INDG258) [1].

8.2.1.4 Other technologies

NOTE Table 3 provides examples of other geophysical detection technologies.

Table 2 – Detection methods (normative)

Method [1] (to be determined in consultation with the client)	Survey grid/search resolution [2]				Quality levels achievable	Typical application (informative)
	EML [3]	GPR		Other techniques [4]		
		General	Post-processing			
M1	Orthogonal search transect at ≤10 m intervals and when following a utility trace, search transects at ≤5 m intervals	Use as applicable	No	≤5 m survey grid	B1, B2, B3, B4	Used where the density of services is typical of an undeveloped area
M1P			Yes		B1P, B2P, B3P	
M2	Orthogonal search transect at ≤5 m intervals and when following a utility trace, search transects at ≤2 m intervals	Either: a) ≤2 m orthogonal; or b) high density array [5]	No	≤2 m survey grid	B1, B2, B3, B4	Used where the density of services is typical of a suburban area or where the utility services cross a boundary of a survey area
M2P			Yes		B1P, B2P, B3P	
M3	Orthogonal search transect at ≤2 m intervals and when following a utility trace, search transects at ≤1 m intervals	Either: a) ≤1 m orthogonal; or b) high density array [5]	No	≤1 m survey grid	B1, B2, B3, B4	Used where the density of services is typical of a busy urban area or for clearance surveys prior to operations such as borehole/drilling/fencing/tree planting
M3P			Yes		B1P, B2P, B3P	
M4	Orthogonal search transect at ≤2 m intervals and when following a utility trace, search transects at ≤0.5 m intervals	Either: a) ≤0.5 m orthogonal; or b) high density array [5]	No	≤0.5 m survey grid	B1, B2, B3, B4	Used where the density of services is typical of a congested city area
M4P			Yes		B1P, B2P, B3P	

***NOTE 1** In general the effort increases from M1 to M4 and the addition of post-processing. For areas with a greater density of utilities or areas considered high risk by the client, a detection method that has a higher level of effort should be selected.*

***NOTE 2** "P" indicates off-site post-processing has been included.*

[1] It is a requirement that a minimum of GPR and EML techniques are used (see **8.2.1.1.2**).
[2] The tolerance for orthogonal transect centres and survey grids shall be ±0.1 m.
[3] It is a requirement that passive EML is deployed over the whole survey area and that where an active EML method can be used, it is used (see **8.2.1.3.2**).
[4] The transect centre depends on technique used.
[5] A high density array comprises 100 mm or closer antenna separation.

Table 3 – Other technologies (informative)

Technique	Notes
Acoustic transmission (sounding)	Used to demonstrate connectivity of open drains only.
Drain tracing dye	Used to demonstrate connectivity only for foul, surface water and combined drainage.
Earth resistance	Used for detecting variations in earth resistance caused by shallow variations in soil, e.g. trench backfill.
Electromagnetic (EM) ground conductivity	Used for detecting subsurface features. Often used to obtain information over large areas (≥0.5 hectare).
Gyro based pipe location logging	Used for tracing the line of pipes where two access points allow the instrument to be deployed and recovered such as inverted siphons.
Infrared (thermal) imaging	Used for detecting thermal anomalies at the surface associated with underground features.
Magnetometry	Used for detecting subsurface features, in particular ferrous based and fired clayware pipelines. Often used to obtain information over large areas (≥0.5 hectare). It is of limited use in urban and congested areas.
Metal detectors	Used for detecting shallow ferrous objects.
RFID detection	Used to relocate utilities that have been previously tagged with an RFID device. Only relevant where a check can be made against a record of its original placement.
Vibration acoustic	Used to detect the horizontal position (not depth) of pipework where a vibration signal can be induced along the pipe.

NOTE 1 *This table of other technologies is not exhaustive. A number of other geophysical, surveying and inspection technologies are available that might be useful in specific applications.*

NOTE 2 *Where these and other technologies are used, the same standards of record should be adopted as required for the more commonly deployed geophysical detection techniques such as GPR and EML.*

NOTE 3 *The search resolution of these technologies should be agreed with the client prior to any fieldwork being undertaken.*

8.2.2 Marking out detected utilities and survey grids whilst on-site

NOTE The marking out of detected utilities is a key element to the accuracy of a survey.

8.2.2.1 Where wooden pegs are used, they shall be offset and placed to one side of the horizontal position of the utility. This offset shall be made clear by annotating the peg.

NOTE 1 Agreement of the client to the use of pegs should be sought.

NOTE 2 The use of wooden pegs may be used over rough ground and scrub or where a soft surface will not accept the marker.

8.2.2.2 The duty of the utility shall be marked using an agreed letter code and/or colour.

NOTE 1 Where just one colour is used, it should have a stark contrast to the ground.

NOTE 2 Where a range of colours are used to represent different utility types then the colour code should be agreed beforehand with the client.

8.2.2.3 Depth estimations shall be marked on the ground in metres followed by "d" to indicate depth (e.g. "0.9d" – this indicates that the utility has an estimated depth of 0.9 m).

8.2.2.4 Where paint is used, it shall be biodegradable.

NOTE 1 Before using paint, permission should be sought. Consideration should be given to the durability of the bio-degradable paint to be used which might not be consistent with any permits issued.

NOTE 2 The width and length of individual marked lines should be kept to a minimum. Marking out should be sympathetic to the location of the survey with minimal use of a marker with preference to chalk and crayon in areas of high quality hard landscaping.

NOTE 3 Marking out of detected utilities can be with the use of spot marking aerosol paint. These need to be COSHH assessed and any empty/unusable canisters have to be disposed of as commercial waste in an environmental friendly way with the appropriate records kept.

8.2.2.5 Steel pins, spikes or long pegs shall not be used to mark out detected utilities.

NOTE Steel pins, spikes or long pegs are not used as these could damage shallow utilities. Providing a prior assessment of utility depth has been made, the use of survey nails judiciously placed to mark out survey grids is acceptable.

8.2.2.6 The marks representing the detection of the utility shall:

a) depict the alignment of the utility at the scale of capture;
b) include a mark at each change in direction, each junction and each point of termination.

   NOTE Utilities running along curves necessitate a higher frequency of markings than utilities running in a straight line.

8.2.2.7 The time between marking out and the recording of its location shall not exceed 48 hours.

NOTE The time between marking out and the recording of its location should be kept to a minimum.

8.2.2.8 High pressure pipelines shall be marked up in accordance with the utility owner/operator's instructions.

8.2.3 Where the survey detects anomalies other than those caused by utilities, these shall be recorded as specified in **11.5**.

NOTE The use of geophysics might detect anomalies, often referred to as radar anomalies, that are the result of buried features other than utilities. This is particularly true of GPR.

The types of features that may be detected include but are not limited to:

- *voids;*
- *foundations;*
- *thrust blocks;*
- *tanks;*
- *chambers;*
- *basement extents;*
- *ducts (not linked to any street furniture);*
- *reinforced concrete.*

9 Verification (survey type A)

NOTE 1 Verification is the process of exposing a utility and subsequently measuring and recording its accurate location as well as other relevant attributes.

NOTE 2 Verification of a utility that does not have access via a manhole or inspection chamber can be performed using one, or a combination of excavation techniques that protect the integrity of the utility. Such techniques include, for example, vacuum excavation (air only), hydro or dual (air and hydro) and safe hand digging techniques. For guidance on potential dangers of working near underground services and on how to reduce any direct risks to people's health and safety, as well as the indirect risks arising through damage to services, see HSE's Avoiding danger from underground services (HSG47) *[3].*

9.1 General

9.1.1 Survey type A shall comprise exposing the target utility(ies) within the survey area to confirm and record the location and other attribute data.

9.1.2 The quality level achieved shall be documented as QL-A in accordance with Table 1.

9.2 Methodology

NOTE Where it is not possible to lift a manhole cover because it is stuck or obstructed, this should be reported to the client at the earliest opportunity with a request for the cover to be made accessible or lifted, preferably whilst the practitioner(s) are still on-site. It is good practice not to attempt to lift damaged covers but to report the damage to the client for instructions.

WARNING. This PAS refers to physical entry into confined spaces, which is not to be attempted without suitably trained operatives and safety equipment.

Attention is drawn to HSE's publication, *Confined space – A brief guide to working safely* (INDG258) [1].

9.2.1 For survey type A, the data shall be obtained through visual inspection of the utility:

a) at access points such as in a manhole or inspection chamber; and/or

b) by its excavation and exposure.

NOTE 1 Damage to the utility and the surrounding infrastructure should be avoided when exposing the utility and also in undertaking the reinstatement of any excavations. Exposing the utility could be by any number of standard of care techniques including:

a) vacuum excavation with pressurized air and/or water to expose the utility;

b) hand digging techniques to expose the utility;

c) other conventional mechanical excavation technologies used in conjunction with a) and/or b).

NOTE 2 Exact intervals of non-destructive verifications are project dependent and should be specified by the client.

WARNING. For all excavations, assume that underground utilities are present and act accordingly.

Attention is drawn to laws, rules and regulations applicable to vacuum excavating or hand digging near or atop dangerous utilities such as electric, gas, fuel or petroleum.

9.2.2 Data gathered from visual inspection at access points shall include as a minimum:

a) for foul, surface and combined water drainage systems access points (manholes and inspection chambers):
   1) pipe positions and orientation at ground surface;
   2) visible pipe diameters;
   3) material type;
   4) pipe depths (invert levels related to a common datum);
   5) directions of flow;
   6) manhole/inspection chamber size;
   7) manhole/inspection chamber soffit depth and depth to base;
   8) connectivity diagram;
   9) manhole/inspection chamber layout and/or photographs;

b) for telecoms/electrical utility manholes and inspection chambers:
   1) ducts position and orientation at ground surface;
   2) number and size of ducts on each face;
   3) material type;
   4) depth to top of ducts;
   5) manhole/inspection chamber size;
   6) depth to base;
   7) manhole/inspection chamber layout and/or photographs;

c) for gas/water utility manholes and inspection chambers:
   1) depths and diameter of the utility, when visible in manhole/inspection chamber;
   2) valve connectivity;
   3) material type;
   4) manhole/inspection chamber layout and/or photographs.

9.2.3 Excavations shall be:

a) a single spot excavation (commonly known as an inspection pit, test hole or pothole) for the verification of an individual utility; and/or

b) a trench excavation for the verification of multiple utilities.

NOTE 1 The verification measurements should only be attributed to the utility at the exact point of excavation. Further test holes might be required along the same utility route.

NOTE 2 Verification might not be achievable at all locations within a survey area due to ground conditions or construction methods.

NOTE 3 The thrust block should not be disturbed, e.g. no vacuum or hand excavation behind or around the thrust block.

NOTE 4 Suitable safe systems of work should be planned and applied, including consideration of the installation of shoring equipment or stepped battered excavations when site conditions warrant it.

9.2.4 The location of the utility to be excavated shall be determined by:

a) utility detection; and/or

b) on-site utility features obtained through site reconnaissance; and/or

c) utility records.

*NOTE Excavation verification work should be undertaken using utility detection data [**9.2.4** a)] undertaken in accordance with this PAS. However, it can be undertaken using data from site reconnaissance [**9.2.4** b)] or a desktop utility records search [**9.2.4** c)].*

9.2.5 The information gathered once the utility has been exposed shall include as a minimum, depth from top of utility to a reference point installed on the surface level.

NOTE 1 Where safe working practices allow, the information gathered should also include:

a) nature of utility (i.e. pipe, cable or other);

b) configuration of multiple utility layout;

c) diameter of utility (external diameter only);

d) material type;

e) backfill materials used;

f) observation of the condition of utility;

g) prevailing ground conditions;

Attention is drawn to HSE's Avoiding danger from underground services *(HSG47) [3] and in particular to guidance on confined space entry.*

NOTE 2 Where information on subsurface ground conditions (i.e. soil/rock type) is requested, it should be in accordance with BS EN ISO 14688-1 and BS EN ISO 14689-1.

10 Location

10.1 General

10.1.1 A location survey shall comprise a topographic survey to:

a) locate topographic features to provide new mapping and/or to validate the utility data obtained through the survey type D or C; and/or

b) locate the utility data obtained through a survey type B; and/or

c) locate the utility data obtained through a survey type A; and/or

d) locate GPR and EML transects.

***NOTE** Location points identified through detection or verification should be given absolute coordinates based on a national grid and datum (e.g. OSGB36 or Irish Grid).*

10.1.2 All topographic detail and utility location points identified via detection or verification shall be located by geospatial surveying techniques to an accuracy of ±50 mm horizontally and ±25 mm vertically, using a total station and/or real-time kinematic (RTK) global navigation satellite system (GNSS) equipment.

***NOTE 1** The horizontal and vertical accuracies specified are equivalent to survey detail accuracy band F or 1:200 legacy output scale as defined in RICS,* Measured surveys of land, buildings and utilities 3rd edition specification and guidance note 2014 *[6]* [1].

***NOTE 2** Examples of topographic detail that might be needed to be located include buildings, kerbs, vegetation, walls, manhole covers, inspection covers, valve covers, cabinets and traffic signals. For further guidance see RICS,* Measured surveys of land, buildings and utilities 3rd edition specification and guidance note 2014 *[6]* [1].

10.1.3 All survey points located shall be referenced to a framework of survey control. The survey control shall be established using GNSS and/or via a total station traverse between survey control points.

10.1.4 Where the framework of survey control uses a local site grid, the local site grid shall be referenced to a national grid and datum (e.g. OSGB36 or Irish Grid).

***NOTE** The practitioner should consider if the type of location and data capture being used is appropriate to the deliverable data required. For example, GIS systems dictate that certain attributes are captured in order to provide full functionality of metadata.*

10.1.5 Where the use of geospatial surveying instruments is restricted due to insufficient satellite signals or obstruction to line of sight, measuring tapes or electronic distance measuring tools shall be used for infill surveys.

***NOTE 1** The most accurate practical methods of positioning should always be chosen.*

***NOTE 2** Infill surveys apply to small areas only, usually ≤100 m^2.*

***NOTE 3** For further requirements and guidance on the use of measuring tapes and electronic distance measuring tools, see **10.3**.*

10.1.6 Three-dimensional coordinates shall be recorded for all identified utility location points. Where no depth or an uncertain depth reading is obtained, a null level shall be recorded.

10.2 Total station and global navigation satellite systems (GNSS)

10.2.1 The total station or GNSS system shall be used in accordance with the manufacturers' instructions, procedures, calibration and any instrument or process limitations.

10.2.2 All survey points shall be either:

a) stored digitally within the total station or GNSS system as coded detail points for post-processing; or

b) plotted directly onto digital drawings on-site using a precision mobile system for data collection.

[1] In preparation.

10.2.3 The survey detail pole shall be held vertically above the point being surveyed by reference to a plate bubble attached to the pole.

10.2.4 The GNSS system shall be configured to work with either available GNSS correction services or a base and rover system with a post-processed base position.

10.2.5 When using GNSS as a data collection method, this shall be used in accordance with RICS guidance, *Guidelines for the use of GNSS in land surveying and mapping* [NR2].

10.3 Measuring tapes and electronic distance measuring tools

*NOTE 1 The use of measuring tapes and electronic distance measuring tools to accurately depict positions of utilities is not recommended and should only be used for infill areas (see **10.1.5**). This is due to the lower accuracy levels and systematic errors of the process versus the accuracy levels that a dedicated survey instrument delivers.*

NOTE 2 Relative surveying techniques reference a utility by offset measurements from a permanent physical feature identified on a map (such as a kerb or wall). This technique is susceptible to a number of different types of errors including:

- *poor and inaccurate tape measurement due to factors such as slope, distance, temperature and equipment;*
- *movement, realignment or dismantling of the physical feature the utility is referenced from making it inaccurate (and sometimes impossible) to re-establish the location of the utility;*
- *scaling and/or transcription errors when plotting and/or locating the utility from the physical feature it was referenced from.*

10.3.1 Measuring tapes and electronic distance measuring tools shall not be used to position a utility for distances ≥30 m or ground sloping at a gradient of ≥10%. Where using such equipment, minimal gradient measurements or slope measurements shall be adjusted to the horizontal.

NOTE The use of measuring tapes and electronic distance measuring tools do not meet the accuracy requirements of QL-B1 (see Table 1).

10.3.2 Where offset measurements are used, the offset distance shall not exceed 10 m or 1/3 of the length of the baseline whichever is the least.

10.3.3 For utility location points that are >10 m from the baseline, trilateration shall be from three hard points of detail identified on the topographic base map.

10.3.4 Measurements shall be taken to two decimal places of a metre. Baselines shall be checked and scaled for relative length between two known hard points of detail shown on the topographic base map.

10.4 Survey/mapping accuracies

NOTE GNSS/total station combined with Ordnance Survey base mapping can provide high level relative accuracy but not necessarily absolute accuracy.
If Ordnance Survey base mapping is increased in production scale above its base scale (1:1 250 or 1:2 500) the relative accuracy of mapped features might diminish.

10.4.1 Where existing base mapping data are used, checks shall be undertaken on-site to demonstrate the location accuracy of the base mapping provided. These checks shall include as a minimum:

a) visual checks that features on-site are represented on the drawings provided (known as currency);
b) dimensional checks of site features against those shown at scale on the drawings provided to ensure the correct scale is used when plotting points;
c) instrumental checks to demonstrate the accuracy of the survey control.

NOTE 1 Outdated or inaccurate topographic data do not necessarily prevent the practitioner from completing the utility detection/verification and location using either total station or GNSS to obtain an absolute geospatial location, as recorded location data may be incorporated into an updated topographical survey at a later date. Relative positioning should not be undertaken by tape measurements, using inaccurate, incomplete plans containing insufficient important topographical features, as this might lead to irreconcilable and/or intolerable inaccuracies in the deliverables.

NOTE 2 Ordnance Survey base mapping provides topographical representation covering the whole of Great Britain. It is surveyed and reproduced to tolerances appropriate to the scales of 1:1 250 for urban areas 1:2 500 for rural areas and 1:10 000 for mountains and moorlands which might deliver a base framework for some utility surveys and asset records.

Ordnance Survey base mapping data does not contain sufficient street furniture or ground levels for a full utility survey. In its base form, it is suitable for the depiction of survey type D utility data. It can be rendered suitable for the depiction of survey type A, B *or C utility data if appropriate topographical metadata are attached to the underlying data features.*

***NOTE 3** The inherent accuracy of Ordnance Survey base mapping should be assessed before use.*

***NOTE 4** Table 4 shows the expected relative accuracy for topographic features within each scale category of Ordnance Survey data. The values apply up to the stated maximum measured distances quoted in Table 4.*

10.4.2 Use of supplied base plan survey data shall be reflected in the title block of the deliverable.

Table 4 – Relative accuracy of map data (informative)

Scale and method of original survey		Expected relative accuracy at differing confidence levels m			Maximum measured distance m
		68%	95%	99%	
1:1 250 scale	Maps surveyed at 1:1 250 scale using instrumental methods to provide a framework of controlling detail	±0.4	±0.8	±1.0	60.0
1:2 500 scale resurvey/ reformed	Maps surveyed at 1:2 500 scale using instrumental methods to provide a framework of controlling detail	±0.9	±1.8	±2.3	100.0
1:2 500 scale overhaul	Maps originally recompiled from pre-1946 County Series mapping	±1.2	±2.3	±3.0	200.0
1:10 000 scale	Maps surveyed at 1:10 000 scale using instrumental methods to provide a framework of controlling detail	±3.5	±6.7	±8.8	500.0
SOURCE: Ordnance Survey, http://www.boundary-problems.co.uk/boundary-problems/osmaps.html.					

11 Deliverables

NOTE 1 Deliverables provide the client with an understanding of the survey accuracy/confidence levels, methodologies used together with any cautionary advice notes/limitations.

NOTE 2 Survey data can be presented in a variety of outputs, such as CAD, GIS or BIM file formats, and/or in other project specific deliverable. The practitioner should agree with the client the format and media for file transfer.

11.1 Report

NOTE 1 The addition of a report affords the opportunity to outline the survey methods used and the success or otherwise that the survey has been able to achieve. It allows the practitioner to define areas of conflict and areas where further survey work or verification might be needed.

NOTE 2 The format for presenting this information may be textual (tabular or otherwise), photographic, planimetric, or graphic.

NOTE 3 A report can consist of a separate document or can be featured within CAD/GIS/BIM deliverables.

A report shall be produced and, as a minimum, contain the following:

a) a description of the survey project requirements and defined survey area;

b) a list of the detection methodologies used during the survey;

c) survey outcomes including:

   1) planimetric information (see **11.2**);

   2) metadata (see **11.3**);

   3) a description of how successful each detection methodology proved to be and a plan showing any areas where these detection methodologies were not successful;

   4) a list of any utilities that would have been expected to be present that were not detectable using these detection methodologies;

   5) a list of buried features and obstructions other than utilities detected during the execution of the survey (see **11.5**);

   6) plans showing all areas of conflict between record information, site information and detected utilities;

   NOTE Photographs should be provided, where available.

   7) for a verification survey, the verification deliverable (see **11.6**);

   8) recommendations for any further survey work provided during the execution of the works.

11.2 Planimetric information

11.2.1 The planimetric information shall be in the form of one or a combination of CAD drawing, GIS or BIM model as agreed with the client.

11.2.2 Where the client does not prescribe a format for the deliverable, the output shall be in a 2D or 3D drawing in both its native digital form and as a paper drawing.

NOTE The drawing can be derived from a CAD, GIS or BIM environment.

11.2.3 Where the client does not prescribe a specific layer/model naming convention, line style and line weight, the CAD/GIS/BIM drawing layers, model names and colour coding shall be in accordance with TSA's *The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey* [NR1].

11.2.4 Metadata and any attribute data obtained shall be associated with its related CAD/GIS/BIM objects.

NOTE It is important that the same layers, colours and line weights are featured, irrespective of practitioner. This assists the client in becoming familiar with the conventions of this PAS.

11.2.5 Where abbreviations are used, the abbreviations shall be in accordance with TSA's *The essential guide to utility surveys – Detailed guidance notes for specifying a utility survey* [NR1].

11.2.6 A BIM deliverable shall be in accordance with the employer's information requirements (EIR) and the BIM execution plan (BEP) as specified in PAS 1192-2:2013, **5.3** and **7.2** respectively.

11.3 Metadata and attribute data

Metadata shall be provided as part of the deliverables with the following recorded as a minimum:

a) the date the information was obtained or where information is taken from records, the date shown on the record drawing;

b) utility type;

c) quality level of the utility segment in accordance with Table 1 (QL-A, QL-B1, QL-B1P, QL-B2, QL-B2P, QL-B3, QL-B3P, QL-B4, QL-C or QL-D);

d) detection method in accordance with Table 2 (M1, M1P, M2, M2P, M3, M3P, M4 or M4P).

NOTE 1 *In addition to the above metadata, attribute data at each utility location point may include the following:*

a) utility owner;

b) electricity cables: depth (top of utility), low/high voltage;

c) communication cables: depth (top of utility), conventional cable/fibre optic;

d) gas: depth (top of utility), material, pressure (high pressure = HP, intermediate pressure = IP, medium pressure = MP, low pressure = LP);

e) water: depth (top of utility), material, diameter;

f) drainage pipes: depth to invert, use, material, internal dimensions (nominal);

g) manholes: depth to inverts, material, manhole chamber size, shaft size, shaft length, depth to landing stages, use [e.g. foul water (FW), storm water (SW) or combined water (CW)], cover size, cover weight (heavy, medium, light), cover shape, cover level, manhole internal schematic (sketch), coordinates of centre of cover;

h) inspection chambers: inspection chamber depth, number of ducts on each face of the inspection chamber, size of each duct, number of services in each duct, depth to crown of each duct;

i) oil pipelines: depth (top of utility), pressure, size, diameter.

NOTE 2 *For further information on metadata, see metadata standards such as UK GEMINI 2 [7] and BS EN ISO 19115 (series).*

11.4 Unknown utilities

Any utility discovered that is unidentified during the execution of any of the survey types shall be marked as "unknown utility" in the deliverables.

11.5 Buried features and obstructions other than utilities

Where buried features and obstructions other than utilities are detected during the execution of any of the survey types, these shall be noted and reported in the deliverables.

11.6 Verification deliverable

11.6.1 Visible information shall be obtained and recorded from physical sighting of the exposed utility.

11.6.2 The measurement results obtained from exposing the utility shall be recorded on a trial pit/slit trench data sheet. This shall include as a minimum:

a) utility type;

b) utility depth (top of utility);

c) relative measurements to local detail for the location of the excavation;

d) geospatial location of the utility;

e) digital photographs taken of the location, open excavation and utility(s) as exposed;

f) a description and location plan of the excavation.

NOTE *The following measurement results should also be obtained, where accessible:*

a) utility diameter (external);

b) utility material;

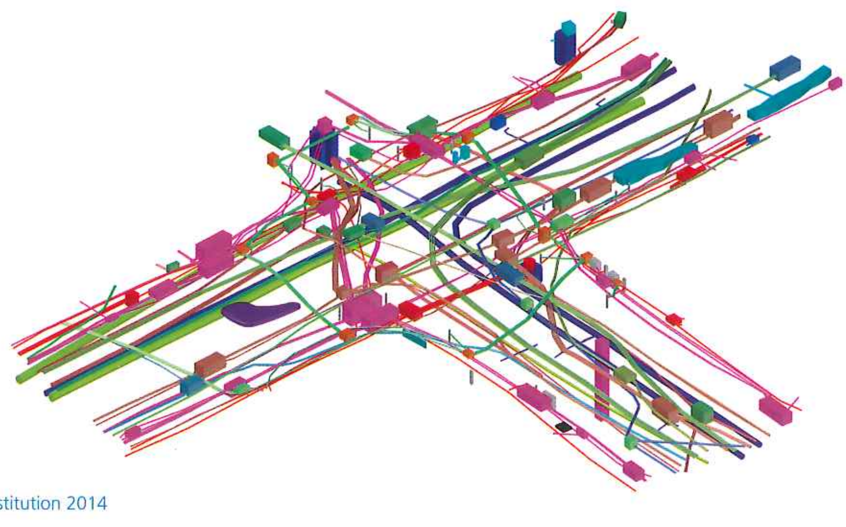
c) note of adjacent utility markers, warning tapes and protection tiles or shields;

d) any accompanying utility apparatus such as pilot cables next to HV cabling.

11.7 Retention of survey data/records

All recorded and processed data, site notes, metadata, and intermediate stage processing files shall be retained for a minimum of five years, and shall be made available to the client on request.

NOTE *A longer retention period may be required in the client's specification.*

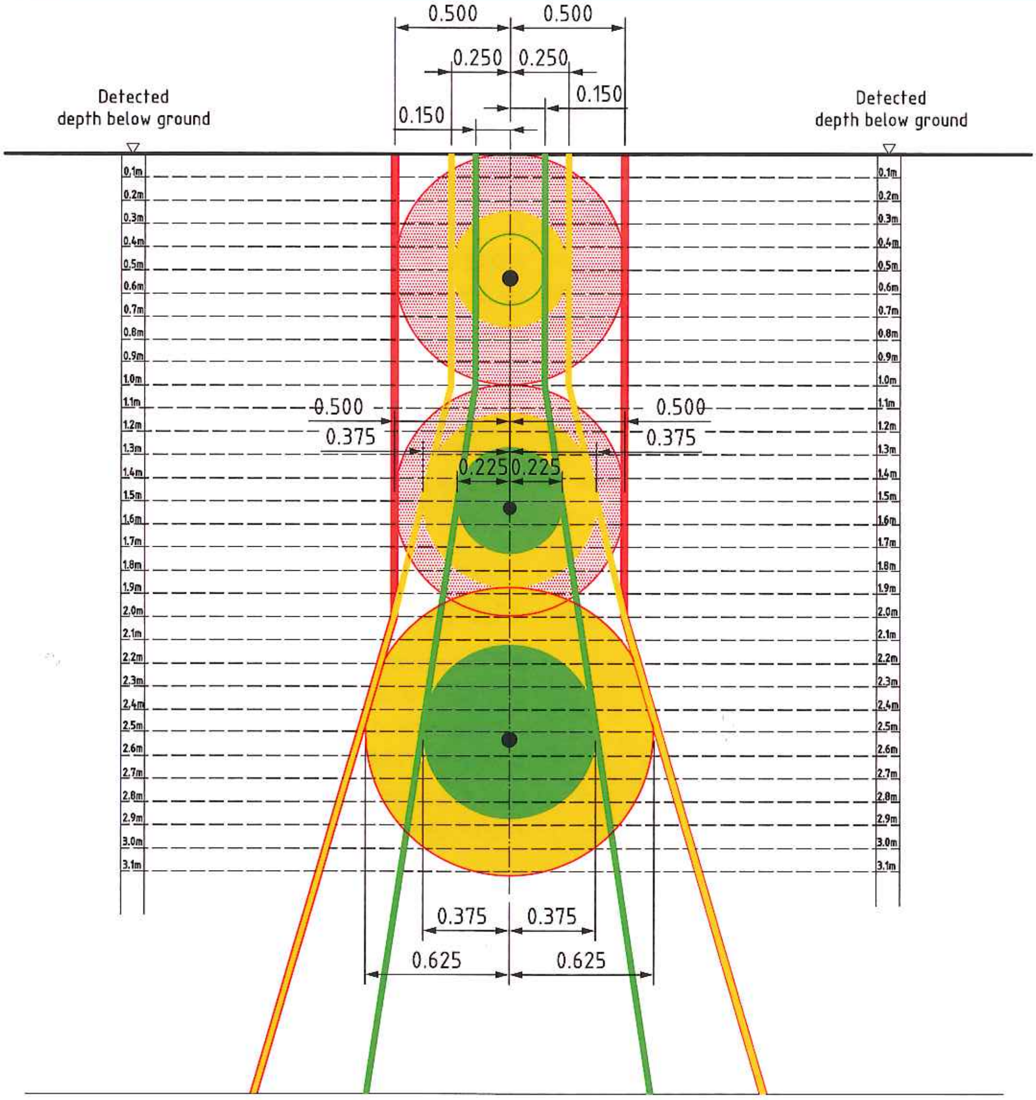


Annex A (informative) Accuracy

Figure A.1 illustrates the horizontal and vertical accuracies for QL-B1, QL-B1P, QL-B2, QL-B2P, QL-B3 and QL-B3P and how these are affected by depth. Each cone in the chart shows the envelope of expected accuracy. QL-B4 represents routes where detection was attempted but unsuccessful. Hence QL-B4 describes assumed routes and cannot be represented within the chart. The three sets of circles show examples of expected accuracies of detected utilities at 1.00 m, 1.50 m and 2.50 m deep.

Drainage invert levels are shown at manhole chambers with the manhole cover level. All other depths are shown to the top (crown) of the utility segment. Where the detection methods used detect depths to the centre or invert of the utility, these are adjusted by the practitioner to account for the variance.

Figure A.1 – Chart of horizontal and vertical accuracy for QL-B (informative)



Key

- Green: QL-B1 or QL-B1P, ±15% of depth or 0.15 m (whichever is greatest)
- Yellow: QL-B2 or QL-B2P, ±25% of depth or 0.25 m (whichever is greatest)
- Pink hatched: QL-B3 or QL-B3P, detection successful but no depth, horizontal ±0.50 m

***NOTE** The accuracy decreases beyond 2.00 m depth.*

- ● Utility with 63 mm diameter

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Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN ISO 14688-1, *Geotechnical investigation and testing – Identification and classification of soil – Part 1: Identification and description*

BS EN ISO 14689-1, *Geotechnical investigation and testing – Identification and classification of rock – Part 1: Identification and description*

BS EN ISO 19115 (series), *Geographic information – Metadata*

PAS 1192-2:2013, *Specification for information management for the capital/delivery phase of construction projects using building information modelling*

Other publications

[1] HEALTH AND SAFETY EXECUTIVE. Confined spaces – A brief guide to *working safely. INDG258. Sudbury: HSE Books, 2013.*

[2] GREAT BRITAIN. New Roads and Street Works Act 1991. London: The Stationery Office.

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[5] EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE. *Electromagnetic compatibility and Radio spectrum Matters (ERM); Code of Practice in respect of the control, use and application of Ground Probing Radar (GPR) and Wall Probing Radar (WPR) systems and equipment,* European Telecommunications Standards Institute, 2009.

[6] RICS GEOMATICS (MEASURED SURVEYS WORKING GROUP). *Measured surveys of land, buildings and utilities 3rd edition specification and guidance note 2014.* London: RICS, 2014.[2)]

[7] ASSOCIATION FOR GEOGRAPHIC INFORMATION. UK GEMINI, *Specification for discovering metadata for geospatial data resources.* v2.2. 2012, London: AGI, 2012.

Further reading

AS 5488, *Classification of subsurface utility engineering* [STANDARDS AUSTRALIA]

ASCE C-I 38-02, *Standard guideline for the collection and depiction of existing subsurface utility data* [AMERICAN SOCIETY OF CIVIL ENGINEERS]

BS 1192, *Collaborative production of architectural, engineering and construction information – Code of practice*

BS 5930, *Code of practice for site investigations*

BS 7000-4, *Design management systems – Part 4: Guide to managing design in construction*

BS 8541 (Parts 1-4), *Library objects for architecture, engineering and construction*

BS EN 50249, *Electromagnetic locators for buried pipes and cables – Performance and safety*

BS ISO 5500, *Asset management – Overview, principles and terminology*

BS ISO 55001, *Asset management – Management systems – Requirements*

BS ISO 55002, *Asset management – Guidelines for the application of ISO 55001*

HIGHWAY AUTHORITIES AND UTILITIES COMMITTEE. *Code of practice for recording underground apparatus.* HAUC(UK), 2002 [3)]

S250-11, *Mapping of underground utility infrastructure* [CANADIAN STANDARDS ASSOCIATION]

[2)] In preparation
[3)] Under revision

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