ATKINS

Locating Underground Drainage Apparatus - In Search of Best Practice

Final Report

Scottish Roads Research Board

14 March 2016

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1 Introduction

1.1. Background to Study

The Society of Chief Officers of Transportation in Scotland (SCOTS) has identified a need to review the current practice of locating and surveying underground drainage apparatus. The current methods used by the Scottish local authorities have limitations in terms of the accuracy of the survey results, and they are influenced by a number of factors, including, the ground conditions, pipe material and pipe depth. Where confidence cannot be instilled in the survey methods used to detect underground drainage apparatus, it is common for excavation works to be carried out. This consequently impacts on the road network causing deterioration and user delays.

Accordingly Atkins Limited was appointed by The Scottish Road Research Board to undertake research on behalf of SCOTS to determine best practice in the detection of underground drainage apparatus. This project seeks to review the existing technologies in this country and across the globe which are used to detect and survey underground drainage apparatus. This is to determine if any improvements can be made to the practices which Scottish local authorities currently use to detect and survey apparatus such as culverts, cundys and drains.

In addition this study has also examined methods of locating underground apparatus in other industries, such as the water and gas and petro-chemical fields to identify if there are methods in use in other industries or other countries which could be applied by Scottish local authorities so as to minimise the need to carry out excavations which both damage roads and delay travellers.

The project was set up in two stages:

- a research stage as described above; and
- a follow up stage involving field trials, if this was demonstrated to be necessary or useful.

Based on the findings of the research phase of the project the second stage is not considered necessary and is not being pursued.

1.2. Project Objectives

The objectives of this project are as follows:

- Identify improvements to current practices in the field of underground drainage detection;
- Improve journey transport times by reducing the requirement of excavations within the roads network;
- Extend the life of the road network by reducing the possible damage caused by excavation and reinstatement works;
- Improve health and safety by reducing the number of construction incidents which occur as a result of excavating within our road network; and
- Reduce financial costs to Scottish Roads community and the cost to the public caused by delays due to excavation works.

For full details of the project objectives please refer to the SRRB Research Project Proposal in Appendix A.

1.3. Industry Surveys

During the project and based on discussions with the sponsor and industry representatives we identified that it would be helpful to explore the use of various techniques and the level of knowledge and understanding of all parties. Accordingly it was agreed to undertake short online surveys amongst the SCOTS drainage community and contractors offering detection services.

1.4. Underground Drainage Detection Techniques

The following non-intrusive detective techniques were selected as being the most appropriate for investigation with respect underground drainage apparatus detection. There are many other technologies available. Please refer to PAS128[1] guidance for more information.

- **GPR- Ground Penetrating Radar-** a surface transmitter emits radar waves that can penetrate through ground materials, and these waves are reflected back to the instrument by a change of ground material or other buried objects. GPR in its simplest form only has real-time capability, with no ability to capture digital records. There are GPR systems where the data recorded are usually surveyed in grids and post-processed and interpreted off-site. This instils confidence in the data and accurate survey grids are established so that detected features found during post-processing and interpretation can be located on drawings. Digital records can be created with these systems.

- **EML- Electromagnetic Location-** this detects buried utilities via a hand-held receiver using radio frequency and electromagnetic signals that are present in metallic utilities as a result of current flow or re-transmitted low frequency radio signals (passive EML). Electrical signals can be induced at the ground surface from a transmitter, by direct connection from a signal generator or from a sonde or tracing wire introduced into a duct or pipe (active EML). Just like GPR, EML facilities are unable to record what was detected on-site so it relies on the person carrying out the survey marking the detected position and depth on the ground surface as the survey progresses. This has the advantage of providing quick result, however does not allow for any post-processing and retrospective interpretation of the result to be carried out and one of the major disadvantages is that no digital record is made. In turn this means that the information could be easily lost, and it is harder to share with Clients.

- **CCTV Camera Surveys**- camera survey which follows the course of the sewer and records the existing condition. A camera attached to a cable, is lowered down the manhole and enters the sewer/drain line. This can locate any blockages/ragging, or identify the internal condition of the drain or sewer.

- **Drain tracing dye-** used to demonstrate connectivity only for foul, surface water and combined drainage. This is only useful where an inlet and outlet are available and access to the pipe system is required to ‘see’ the dye.

- **Gyro Based Pipe Logging-** used for tracing the line of pipes where two access points allow the instrument to be deployed and recovered such as inverted siphons.

- **Electro Magnetic techniques –** such as **Magnetic Flux leakage is** used in tandem with a ‘pig’ which is normally inserted into the pipe in question for detecting subsurface features, in particular ferrous based and fired clayware pipelines. The pig normally travels along the pipeline and is used to detect and identify the metal loss defects such as corrosion and cracks on the interior of the pipe wall. Often used to obtain information over large areas (≥0.5 hectare). It is of limited use in urban and congested areas.

- **RFID Detection- Radio-frequency Identification-** helps to identify or locate the position of utilities by detecting pre-defined radio frequency resonances. Discrete low frequency RFID markers which come in the form of small electronic markers are placed in a trench, near to the pipe, or can be fixed to the pipe, during excavation. The tags can be programmed with specific pipe information e.g. pipe material/diameter/design flow information and then read later to confirm this basic data using a special locator. The locator ‘excites’ the RFID tag to respond with a defined frequency which is used to ‘read’ the tag and then confirms the asset details. This is essentially a tagging device which is used to locate utilities that have been previously tagged with an RFID tag. It is only relevant for tagged pipes to check their placement/pipe material/ diameter etc. against the asset record.

- **Vibration and Acoustic Techniques –** Acoustic techniques have been adopted in condition assessment of utilities as they can measure corrosion loss or determine the volume of debris in a pipe. The sonar technique is an exciting area of research which offers the user the possibility of constructing a sonar image which can be used to assess the pipe interior. In sonar surveys the time of the sound from the point of excitation, through transmission and reflection to the point that it is finally received is measured. The distance from the source point to the intended target can then be determined by the speed of the sound travelling through the medium, and a sonar image can then be constructed of the

[1] PAS: Publically Available Specification

pipe interior. Issues such as depth of water within the pipe have to be assessed separately because of the speed of sound in water and air is different. Vibro-acoustics is currently being researched as part of the Mapping the Underworld (MTU) project[2] with the aim of establishing a system as a standalone or part of the multi sensor device (this is discussed further in Section 2). It is being used as a comparative performance assessment between the outputs and the usefulness of geophones and scanning laser technology to detect the acoustic responses at the ground surface. It can be used to detect the horizontal position (and depth) of pipework where a vibration signal can be induced along the pipe.

1.5. Structure of this Report

This report includes the following:

- Findings from the Desktop Study- see Section 2;
- Surveys with Local Authorities and Survey Contractors – see Section 3; and
- Conclusions and Recommendations – see Section 4.

[2] See: http://www.mappingtheunderworld.ac.uk/

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2 Desktop Study

2.1. Introduction to Desktop Study

The primary aim of the desktop study was to review current methods for the detection of underground utilities (including underground drainage apparatus).The review looks at case studies which set an example of good practice in underground drainage apparatus detection. Atkins have also explored examples internationally, to broaden the focus of this study. In particular, current industry best practice has been examined to illustrate possible mechanisms for improvement in detecting underground drainage apparatus.

In order to successfully deliver appropriate information to the client, Atkins has used the specialist skills and in-depth personal knowledge of key personnel in order to ascertain all the relevant information on the detection of underground drainage apparatus. We have also utilised e-journals, contacted detection equipment manufacturers' and referred to relevant British Standards guidance. We have also consulted with our colleagues in other disciplines within the company, such as oil and gas, telecommunications and power, to establish their experience in underground apparatus detection.

The following sections summarise the finding of the desktop study and identifies areas which may require further research.

2.2. Industry Best Practice

When identifying improvements in current methods of detecting underground drainage apparatus, it is paramount to look at examples of industry best practice. When researching for best practice guidance on underground utility detection, it should be noted that Atkins sponsors research, recognising the need for the development of new process, procedures and techniques. Through one of our research programmes Atkins is a sponsor for the development of "PAS128:2014: Specification for underground utility detection, verification and location", a programme initiated and principally supported by the Institution of Civil Engineers (ICE).

Further research identified two related academic research projects:

- 'Mapping the Underworld'; and
- 'Assessing the Underworld'.

These are both funded by the Engineering and Physical Sciences Research Council (EPSRC).

PAS128, and the aforementioned research projects are summarised below.

2.2.1. PAS128 Document

PAS128 came into effect on 30th June 2014, therefore it is relatively new to the industry. It is sponsored by the Institution of Civil Engineers and facilitated by BSI Standards Limited, and published under license from the British Standards Institute. However it has not yet developed into a formal British Standard document at the time of the publication of this report. As Atkins helped fund the development of the PAS we currently use the document as guidance when carrying out any project within roads which will require location of existing underground assets.

Underground utility surveying is a niche element of civil engineering and the PAS128 process enables a specification to be rapidly developed in order to provide contractors and clients with a robust specification for their contracts requiring the location of underground utilities. Key reasoning behind the development of PAS128 was to improve levels of service, provide greater consistency of reporting and to raise client satisfaction with accurate utility data. This is required in order to reduce the disruption on the UK road network due to unnecessary excavations being required to detect surface water drainage and other services. PAS 128 can be likened to a risk management tool, which focuses on increased effort applied at the start of the project which reduces the risk (and often as a result the overall project cost) to clients and contractors on the project due to unforeseen utilities.

The PAS sets out a hierarchical approach to the detection of services and the following survey phases allows a client to manage the detection process and stop it at any stage depending on the findings of a particular survey type. The survey types are defined as follows:

- Survey Type D-Desktop Utility Record Search- utilities identified through collation of existing utility records. A desktop utility record search is a pre-requisite for all other survey types.
- Survey Type C- Site Reconnaissance- the existing records are supported and validated during a visual inspection during a site visit.
- Survey Type B- Detection- where underground utilities are detected by geophysical techniques. This method can conform to PAS without the need to conduct Survey Type A or C.
- Survey Type A- Verification- where underground utilities are observed and located at a manhole or inspection chamber, or are excavated and exposed.

The PAS hierarchical process clearly identifies excavation as a last resort which should only be adopted when other survey techniques have been exhausted. It treats the Desktop Utility Record Search as an essential element of any detection methodology. Whether the underground utilities are located by means of geophysical detection methods or by excavation, all records of existing underground assets must be examined and all new detections recorded. It should also be noted that when a conduit is found it is imperative that it is proved and that any blockages are eliminated. There are proven techniques for removing many blockages from conduits.

PAS also strongly recommends carrying out geophysical surveys on a project. To comply with the PAS a minimum of two detection methods must be adopted; e.g. Ground Penetrating Radar (GPR, the most commonly used technique) and Electromagnetic Location (EML) may be a suitable combination.

This report will discuss the advantages of using Survey Type B-Detection, and focus on the supporting techniques available to assess the underground cundies and drainage pipes without resorting to excavation methods

PAS128 Section 8 Note 1 states:

“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.”

It has to be recognised that since the PAS128 document is relatively new it may not have fully been disseminated through the industry. It is however expected that with time, further education and training, and experience in the application of the PAS, will lead to recognition of its benefits and more effective project planning and safer (and potentially less) utility related works being carried out on roads. In creating the PAS document, the development of guidelines and standards in other countries such as the USA, Canada and Australia has been taken into consideration. It has also been acknowledged that the different survey methods have varying levels of accuracy and certainty around the results, due in part to variable ground conditions. Verification through detection and excavation provides more accurate results than just carrying out a desktop utility record search. An increase in accuracy and confidence levels in results will require initial investments of finances and time, which the industry need to be willing to make in order for improvements to be made.

2.2.2. Mapping the Underworld

Mapping the Underworld[2] (MTU) is a research programme funded by the EPSRC (Engineering and Physical Science Research Council) which identifies problems associated with inaccurate detection of utilities, especially in urban areas with increasing traffic volumes. One of the aims of this project is to create a research tool which would have ‘x-ray specs’ and enable 3D-imaging of sub-surface utilities, without the need to excavate. The project started in 2005 with four individual research projects determining whether a multi-sensor location tool was feasible. This tool would map and position the utilities, collect the data and integrate it to yield a single repository for records, and radio frequency identification tags to assist in future pipe location. Currently the project builds on this research by looking to develop a multi-sensor device using ground penetrating radar (GPR), acoustic and electromagnetic technologies to locate all infrastructure in all ground conditions without the need to excavate. This multi-sensor device will employ surface-down as well as in-pipe capabilities with the aim to detect every sub-surface utility, which was commonly thought to be unachievable. This would provide major health and safety benefits and will also provide a more sustainable

approach to survey techniques. The creation of a multi-sensor device for the remote assessment and monitoring of sub-surface assets will lead to street works reducing and becoming more focused. In addition, road occupation will be minimised and road congestion levels reduced.

2.2.3. Assessing the Underworld

Assessing the Underworld[3] (ATU) is part of the same EPSRC funded research programme as MTU and is part of a 25-year vision to make street works more sustainable. It develops two existing MTU research themes which aim to locate, map in 3-D and record the position of underground services without excavation, using a single shared multi-sensor platform and to integrate this information with the utility company's records, in a single, unified database. This information can then be downloaded to a single repository to be used by Contractors and Clients alike.

The aim of this project is to undertake fundamental enabling research to create a prototype multi-sensor device to carry out condition assessment of buried utility service pipe/cables, road and pavement structures and ground conditions. This is done by combining novel geophysical approaches deployed from both ground surface and robotic devices that can be deployed in pipeline (for example water distribution pipe). The results of this work will combine the records of three infrastructures and sustainability assessment methods to inform engineers and other stakeholders on most effective approach when working on projects which involves searching for utilities in and beneath the streets.

The affiliated research includes:

- **Asset tagging (University of Oxford):** the aim is to provide a cheap and passive system to be incorporated into the pipe wall which will subsequently resonate when scanned using GPR. In the initial phase of this project a system of pipe-mounted passive tags was developed and tested at a Gaz De France test site in Paris, where they were proved to be effective. The current phase is trying to bring the project closer to commercial realisation. The main advantages of this research is that the system incorporates passive 'tags' in the pipe to enhance GPR detection as plastic pipes (potable water / gas) are particularly difficult to detect with current methods. There is a sister project running at Birmingham which is investigating micro-scale sensors that will provide additional information, not only location.

- **Identifying the position of buried pipes and cables in urban environment (University of Nottingham):** the aim is to investigate various novel surveying strategies to try to improve the ability to accurately position assets in the urban environment using the following methods: laser scanners; high sensitivity GPS receivers-GPS/total station data integrated/ integration of GPS with inertial sensors, use of ground based transmitters to augment satellite data/ potential to use multiple satellite constellations such as Europe's Galileo System, China's Compass and Russia's Glonass constellation along with GPS/integration of GPS and GPR data, and use of augmented reality in picturing location of asset.

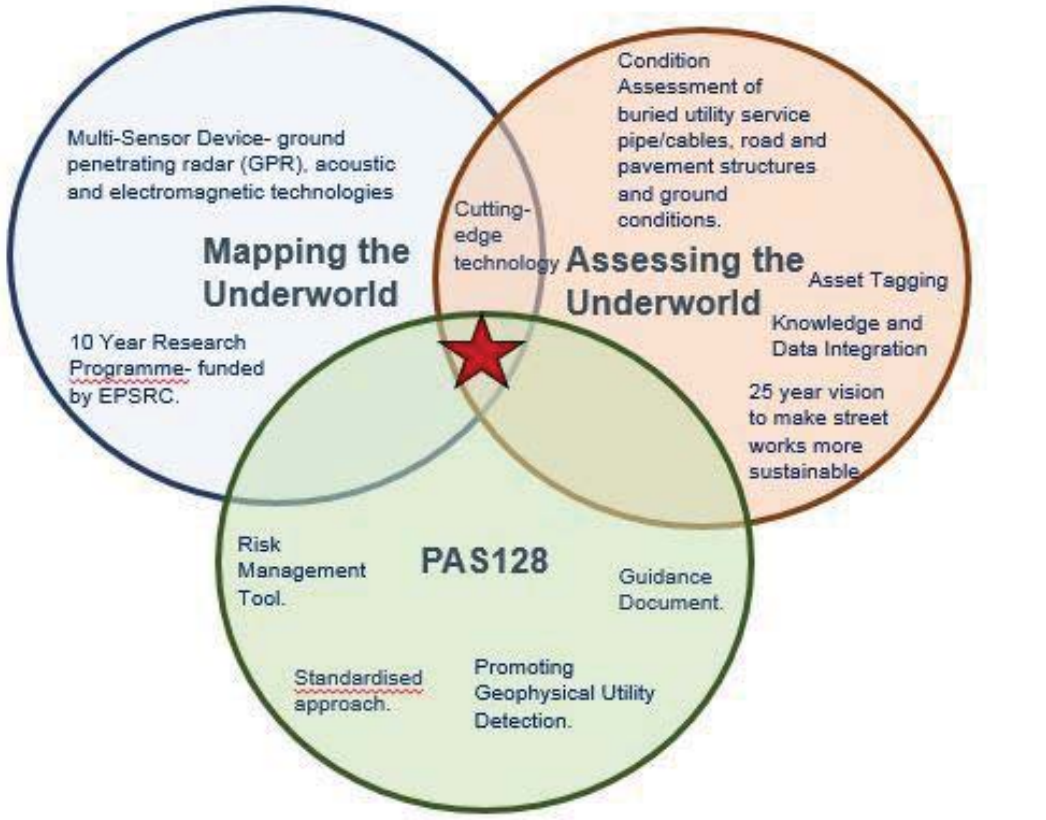
- **Knowledge / Data Integration and VISTA project (Universities of Leeds / Nottingham):** research is being undertaken into Knowledge and Data Integration (KDI, funded by the EPSRC) to unify the databases of utility companies so that they adopt a common way of recording data. VISTA is a follow-on project funded by the DTI, which aims to advance both KDI and the accuracy of positioning involving 20+ companies that make up a stakeholder community. The main purpose of VISTA is to bring together existing paper and electronic records along ground based and satellite surveys to produce a unified database.

[3] See: http://assessingtheunderworld.org/affiliated-research/

2.2.5. One Shared Vision

Atkins has concluded that PAS128, Mapping the Underworld (MTU) and Assessing the Underworld (ATU) all work in perfect harmony, and promote a common goal: reducing the number of excavations needed in the UK road networks and promoting best practice in the detection of underground utilities. By linking up the three initiatives to this common goal, we can create a shared vision and way forward. This is illustrated in Figure 2-1.

Figure 2-1 Shared Vision in Utility Managment and Detection



Recognised a need for change.

Sharing the Common Goal of reducing the number of excavations in the UK road networks.

Promoting excavation as a last resort.

Promoting excellence in the field of underground utility detection.

Improving health and safety for road users, and people carrying out the surveys.

2.3. Case Studies

In order to establish a set of examples of good practice in the field of underground drainage apparatus detection and suggest future improvements for the drainage detection industry, a variety of case studies were explored. These are described in more detail below.

2.3.1. UK - Atkins Case Study - Locating Watercourse Culverts

During the desktop research phase we utilised our internal knowledge sharing system and identified a project in which Atkins has successfully located existing underground assets, using a GIS (Geospatial Information System) analysis process. The following is description of the project[4].

As part of the wider duties placed on the council as a Lead Local Flood Authority (LLFA), under the Flood and Water Management Act (2012) Atkins was commissioned to undertake a desktop study to identify the potential location of highway culverts across the county in advance of asset survey works to confirm and assess condition. A prioritisation procedure was then developed to allow the survey works to target those areas at greatest perceived risk.

In essence, Atkins approach included locating watercourse culverts under roads for the authority by developing a desktop GIS analysis to identify potential sites and prioritise them based on various GIS background data sets. This helped the LLFA move from a very limited list of culverts to a county wide ranked list which they could then validate on site, confirm condition and take any remedial action required.

Data sources utilised comprised OS Mastermap, EA Designated River Network, road traffic / priority data, asset data and historical flooding registers. Locations of possible highway culverts were identified based on a GIS interrogation of the road and watercourse networks. Asset data provided by the council was then used to identify where watercourse crossings were known to be bridges. Drainage asset data was also identified and summarised.

Road network data, comprising a road centre-line with associated categorisation information, was also assigned to each watercourse crossing based on the points of intercept. The client had previously undertaken a risk assessment process associated with wet spots. Atkins matched the wet spot data to each watercourse crossing and the relative scores from this were assigned to the adjacent watercourse crossing where applicable.

Consequence of failure was assessed based on a qualitative points based rapid approach, where cumulative scores are used as the basis of the ranking process. Watercourse width was also used as a differentiator to reflect the higher levels of risk associated with a wider primary river over a smaller one.

In the absence of other data wet spot history was used as a differentiator for probability of failure. The risk score gave a prioritised ranking of potential culvert locations. This allowed the targeting of inspections and data collection to those assets which have been identified as at greatest risk of failure. Atkins subsequently undertook a mix of desktop and site based inspections to confirm the presence and condition of culverts, and allow updating of the asset register.

This example illustrates the first step in using PAS 128, i.e. a Survey Type D - Desk top Utility Record search to inform the Client of the location of various watercourse routes over a county wide area through the collation of existing utility records. A desktop utility Type D survey and record search is a pre-requisite for all other survey types.

2.3.2. UK - Heathrow Airport

The Heathrow Airport case study was highlighted in a paper[5] by John Robinson, Managing Director, Subscan Technology. This is an example of the successful dissemination of PAS128 and improved efficiency when undertaking work involving underground utilities.

At Heathrow Airport, there are particularly strict processes and procedures set for any work activity which involves underground utilities. These processes are filtered down to a preferred contractors' list, selected by

[4] The report is confidential to Atkins' client. It should be noted that the client was an English local authority and accordingly the legislative framework is different from that applying in Scotland.
[5] "PAS128:- Raising Standards in buried services surveying and the utility mapping sector", Geospatial Engineering, pp 34-37, Chartered Institution of Civil Engineering Surveyors, August 2015.

the airport. Since the launch of PAS128, the contractors now have a clear and concise national specification document to keep them on track. This is absolutely key to success in projects, and with increased education projects should run more smoothly, with less risk of striking underground utilities. The level of detail which is provided on this project far exceeds previous data and the end result yields fewer delays due to unexpected buried infrastructure and construction costs are easier to predict. The combination of:

- PAS128 specification document; and
- the introduction of Qualifications and Credit Framework (QCF) qualifications (NB: not applicable in Scotland)

raises standards among practioners and increases the confidence of the engineering community in the accuracy of the data. The principles of this project can be transferred to underground drainage detection projects.

The main lesson which can be gleaned from this project is that the application of PAS128 associated with encouraging the engineering community to raise the standards of their staff, through appropriate education, offers many advantages to clients; particularly increased confidence in the delivery of the project and improved accuracy of detecting buried services.

2.3.3. Malaysia - Underground Utility Mapping and its Challenges in Malaysia

This case study of good practice examples from Malaysia, is contained in the 'Underground Utility Mapping and Its Challenges in Malaysia' Paper[6] by Hasan Jamil, Zoher Nomanbhoy and Mohd Yunus Mohd Yusoff. In simple terms, this case study looks at the role of The Department of Survey and Mapping Malaysia (JUPEM) in driving forward changes in utility mapping industry. JUPEM have been given a mandate by the Government to collate underground utility data from various utility companies with the objective of maintaining a single repository that will serve as a centre for utility data. This along with a new surveying qualification from the Malaysian government established a data collection / collation source for all future data gathering.

2.3.4. Hong Kong - New Utility Survey Institute

This case study[7] exemplifying the introduction of a Code of Practice for the survey and management of utility services comes from Hong Kong. A disastrous Land slip in the Kwun Lung Lau area of Hong Kong in July 1994, caused by a leaking water main, focussed the attention of the authorities on the important issue of utility service management with particular emphasis on the inspection and maintenance of water carrying services affecting slopes. This Code of Practice was revised by various Government departments and two Hong Kong professional Institutions namely: the Hong Kong Institution of Engineers (HKIE) and the Hong Kong Institute of Utility Surveys (HKIUS). In early 2002 a set up meeting was arranged to discuss the issues within the utility survey industry with a view to standardising the different forms of utility survey and issues such as training, specification and report format. A new Professional Diploma in Utility Survey and Management was launched in September 2009, by the HKUIS Registered Training Organization called The Utility Training Institute while the Polytechnic University of Hong Kong launched a stream in Utility Survey and Management, within their B.Sc. (Hons) course in Geomatics. This example gives an in-sight into how other countries are advancing their knowledge of Utility Management by creation of professional bodies, codes of practice and the development of relevant qualification to raise standards among the engineering community.

2.3.5. USA Case Study - Detection of Buried Agricultural Drainage Pipe with Geophysical Methods

This study[8] provides a good comparison of the use of geophysical techniques to solve one of the more frustrating problems confronting farmers and land improvement contractors in the Midwest United States: the location of buried agricultural drainage pipes. This research was funded by the Ohio State University – Ohio Agricultural Research and Development Centre. The authors sought to review the efficiency of four conventional currently-used near-surface geophysical methods to locate buried agricultural drainage pipes:

[6] Proceedings of FIG Working Week 2012, Rome, Italy 6–10 May 2012, Paper 5636.
[7] Case Study published by the Hong Kong Institution of Engineers (HKIE) and the Hong Kong Institute of Utility Surveys (HKIUS) – 17 April 2015 (associated with a Memorandum of Understanding).
[8] Applied Engineering in Agriculture, Vol 20(3): pp 307 – 318, 2004

geomagnetic surveying; electromagnetic induction; resistivity and ground penetrating radar (GPR). In 11 test plots in the Midwest under a variety of soil texture conditions GPR was the method that proved most successful at detecting clay tile and corrugated plastic tubing drainage pipe down to depths of around 1 metre from surface. Over all eleven test plots on which GPR was tested, the average effectiveness was found to be 81% in terms of detecting the presence of and locating subsurface drainage pipe.

This case study also reported two preliminary surveys of the Ohio Chapter of the Land Improvement Contractors of America (OLICA) on their perceptions on current methods of locating underground agricultural drainage as well as perceptions of newer methods of locating underground agricultural drainage. With regard to existing methods of detection 52% of respondents indicated that they were “moderately to completely dissatisfied with the present methods of locating underground pipe” and 69% indicated that their businesses would experience economic benefit in having more effective and efficient methods of locating underground agricultural drainage. Considering newer methods of detection it was found that while OLICA contractors perceived GPR as an efficient method for underground drainage detection, they also highlighted cost barriers to employing the technique, only 17% percent of those surveyed felt they could afford to purchase GPR equipment and only 11% stated they could afford to periodically hire equipment for that purpose. This is a good example of the barriers to entry in using new techniques, even with an established need for them and with evidence that new methods (such as GPR) are preferable to the current status quo in the industry.

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3 Industry Surveys

3.1. Approach and Methodology

In order to ascertain the current practice in underground drainage detection and in order to identify potential improvements it was determined that we should undertake two surveys:

- A survey of members of SCOTS (i.e. Scottish roads authorities); and
- A survey of companies providing services to roads authorities, utilities and other organisations.

A variety of data gathering techniques were considered such as online questionnaires, emails, postal surveys and interviews. Due to a likely low response rate to email and postal surveys these were deemed to be unsuitable survey techniques. Interviews were thought to be the most effective means of data gathering, but would be time-consuming due to the large number of survey participants.

Therefore it was decided that the most effective method was the use of online questionnaires using “Survey Monkey” an online questionnaire tool. This was deemed to be the most effective method due to the large target audience and potential number of survey participants. Survey Monkey was utilised as it incorporates built-in data analysis tools which allow data collation to be completed quickly and effectively. Survey participants were also invited to provide their contact details and indicate if they were willing to be re-contacted, to enable further clarification to be sought where required.

3.2. Road Authority Survey

The survey was designed to identify current practice for underground drainage detection in roads authorities and to ascertain knowledge of past and ongoing improvements in the field of underground drainage detection. The questionnaire is included at Appendix B, Key points relating to the approach adopted include:

- Q1 and Q2 look to establish what techniques are most commonly used;
- Q3 and Q4 invited the participants to provide further information on any particular combination of technique and contractor they may have used which they found particularly effective;
- Q5 and Q6 examine the effectiveness and the accuracy of each technique in locating the presence of underground drainage apparatus;
- It was recognised that there were certain limitations to the different techniques and these were explored further in Q7 and Q8;
- Q9 and Q10 seek to understand the general attitude amongst road authorities to improvements achieved in underground drainage apparatus detection thus far and to potential improvements in the future. As highlighted in the desktop research, PAS128 document has been recently created to showcase industry best practice in underground utility detection; and
- Q11 aims to identify whether this has been effectively disseminated amongst roads authorities.

Once the questionnaire was finalised and agreed with the client an email was sent to the secretary of the SCOTS drainage group who in turn forwarded to representative of each roads authority. The email included a link to the online survey. The road authority representatives were invited to forward the survey to colleagues if they considered they could also contribute to the survey. A list of the road authorities and participants involved is provided in Appendix C.

3.3. Road Authority Survey Results

Responses were received from 17 Individuals employed by Roads Authorities. This was deemed to provide a representative cross section of views and experience and is thus sufficient for the purpose of analysis. The questionnaire responses are included in Appendix D. The information was collated and analysed in order to form the basis for the results presented below.

The results have been divided into the following sub-sections which follow the flow of the questions:

- Current practice in Local Authorities
- Perceived effectiveness and accuracy of the techniques
- Limitations of the techniques
- Attitudes to improvement in underground drainage detection
- Awareness of industry best practice.

It should be noted that as not all respondents answered all questions it is not possible to directly compare results between tables.

3.3.1. Current Practice

This section looks to identify current practice amongst roads authorities for detecting underground drainage apparatus.

Table 3-1 Q1-When undertaking drainage detection surveys, which of the following techniques do you use?

Technique	Frequently Use (%)	Occasionally Use (%)	Never Use (%)
CCTV Camera Survey	71	29	0
Acoustic Transmission	15	23	62
Drain Tracing Dye	81	19	0
Gyro Based Pipe Logging	0	8	92
Magnetometry	0	17	83
RFID Detection	0	25	75
Vibration Acoustic	0	17	83
Excavation	50	50	0
Other	0	33	67

Table 3-2 Q2- Who normally carries out these surveys

Technique	Don't Use (%)	"In house" resources (%)	A Specialist Surveying Contractor (%)	Other (%)
CCTV Camera Survey	0	12	82	6
Acoustic Transmission	57	14	29	0
Drain Tracing Dye	0	88	12	0
Gyro Based Pipe Logging	74	0	18	9
Magnetometry	83	0	8	8
RFID Detection	67	0	25	8
Vibration Acoustic	73	0	27	0
Excavation	0	59	29	12
Other	50	0	40	10

From Table 3-1 it can be concluded that CCTV, drain tracing dye and excavation are the most popular techniques of uncovering underground drainage apparatus. All respondents indicated they used excavation as a location technique with 50% of respondents saying they did so on a frequent basis. This suggests that roads authorities favour excavation as a technique and that they are likely to require encouragement or incentives to use other techniques in future.

Furthermore, it can be ascertained from Table 3-2 that the majority of roads authorities outsource their CCTV camera surveys, whilst carrying out their drain tracing dye and excavation in-house. Multiple respondents mentioned occurrence of blockages in drainage pipes which resulted in progression to excavation as the next step. It should be noted that techniques are available to remedy this problem such as using vacuum vactors which are specifically designed to clean the silt and debris from heavily silted sewers and cutters to remove tree roots, etc.

In the methods detailed in the answer options, only three respondents highlighted desktop study as one of the "other" methods that they employ to locate sub-surface drainage, with a further two using water divining techniques and one authority using GPR occasionally.

3.3.2. Perceived Effectiveness and Accuracy of the Techniques (Q3 and Q4)

This section moves on to examine the perceptions of the Local Authorities on the effectiveness of the techniques at detecting the presence of underground drainage apparatus, and also the accuracy of the output generated.

Table 3-3 Q3- Is there a particular combination of contractor and technique you find to be particularly effective?

Answer	Responses
Yes	11.76%
No	88.24%

It was found from Questions 3 and 4 that there was no particular combination of preferred Contractor or technique that was particularly effective for most respondents. In Question 4 we asked respondents to identify any particularly effective contractors / techniques. Of the respondents that indicated they had preferred combinations of contractors and techniques the technique best executed by these contractors was CCTV Camera Survey. The reason for the perceived efficiency was the experience / knowledge of the practitioner in conducting the survey. This suggests that appropriate training and knowledge of surveyors increases efficiency of non-excavation techniques, and the likelihood of Local Authorities in utilizing them.

Limitations of the Techniques (Q5 and Q6)

This sections identifies any limitations associated with the techniques.

Table 3-4 Q5 – On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique in identifying the presence of underground drainage apparatus?

Technique	Don't know (%)	1 – 3 (%)	4 – 6 (%)	7 – 10(%)
CCTV Camera Surveys	0	0	6	94
Acoustic Transmission Sounding	60	7	13	20
Drain tracing dye	0	6	35	59
Gyro Based Pipe Logging	77	15	0	8
Magnetometry	77	15	8	0
RFID Detection	64	14	14	7
Vibration Acoustic	79	7	7	7
Excavation	0	0	18	82
Other	50	0	33	17

Table 3-5 Q6 - On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus?

Technique	Don't know (%)	1 – 3 (%)	4 – 6 (%)	7 – 10(%)
CCTV Camera Surveys	0	0	18	82
Acoustic Transmission Sounding	60	7	13	20
Drain tracing dye	0	29	46	35
Gyro Based Pipe Logging	74	13	0	13
Magnetometry	72	14	7	7
RFID Detection	60	20	7	13
Vibration Acoustic	79	7	7	7
Excavation	0	12	12	76
Other	56	0	22	22

Most respondents indicated that their preferred techniques were CCTV; Dye tracing and Excavation which suggests that roads authorities have more experience in using these techniques for location of subsurface drainage apparatus. Respondents also rated accuracy of these techniques highly (7 – 10) indicating greater confidence in the quality of output from employing these methods. The least popular techniques in the responses were Acoustic Transmission sounding; Gyro based pipe logging and magnetometry which suggests that the LA's had little experience in some of the more 'technically challenging' methods of detection.

A few respondents also mentioned the higher cost of using newer techniques, as well as problems in acquiring those services from contractors due to procurement framework limitations. 2 respondents also indicated that other techniques were time-consuming compared to excavation, although not stated explicitly we assume this is most likely due to the need to post-process or interpret the output after the on-site survey.

3.3.3. Attitudes to Improvement (Q7 and Q8)

This section seeks to identify any trends in attitude towards the improvement of the way the Local Authorities detect underground drainage apparatus.

Table 3-6 Q7 – There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

Technique	Poor knowledge of how to use it (%)	Poor / out of condition equipment	Lack of confidence in output	Limited specification	Other
CCTV Camera Surveys	6	18	18	40	18
Acoustic Transmission	50	8	8	17	17
Drain tracing dye	7	0	33	47	13
Gyro Based Pipe Logging	70	0	10	10	10
Magnetometry	67	0	11	11	11
RFID Detection	55	0	27	9	9
Vibration Acoustic	64	0	9	18	9
Excavation	9	0	18	64	9
Other	20	0	0	60	20

The purpose of this question was to determine the factors which dissuade authorities from using more sophisticated techniques for underground utility detection. Most respondents rated "Limited specification" as the main limiting factor to effectiveness of techniques which were familiar to them. Techniques that the

majority of respondents did not use or used infrequently (as noted in questions 5 and 6) however were limited due to “poor knowledge of how to use it”. This identifies a need for improved education on the application of techniques and improved specification of equipment to encourage authorities to change to using to these methods in favour of excavation.

Again, time and speed of acquiring results from alternative techniques was mentioned by several respondents as a common limitation. In addition to this, ground conditions was mentioned by one respondent as a limiting factor for some techniques (such as GPR) which lead to outputs that are considered “useless”.

Question 8 asked about the main factors that limited effectiveness. There was a wide range of responses to this question with no discernible pattern.

3.3.4. View of How Practices Have and Can Improve Q9 and Q10

This section seeks to illustrate whether the roads authorities are aligned with industry best practice.

Table 3-7 Q9 – In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

Answer	Responses (%)
No	25
A little	50
A lot	25
Totally transformed	0

Table 3-8 Q10 – Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Answer	Responses (%)
Confident major improvements can be made	29
Confident that some improvements can be made	53
Have little confidence that improvements can be made	12
Do not think any improvements can be made	6

It was noted from this section that there was not a lot of optimism about the progress of underground drainage apparatus detection over the last 10 years with 75% of respondents seeing little or no improvement of drainage utility detection and 25% noting that there had been a lot of improvement. Whilst acknowledging that improvements had been made, the fact that so few held the view to the contrary suggests that majority of roads authorities are not keeping abreast with developments in technology and industry standards. However over 80% of respondents expressed the opinion that improvements could be made to the current status quo.

3.3.5. Awareness of Industry Best Practice Q11 and Q12

This section asks specifically about awareness of document PAS128:2014 which provides a standard basis for the use of more modern and less intrusive techniques. Respondents were asked if they were aware of PAS 128: 2014 – Specification for Underground Utility Detection, Verification and Location, the new document which sets the standard in utility detection.

Table 3-9 Q11 – Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

Answer	Responses (%)
I use it all the time	0
I use it occasionally	6
I have heard about it, but not used it	47
I have never heard of it	47

It was found that approximately 94% of Local Authority respondents had not used this Best Practice document and that nearly 50% did not even know of its existence. Only 6% had used it occasionally but no information was forthcoming on how effective the document was in helping the respondents to locate the underground drainage in a systematic way.

3.4. Survey Methodology (Contractors)

The survey questions were designed to understand current practices for underground utility detection amongst survey contractors and to illustrate industry best practice. The aim of the questionnaire is to investigate the experience of underground utility detection contractors. Secondly, it is intended to determine contractors' opinions on underground drainage detection apparatus. The structure adopted was:

- Q1 identifies usage of common industry techniques;
- Q2 and Q3 ascertains opinions on the efficiency and accuracy of these techniques;
- Q4 and Q5 focus on opinions on effectiveness and accuracy of underground drainage detection apparatus in particular;
- Q6 and Q7 seek to ascertain the attitude amongst survey contractors towards improvements made in detection of underground utilities and determining optimism with regard to future potential improvements;
- Q8 is intended to obtain the contractors understanding of the "Mapping the Underworld Project", which was identified as one of the Industry Best Practice Initiatives; and
- Q9 aims to identify whether there is a good spread of PAS128 accreditation in the industry.

The full Questionnaire, which was sent out to the Survey Contractors, is attached at Appendix E.

As we did not have a core group engaged, as in the case of roads authorities, we contacted a sample of contractors and asked them if they would participate. We then sent a link to the survey out to named contacts at six contractors who had indicated a willingness to participate. A list of survey participants is provided at Appendix F.

3.5. Survey Results and Discussion (Contractors)

Responses were received from representatives of 6 survey contractors. Whilst a small sample and not statistically robust it is sufficient to help understand how the "other side" of industry sees things. The questionnaire responses were downloaded from Survey Monkey and are included in Appendix G. The information was collated and analysed in order to form the basis for the results presented here.

All the data contained in this report is sourced from the questionnaire scripts and summarises the responses given. For additional clarification, full survey responses are appended in Appendix D.

The results section has been split up into the following sub-sections which follow the flow of the questions:

- Current practice in locating underground utilities by survey contractors
- Perceived effectiveness and accuracy of the techniques in locating any underground utilities
- Perceived effectiveness and accuracy of the techniques in locating underground drainage only
- Attitudes to improvement in underground utility detection
- Awareness of industry best practice.

It should be noted that as not all respondents answered all questions it is not possible to directly compare results between tables. Also given the differing business models adopted some services may not be offered for commercial or practical reasons; not because they are not requested or considered appropriate.

3.5.1. Current Practice

This section looks to determine current practice amongst contractors for detecting underground utilities. The tables below summarise the responses from Q1.

Table 3-10 Q1 – When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Technique	Frequently (%)	Occasionally (%)	Never (%)
Ground Penetrating Radar	66	17	17
Electromagnetic Location	100	0	0
CCTV Camera Surveys	34	33	33
Acoustic Transmission - sounding	60	20	20
Drain tracing dye	40	40	20
Gyro Based Pipe Logging	0	20	80
Magnetometry	0	25	75
RFID Detection	0	40	60
Vibration Acoustic	0	60	40
Excavation	17	33	50

From Table 3-10 it can be concluded that ground penetrating radar, electromagnetic location and acoustic transmission are the most common survey techniques for the underground utilities by survey companies. CCTV camera surveys and drain tracing dye also appear to be techniques used relatively frequently. Of the other techniques only vibration acoustic appears to be utilised to any meaningful extent. Assuming the companies that responded are typical this suggests that the mover to new techniques is slow, but we cannot tell from these responses if this is due to the companies not offering the service or there not being a market for them.

3.5.2. Perceived Effectiveness and Accuracy of Techniques with Regard to Underground Utilities in General

This section examines the perceptions of survey contractors as to the effectiveness of the techniques at detecting the presence of underground utilities, and also the accuracy of the techniques.

The perceived efficiency of these techniques by survey contractors is summarised Table 3-11. Survey companies rate ground penetrating radar, electromagnetic location, CCTV camera surveys and excavation as techniques with good efficiency (interpreted here as being a rating of 7 – 10). However it would seem that the contractors had little or no experience of gyro-based pipe logging, magnetometry, RFID detection and vibration acoustic. Presumably because these are services they do not offer. What we cannot tell is the reason for not offering these services.

Maybe it is not surprising, but the companies also rated the techniques which they offered and rated as effective, as having high levels of accuracy.

Table 3-11 Q2 – On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Technique	Don't know (%)	1-3 (%)	4-6 (%)	7-10 (%h)
Ground Penetrating Radar	0	17	17	66
Electromagnetic Location	0	0	0	100
CCTV Camera Surveys	17	0	0	83
Acoustic Transmission - sounding	20	0	40	40
Drain tracing dye	0	0	40	60
Gyro Based Pipe Logging	6	0	20	20
Magnetometry	60	0	20	20
RFID Detection	40	20	40	0
Vibration Acoustic	50	0	50	0
Excavation	17	0	0	83
Other	75	0	0	25

Table 3-12 On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities?

Technique	Don't know (%)	1-3 (%)	4-6 (%)	7-10 (%)
Ground Penetrating Radar	0	17	33	50
Electromagnetic Location	0	0	20	80
CCTV Camera Surveys	17	0	33	50
Acoustic Transmission - sounding	20	0	60	20
Drain tracing dye	0	0	60	40
Gyro Based Pipe Logging	60	0	20	20
Magnetometry	60	0	20	20
RFID Detection	60	0	40	0
Vibration Acoustic	40	0	60	0
Excavation	17	0	17	66
Other	50	0	25	25

3.5.3. Perceived Effectiveness and Accuracy of The Techniques with Regard to Underground Drainage

This section looked to examine the perceptions of the survey contractors on the effectiveness of the techniques at detecting the presence of specifically underground drainage apparatus, and also the accuracy of the techniques.

When examining detection techniques specific to locating underground drainage apparatus, it can be concluded from Table 3-13 that the techniques respondents felt were the most efficient were CCTV camera surveys, drain tracing dye and excavation. Techniques that were previously rated as efficient for locating underground utilities, namely Ground Penetrating Radar and Electromagnetic Location did not stand out as the most efficient methods for the detecting underground drainage apparatus.

The lack of knowledge, or experience of, the efficiency and accuracy of gyro based pipe logging, magnetometry, RFID detection and vibration acoustic as previously indicated was reinforced.

Table 3-13 Q4 – Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Technique	Don't know (%)	1-3 (%)	4-6 (%)	7-10 (%)
Ground Penetrating Radar	0	33	33	33
Electromagnetic Location	0	40	40	20
CCTV Camera Surveys	0	0	17	83
Acoustic Transmission - sounding	20	0	60	20
Drain tracing dye	0	0	40	60
Gyro Based Pipe Logging	60	0	0	40
Magnetometry	60	20	0	20
RFID Detection	40	20	20	20
Vibration Acoustic	60	0	20	20
Excavation	33	0	0	67
Other	50	0	0	50

Table 3-14 Q5 – Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 – 10 (1 being very poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

Technique	Don't know (%)	1-3 (%)	4-6 (%)	7-10 (%)
Ground Penetrating Radar	17	17	17	50
Electromagnetic Location	2	0	20	60.
CCTV Camera Surveys	17	0	0	83
Acoustic Transmission - sounding	40	0	60	0
Drain tracing dye	20	0	0	80
Gyro Based Pipe Logging	60	0	20	20
Magnetometry	60	0	20	20
RFID Detection	60	0	40	0
Vibration Acoustic	60	0	40	0
Excavation	17	0	17	67
Other	50	0	0	50

Surveying contractors rated Electromagnetic location, CCTV camera surveys, drain tracing dye and excavation as having good accuracy (60% or more of respondents rated 7 or higher), whilst ground penetrating radar had varying accuracy ratings. Some 50% of users rated it as having high accuracy rates for locating underground drainage, with the remaining respondents rating it lower in accuracy (or had no knowledge) suggesting that they believed it produced dubious results. This could be due to varying ground conditions that can affect Ground Penetrating Radar's signals during survey.

3.5.4. Attitudes to improvement of underground utility detection

This section seeks to identify any trends in attitude towards the improvement of the way the survey contractors detect underground utilities.

As illustrated in tables 3-15 and 3-16 all the respondents from survey contractors believed that there had been some improvement in the detection of underground utilities and that they were all reasonably optimistic that some level of further improvement could be made in the techniques used to detect underground utilities.

Table 3-15 Q6 – In your view has the detection of underground utilities significantly improved over the last 10 years?

Answer	Responses (%)
No	0
A little	50
A lot	33
Totally transformed	17

Table 3-16 Q7 – Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?

Answer	Responses (%)
Confident major improvements can be made	33
Confident that some improvements can be made	50
Have little confidence that improvements can be made	17
Do not think any improvements can be made	0

Half of respondents believed that the improvement in underground utility detected had been major (improved "a lot" or "totally transformed"). This suggests that a significant proportion of the industry are keeping abreast of changes in latest detection techniques and standards. It is also noted that over 80% of respondents were confident that "major improvements" or "some improvements" could be made in underground utility detection techniques indicates that the majority of survey contractors are aware of future developments in their field.

One respondent in particular justified his confidence in "major improvements" due to the development of a single device with multiple geophysical technique capability. This technique would allow for new, geo-referenced deliverables for clients, which indicates awareness of research conducted with "Mapping the Underworld" and "Assessing the Underworld" initiatives.

3.5.5. Awareness of industry best practice

This section seeks to illustrate whether the Survey Contractors are aligned with Industry Best Practice, specifically in their awareness of new industry best practice document called PAS 128: 2014 – Specification for Underground Utility Detection and of current industry-led research which aims to decrease excavations "Mapping the Underworld".

Table 3-17 Q8 – "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?

Answer	Responses (%)
Yes	50
No	50
Not Sure	0

Table 3-18 Q9 – Does your company comply with PAS128:2014 "Specification for Underground Utility Detection, Verification and Location?"

Answer	Responses (%)
All services are provided on the basis of PAS128:2014	67
We can meet the requirements of PAS128:2014, if requested by a client	0
Not at present but we are moving towards compliance with PAS128:2014	0
We are reviewing our status in respect of PAS128:2014	0
I am not aware of PAS128:2014	3
We have no plans to adopt PAS128:2014	0

As seen in Table 3-17, only half of the respondents were aware of the "Mapping the Underworld" industry-led research in non-excavation methods of detecting and mapping underground utilities. In contrast, two-thirds of the respondents (Table 3-18) were not only aware of industry best practice document PAS 128:2014, but were already providing services on the basis of PAS 128:2014. One respondent was a co-author of the document as well as a collaborator in the "Mapping the Underworld" initiative.

Respondents also indicated that training for survey staff for any new developments would be a key part of using new detection techniques and that work is still needed in professionalising the industry, despite the advances made with PAS 128:2014 in providing clear-cut specifications in detection of underground utilities and making survey contractors accountable.

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4 Conclusions and Recommendations

4.1. Conclusions

4.1.1. From Desktop Research

Below we present the conclusions of our desktop research:

- PAS128, Mapping the Underworld and Assessing the Underworld highlight industry best practice in underground utility detection and they all work towards the following goals, which fulfil the project objectives from Section 1.2:
  - Improve journey transport times by reducing the requirement of excavations within the roads network.
  - Extend the life of the transport network by reducing the possible damage caused by excavation and reinstatement works.
  - Improve health and safety by reducing the number of construction incidents which occur as a result of excavating within our road network.
  - Reduce financial costs to Scottish Roads community and the cost to the public caused by delays due to excavation works.
  -
- By educating the Roads Authorities in the use of PAS128 as a guidance document, it is possible to provide consistency and clarity to the approach of detecting, and recording the location of, their underground drainage apparatus.

- Congestion of the road network can also be avoided by utilising other approaches such as undertaking surveys which impact on the road network at quiet times, e.g. at night, coupled with Type D Desktop study. However this will need to be assessed taking into account other factors such as increased risk to operatives if working during the hours of darkness, provision of additional lighting, noise affecting neighbouring properties, etc.

- The case studies provide examples of the development of good utility survey management and also good practice in underground utility detection - from which common principles should be adopted.

- Creating a unified database for utility records which can be used by the whole of the engineering community would incentivise the setting of industry standards which would ensure better and more accurate survey results. This is being explored in the ATU VISTA project, where existing paper and electronic records are being brought together, alongside ground based and satellite surveys to produce a unified database. Also good examples of unified utility databases are set in the Malaysia Case Study and the Hong Kong Case Study.

4.1.2. From Roads Authority Surveys

The key points from the Roads Authority Survey are:

- Currently in Road Authorities the most common methods of detecting the underground drainage apparatus are through excavation, CCTV camera surveys and drain tracing dye.

- Excavation is an unfavourable method of detecting underground drainage apparatus since it has many disadvantages to the road network and its users. The reason for commonly using the excavation method seems to lie with the confidence the Road Authorities have towards its efficiency in detecting the presence of the apparatus and the also accuracy of the technique. Another reason brought up was that while CCTV is very effective for picking up the route of a cundy and its condition, the camera cannot always traverse the pipe because of blockages or pipe collapses leading to the need for excavation instead. Another reason could be that using excavation techniques can be more cost effective than procuring external specialist technology. However this is normally based on simply considering direct costs, and does not take into account the wider costs arising from network disruption, etc.

- Several Road Authority respondents also indicated that time-pressure led to the use of excavation as other techniques were deemed relatively time-consuming.

- The use of acoustic transmission-sounding, gyro based pipe logging, magnetometry, RFID, vibration acoustic and any other specified technologies is minimal. Road Authorities have little incentive to use other techniques due to lack of experience or knowledge of the efficiency and accuracy of the surveys and lack of familiarity with the output from these methods. Road Authorities are therefore more likely to use technologies that produce relatively quick results for little financial investment.

- Only 25% of the Road Authority survey participants think that the detection of underground drainage apparatus has significantly improved over the last 10 years. The remaining 75% think improvements have been even less.

- Looking ahead, 83% of the survey participants are optimistic that improvements can be made in the future. This indicates that survey participants are aware of upcoming developments in technology that would increase efficiency and accuracy of results, however many mentioned cost as being a barrier currently to techniques other than those already favoured by them.

- At present, only 6% of the Road Authority survey participants use the industry best practice for underground utility detection PAS128, the remaining 94% do not use it at present.

4.1.3. From Contractor Surveys

The key points from the Contractors Survey are:

- Currently the most common methods of detecting underground utilities, including drainage apparatus, are through ground penetrating radar, electromagnetic location, and CCTV camera surveys.

- It is unclear if the popularity of these techniques is due to current demand from clients or due to contractors advising clients as to the benefits of using such techniques instead of excavation due to their expertise in these alternative measures.

- There appears to be good experience in ground penetrating radar and electromagnetic location, as well as relative confidence in their efficiency and accuracy in locating underground utilities.

- 60% or more of respondents believed that drain tracing dye and CCTV camera surveys were efficient in surveying specifically for underground drainage apparatus, and that the results from these two methods in particular is accurate.

- Most survey contractors have also responded that excavation is a very efficient (83% of respondents) and accurate (56% of respondents) method of locating underground utilities, as well as 67% indicating that it is an efficient and accurate method of detecting underground drainage apparatus. However, we note that only 17% of survey contractors responded that they “frequently” used excavation as a technique in surveying for underground utilities.

- Survey contractors also noted that training and certification of competent survey staff for specialist techniques was more important than the technique used itself.

- The less popular methods for underground drainage as well as underground utility location were acoustic transmission, gyro based pipe logging, magnetometry, RFID detection and vibration acoustic. It is unclear if this is due to lack of demand from clients or due to relative inexperience of professionals in the industry in using these particular techniques.

- All respondents believed that there was some level of improvement in the detection of underground utilities in the last 10 years, and the majority of respondents (83.33%) had indicated that they were confident that some or major improvements could be made in the techniques currently used for underground utility detection. This indicates knowledge and awareness on the part of survey contractors of developments in technology and improved techniques that is currently in progress.

- Despite this, only half of respondents were aware of “Mapping the Underworld” research initiative.

- An encouraging 67% of survey contractors are already providing their services on the basis of PAS128:2014, with only 2 respondents indicating they were not aware of it.

4.1.4. Analysis

There is a strong relationship between the three best practice examples:

- PAS128:2014;
- Mapping the Underworld; and
- Assessing the Underworld.

In combination these create a compelling argument that learning from them is key to future improvements in the field of underground drainage detection. The Roads Authorities responses indicate that staff are not up to date in their knowledge of these developments.

This is reinforced by the fact that the techniques most used by survey companies such as GPR, EML and acoustic transmission are techniques in which their Roads Authority clients often lack specialist knowledge or equipment which may be necessary for post-processing and interpretation of output. The fact that these techniques are in wide use suggests that other industries (e.g. utilities) are ahead of the roads sector.

4.2. Recommendations

Based on our research we are able to make the following recommendations:

- Road Authorities need to develop more expertise on best practice in utility detection; become PAS128 accredited, and, become more aware of better ways of detecting underground drainage apparatus. This will be a short term investment, but a long term benefit.

- Road Authorities also need to educate themselves on the other aspects of drainage maintenance work in terms of cleaning blocked pipes using specially developed vacuum vactors for clearing out silt and other debris, using in-line repairs of cracked and broken pipes and opening up underground drainage systems on either side of the transport network.

- Road Authorities require to develop their staff via more training and awareness of the geophysical detection methods available on the market-such as GPR / EML and other processes.

- Road Authorities also require to ensure that their approved contractors include those who are capable and experienced in the full range of techniques and thus provide them with the level of service and expertise required for their particular needs. This may mean they are more expensive, but by reducing excavation and minimising disruption they can offer much better value.

- Excavation needs to be promoted as a last resort, not a first choice. This will need to be embedded into the culture of roads teams in order to fulfil the objectives of reduced road congestion.

- Road Authorities require to develop expertise in more sustainable and non-intrusive survey techniques, and put more emphasis on initial planning by using desk top studies. This may effect attitudes and improve optimism and motivation, to make a change in the current practice.

- Consider the development of a specialist ‘utility detection team’ within Road Authorities. Whilst this may not be feasible for individual authorities it could be done regionally or nationally (potentially through SCOTS) in order to take the burden off project engineers who may find it hard to keep up with developments in one specialist area.

- Such a team of specialists could create a knowledge sharing hub and promote best practice amongst Road Authorities.

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Appendices

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Appendix A. SRRB Research Project Proposal

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SCOTTISH ROAD RESEARCH BOARD

Research Project Proposal

Financial Year 2015-16

Project Title:		**Locating Underground Drainage Apparatus – In search of Best Practice**
Project Officer:	Name:	**David Molloy**
	Phone:	**01698 453615**
	Email:	**David.Molloy@southlanarkshire.gov.uk**
	Division:	**Flood Risk Management, South Lanarkshire Council**

PERCEIVED NEED:

Please indicate the status of the research

Is the project:

1. Of value and priority to the Scottish roads community? ☒
2. Investigating circumstances which are or may be different in Scotland from elsewhere in the UK? ☐
3. Supported by a sound business case? ☒

RESEARCH THEME:

Please indicate the general theme of the research

Geotechnical & Drainage Engineering	☒	Maintenance and Operation of Roads & Other Assets	☐
Design Standards, Specifications & Materials	☐	Traffic & Transportation	☐
Road and Transport Safety & Security	☐	Environment & Sustainability	☐
Bridges and Structures	☐		
Other (please describe):			

DELIVERY PRIORITY:

Please outline how the research aligns with the SRRB's delivery priorities (complete those that apply)

Better Journey Times, Better Reliability, Quality and Accessibility

This research aims to identify methods of working which could improve journey times by reducing the requirement of excavations within the transport network. The possible reduction in excavations would also help extend the life of our network by reducing possible damage associated with reinstatement works.

Low Carbon Technology & Infrastructure, Reduced Emissions

Complete as necessary…

Increased Safety, More Innovation

The use of more effective and efficient non-intrusive surveying and detection equipment may improve safety due to a reduced need to excavate within our transport network. This may lead to a reduction in construction incidents as there is a reduced need for plant and associated road works etc.

Continuously Improving Performance and Organisation

This research aims to identify the most effective and efficient method of locating underground drainage apparatus, and promote possible improvements to current practices. The reduction in excavations associated with more effective surveying can help reduce financial costs of projects and reduce disruption on the transport network.

RESEARCH OBJECTIVE:

Please describe CLEARLY the purpose of the research and how it aligns with the Scottish Government's strategic objectives::

Wealthier & Fairer	☐	Smarter	☒
Healthier	☐	Greener	☒
Safer & Stronger	☒		

TITLE: Locating Underground Drainage Apparatus – In search of Best Practice

This research is intended to review the current practices across the globe of locating and surveying underground drainage apparatus. The study will also look to alternative industries to review their methods of locating underground apparatus e.g. Gas and Petro-Chemical fields.

The current methods used by Scottish Local Authorities of locating underground apparatus have limited ability to provide accurate information and can be affected by various factors including ground conditions, pipe material and depth of pipe. Also the condition of the drainage apparatus can affect the progress of equipment through the conduit to undertake any form of survey and detection. Therefore it is a common occurrence where the survey or detection of the conduit cannot be progressed that the need for excavating is required.

The purpose of this research is therefore to review the existing technologies available to detect and survey underground drainage apparatus and determine if there are any improvements that can be made to how Scottish Local Authorities currently detect and survey underground drainage apparatus such as culverts, cundys and drains.

This research will consist of the following activities:

- Literature Review
- Field testing of current practices
- Interviews with industry professionals (Client, Contractor, Supplier and Manufacturer representatives).

The outputs from this research are listed below:

- Identification of current practices within Scottish LAs
- Identification of the available technology in this field
- Results of the completed field tests
- Collated views from the interviews of industry professionals
- Conclusions and Recommendations.

The costs associated with this research are as follows:

- Consultants to undertake literature review
- Staff time to undertake interview process
- Costs to hire equipment for field testing
- Staff time to prepare report.

(Note: a presentation to the research board detailing the value and purpose of the project may be required).

DISSEMINATION OF RESULTS:

How will the results of the research be disseminated?

Technical / Research Report	☒	Web Site	☐
APG	☐	DMRB / MCHW Standard / Contract Spec	☐
Code of Practice	☐	CD-ROM	☐
Conference (e.g. STAR / ETC / Road Expo)	☐		

Other: (please describe)

ESTIMATED COSTS & TIMESCALES:

Please provide an estimate of funding required and spend profile. Include indication of any match funding.

	Year 1	Year 2	Year 3		Timescale
1st Quarter	£10,000	£ if any	£ if any	**Develop Proposal**	April 2015
2nd Quarter	£10,000	£ if any	£ if any	**Contract Award**	June 2015
3rd Quarter	£5,000	£ if any	£ if any	**Start of Expenditure**	June 2015
4th Quarter	£5,000	£ if any	£ if any	**Expected Completion**	March 2016
Total	**£30,000**	£ if any	£ if any	**Reporting**	April 2016
Less any match funding from other sources…				**Publication**	Summer '16
Less	£ if any	£ if any	£ if any	*Provide details on separate page*	
Cash Bid	**£30,000**	**£ if any**	**£ if any**	*This is the cash bid sought from the Board*	

Note: *An allocation of research funding (in principle) is for one year only. If the project is to be carried out over several years, please indicate anticipated spend in remaining years (Years 2 & 3).*

APPROVED BY:

The bid should be approved by your Line Manager

Signature:	**Date:**
Robert Young (SCOTS)	*4th February 2015*

DISSEMINATION OF RESULTS:

How will the results of the research be disseminated?

Technical / Research Report	☒	Web Site	☐
APG	☐	DMRB / MCHW Standard / Contract Spec	☐
Code of Practice	☐	CD-ROM	☐
Conference (e.g. STAR / ETC / Road Expo)	☐		

Other: (please describe)

ESTIMATED COSTS & TIMESCALES:

Please provide an estimate of funding required and spend profile. Include indication of any match funding.

	Year 1	Year 2	Year 3		Timescale
1st Quarter	£10,000	£ if any	£ if any	**Develop Proposal**	April 2015
2nd Quarter	£10,000	£ if any	£ if any	**Contract Award**	June 2015
3rd Quarter	£5,000	£ if any	£ if any	**Start of Expenditure**	June 2015
4th Quarter	£5,000	£ if any	£ if any	**Expected Completion**	March 2016
Total	**£30,000**	£ if any	£ if any	**Reporting**	April 2016
Less any match funding from other sources…				**Publication**	Summer '16
Less	£ if any	£ if any	£ if any	*Provide details on separate page*	
Cash Bid	**£30,000**	**£ if any**	**£ if any**	*This is the cash bid sought from the Board*	

Note: *An allocation of research funding (in principle) is for one year only. If the project is to be carried out over several years, please indicate anticipated spend in remaining years (Years 2 & 3).*

APPROVED BY:

The bid should be approved by your Line Manager

Signature:	**Date:**
Robert Young (SCOTS)	*4th February 2015*

Appendix B. Road Authority Questionnaire

Research into Underground Drainage Detection Techniques

Survey of Local Authority Highway Drainage Specialists

Atkins Limited is undertaking research for the society of Chief Officers of Transportation in Scotland (SCOTS) to determine best practice in the detection of underground drainage apparatus. The aim is to identify if there are methods in use in other countries or other industries which could be applied in Scotland so as to minimise the need to carry out excavations which both damage roads and delay travellers.

To enable us to understand current knowledge and methods in use across local authorities in Scotland we would appreciate it if you could complete this short questionnaire.

Please feel free to pass this questionnaire on to colleagues in your authority or elsewhere who may be able to contribute to this research.

If you wish to discuss any aspect of this research please feel free to contact:
Sarah Munn (telephone: 0141 220 2191 or by email: Sarah.Munn@atkinsglobal.com)

Thank you.

Drainage survey technique typical uses:

- CCTV Camera Surveys: for locating blockages
- Acoustic Transmission (sounding): for demonstrating connectivity of open drains
- Drain tracing dye: demonstrating connectivity for foul, surface water or combined drainage
- Gyro Based Pipe Logging: tracing the line pipes where two points allow the instrument to be deployed and recovered such as inverted syphons
- Magnetometry: detecting subsurface features, in particular ferrous and fire clay pipelines. Often used to obtain information over a larger area
- RFID Detection: used to relocate utilities that have previously been tagged with a RFID device
- Vibration acoustic: used to detect horizontal position only of pipework, where a vibration signal can be sent along the pipes
- Excavation: used as last resort option when non-invasive techniques fail

1. When undertaking drainage detection surveys, which of the following techniques do you use?

Please tick all that are applicable.

	Frequently	Occasionally	Never
CCTV Camera Surveys	○	○	○
Acoustic Transmission - sounding	○	○	○
Drain tracing dye	○	○	○
Gyro Based Pipe Logging	○	○	○
Magnetometry	○	○	○
RFID Detection	○	○	○
Vibration Acoustic	○	○	○
Excavation	○	○	○
Other	○	○	○

Please list all other techniques you use for drainage detecton surveys.

2. Who normally carries out these surveys?

	Don't use	"In house" resources	A specialist surveying contractor	Other
CCTV Camera Surveys	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○
Drain tracing dye	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○
Magnetometry	○	○	○	○
RFID Detection	○	○	○	○
Vibration Acoustic	○	○	○	○
Excavation	○	○	○	○
Other techniques	○	○	○	○

Other (please specify)

3. Is there a particular combination of contractor and technique you find to be particularly effective?

○ Yes

○ No

4. If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.

Contractor & contact details

Technique

5. On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

	Don't know	1	2	3	4	5	6	7	8	9	10
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

6. On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

	Don't know	1	2	3	4	5	6	7	8	9	10
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

7. There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

	Poor knowledge of how to use it	Poor/out of condition equipment	Lack of confidence in output	Limited specification	Other
CCTV Camera Surveys	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○
Drain tracing dye	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○
Magnetometry	○	○	○	○	○
RFID Detection	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○
Excavation	○	○	○	○	○
Other techniques	○	○	○	○	○

Other (please specify)

8. In your experience, what is the most common limitation?

9. In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

- ○ No
- ○ A little
- ○ A lot
- ○ Totally transformed

Please provide reasons for your answer

10. Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

- ◯ Confident major improvements can be made
- ◯ Confident that some improvements can be made
- ◯ Have little confidence that improvements can be made
- ◯ Do not think any improvements can be made

Please provide reasons for your answer

11. Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

- ◯ I use it all the time
- ◯ I use it occasionally
- ◯ I have heard about it, but not used it
- ◯ I have never heard of it

12. Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

* 13. Finally, about you:

Name	
Authority	
Job Title	
In this role do you have a need to detect / survey drainage apparatus?	
Telephone	
Email address:	

* 14. Would you be happy to be contacted to provide further information?

Appendix C. Road Authority Survey Participants

Survey Participants - Local Authorities

ID Number	Respondant Name	Local Authority	Job Role	Do they use drainage location apparatus?	Available to contact?	Contact Email Address	Contact Number
1	Ian Daniels	Aberdeenshire Council	Principal Roads Engineer	Yes on occasion	No.	N/A	N/A
2	Raj Kumar	East Dunbartonshire Council	Flood Risk Engineer	Yes	No.	N/A	N/A
3	Claire Elliott	Stirling Council	Flood Co-ordinator	Yes	Yes	elliottc@stirling.gov.uk	01786 237636
4	Grant Whyte	Argyll and Bute Council	Technical Officer	Occasionally	Yes	grant.whyte@argyle-bute.gov.uk	01436 658868
5	Barry Scott	East Renfrewshire Council	Senior Engineer	Yes	Yes	barry.scott@eastrenfrewshire.gov.uk	0141-577-3468.
6	Graeme Hedger	West Lothian Council	Team Leader - Flood Risk Management	Yes	Yes	graeme.hedger@westlothian.gov.uk	01506 776926 / 07774479863
7	David Macpherson	East Ayrshire Council	Flooding Officer	Occasionally.	Yes	david.macpherson@ayrshireroadsalliance.org	Not given
8	Steven Miller	Orkney Islands Council	Civil Engineer	Yes	Yes	steven.miller@orkney.gov.uk	01856 873535
9	William Johnstor	Orkney Islands Council	Roads Ops Manager	Yes	No	N/A	N/A
10	Ian Young	Stirling Council	Team Leader Bridge nad Flood Maintenance	Yes	No	N/A	N/A
11	Stuart Cullen	Clackmannanshire Council	Principal Roads and Flooding	Yes	Yes	scullen@clacks.gov.uk	01259 452593
12	Mark Barbour	South Lanarkshire	Assistant Engineering Officer	Yes	No	N/A	N/A
13	Scott MacDonald	Sotuh Lanarkshire	Engineering Officer (Flooding)	Yes	Yes	scott.macdonald@southlanarkshire.gov.uk	01698 455206
14	David Molloy	South Lanarkshire	Flood Risk Management-Team Leader	Yes	Yes	david.molloy@southlanarkshire.gov.uk	01698 453615

ID Number	Respondant Name	Local Authority	Job Role	Do they use drainage location apparatus?	Available to contact?	Contact Email Address	Contact Number
15	Robert Falconer	South Lanarkshire	Assistant Engineering Officer	Yes	No	N/A	N/A
16	Jim Logan	South Lanarkshire	Engineering Officer	Yes	No	N/A	N/A
17	David Beaton	South Lanarkshire	Engineering Officer	Yes	Yes	david.beaton@southlanarkshire.gov.uk	01698 453687

Notes:

1 Respondents highlighted in yellow gave particaulrly insighful responses and are recommneded for follow up activities.

2 Respondent 14 was the SCOTS lead for the project.

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Appendix D. Road Authority Survey Responses

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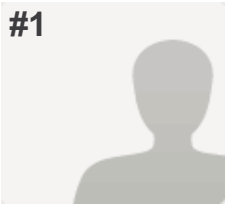

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PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Frequently
Other	Never

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Other techniques	Don't use

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	Don't know
Drain tracing dye	7
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	Don't know

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	6
Acoustic Transmission - sounding	Don't know
Drain tracing dye	5
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	Don't know

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Other
Drain tracing dye	Limited specification
Gyro Based Pipe Logging	Other
Magnetometry	Other
RFID Detection	Other
Vibration Acoustic	Other
Other techniques	Other

Q8: In your experience, what is the most common limitation?

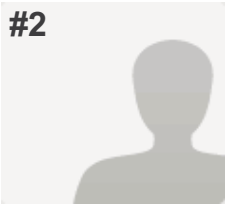
Lack of local knowledge.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	No, Please provide reasons for your answer Perhaps a lack of trying new techniques
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident major improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q13: Finally, about you:

Name	Ian Daniels
Authority	Aberdeenshire Council
Job Title	Principal Roads Engineer
In this role do you have a need to detect / survey drainage apparatus?	Yes on occasion
Telephone	01358 726416
Email address:	ian.daniels@aberdeenshire.gov.uk

Q14: Would you be happy to be contacted to provide further information?	No



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PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	A specialist surveying contractor
Drain tracing dye	A specialist surveying contractor
Gyro Based Pipe Logging	A specialist surveying contractor
Magnetometry	A specialist surveying contractor
RFID Detection	A specialist surveying contractor
Vibration Acoustic	A specialist surveying contractor
Excavation	A specialist surveying contractor
Other techniques	A specialist surveying contractor

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	7
Magnetometry	5
RFID Detection	5
Vibration Acoustic	Don't know
Excavation	8

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	5
RFID Detection	5
Vibration Acoustic	Don't know
Excavation	7

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Limited specification
Drain tracing dye	Limited specification
Gyro Based Pipe Logging	Limited specification
Magnetometry	Limited specification
RFID Detection	Limited specification
Vibration Acoustic	Limited specification
Excavation	Limited specification
Other techniques	Limited specification

Q8: In your experience, what is the most common limitation?

Access

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A little
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Do not think any improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it

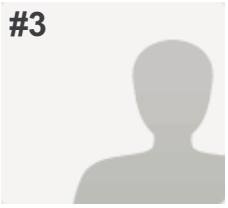
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

No

Q13: Finally, about you:

Name	Raj Kumar
Authority	East Dunbartonshire Council
Job Title	Flood Risk Engineer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	0141 578 8612
Email address:	raj.kumar@eastdunbarton.gov.uk

Q14: Would you be happy to be contacted to provide further information?	No



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PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Occasionally
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Occasionally
Vibration Acoustic	Occasionally
Excavation	Frequently
Other	Never

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	Other
Acoustic Transmission - sounding	A specialist surveying contractor
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	A specialist surveying contractor
Vibration Acoustic	A specialist surveying contractor
Excavation	"In house" resources
Other techniques	Don't use
Other (please specify)	we use both in -house equipment and contractors for CCTV work

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	5
Drain tracing dye	9
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	4
Vibration Acoustic	5
Excavation	9
Other techniques	Don't know

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	5
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	3
Vibration Acoustic	4
Excavation	9
Other techniques	Don't know

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Lack of confidence in output
Drain tracing dye	Limited specification
RFID Detection	Lack of confidence in output
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Limited specification

Q8: In your experience, what is the most common limitation?

Access, either lack of manholes, unfavourable ground conditions, downstream blockages etc making water level too deep to get any meaningful data.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A lot, Please provide reasons for your answer Equipment and practices have improved in my time in post (7years), longer cable lengths allowing for cameras to move further, more robust crawlers, bugs locations more accurate, depth to which bug is detectable has increased significantly (or technology more affordable as has become standard with most contractors to carry both types). Tracer dyes more effective and Env friendly.
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made , Please provide reasons for your answer Aware of new emerging techniques that will hopefully succeed where other methods have failed and excavation has had to take place.
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I use it occasionally

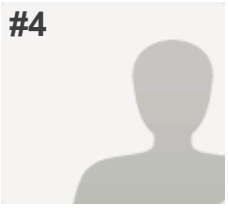
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Standard details for contruction on new drainage networks or standrad policy to make improvements where new development takes place in the vicinity of existing culverts. These should mean access is maintained in all circumstances including allowance for the physical size of vehicles such as vactors and be able to take the appropriate loading, having manholes at regular intervals no more than 70m apart would be sigificant step forward. We have spent significant sums of money locating culverts and installing access points to allow for survey and maintenance work.

Q13: Finally, about you:

Name	Claire Elliott
Authority	Stirling Council
Job Title	Flood Co-ordinator
In this role do you have a need to detect / survey drainage apparatus?	yes
Telephone	01786 237636
Email address:	elliottc@stirling.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes



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PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Frequently
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Frequently
Other	Never
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	"In house" resources
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Other
Magnetometry	Other
RFID Detection	Other
Excavation	"In house" resources
Other techniques	Other
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	8
Drain tracing dye	4
Excavation	9

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	6
Acoustic Transmission - sounding	8
Drain tracing dye	2
Gyro Based Pipe Logging	10
Magnetometry	10
RFID Detection	10
Excavation	9
Other techniques	10

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Poor knowledge of how to use it
Acoustic Transmission - sounding	Poor/out of condition equipment
Drain tracing dye	Lack of confidence in output

Q8: In your experience, what is the most common limitation?

Respondent skipped this question

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

A little,

Please provide reasons for your answer
CAT can be used to estimate depth

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Confident that some improvements can be made ,

Please provide reasons for your answer
Financial benefits will drive development

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

I have never heard of it

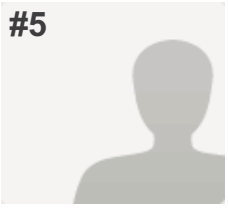
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Respondent skipped this question

Q13: Finally, about you:

Name	Grant Whyte
Authority	Argyll & Bute Council
Job Title	Technical Officer
In this role do you have a need to detect / survey drainage apparatus?	Occasionaly
Telephone	01436 658868
Email address:	grant.whyte@argyll-bute.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes



#5

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 10:18:30 AM
Last Modified: Thursday, September 17, 2015 10:23:11 AM
Time Spent: 00:04:41
IP Address: 212.219.247.151

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Never
Drain tracing dye	Occasionally
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Frequently

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Other techniques	Don't use

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	Don't know

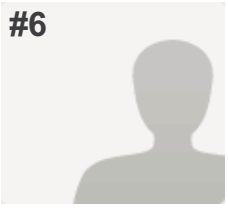
Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Limited specification
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Limited specification
Other techniques	Poor knowledge of how to use it

Q8: In your experience, what is the most common limitation?

Unknown obstructions and strucutres built on top of pipes.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A little, Please provide reasons for your answer More CCTV contractors around.
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	BARRY SCOTT
Authority	EAST RENFREWSHIRE COUNCIL
Job Title	SENIOR ENGINEER
In this role do you have a need to detect / survey drainage apparatus?	YES
Telephone	0141-577-3468.
Email address:	barry.scott@eastrenfrewshire.gov.uk
Q14: Would you be happy to be contacted to provide further information?	Yes



#6

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 10:15:59 AM
Last Modified: Thursday, September 17, 2015 10:27:52 AM
Time Spent: 00:11:53
IP Address: 193.63.72.178

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Never
Drain tracing dye	Occasionally
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Occasionally
Other	Occasionally
Please list all other techniques you use for drainage detecton surveys.	Dowsing or divining rods.

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	Other
Other techniques	A specialist surveying contractor
Other (please specify)	We generally use a framework contractor to undertake excavations on my team's behalf.

Q3: Is there a particular combination of contractor and technique you find to be particularly effective? No

Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	6
Acoustic Transmission - sounding	Don't know
Drain tracing dye	3
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	7
Other techniques	6

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	10
Acoustic Transmission - sounding	Don't know
Drain tracing dye	3
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	6

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Other
Other (please specify)	CCTV cameras can't always navigate underground apparatus and jetting and vacuming provide limited benefit is some kinds of structure. We haven't used most of the more sophisticated techniques for reasons that the perceived cost often outweighs the benefit. There are also procurement barriers.

Q8: In your experience, what is the most common limitation?

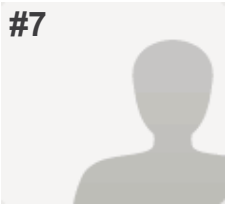
Internal obstruction

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	Please provide reasons for your answer Don't know
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident major improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have never heard of it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q13: Finally, about you:

Name	Graeme Hedger
Authority	West Lothian Council
Job Title	Team Leader - Flood Risk Management
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01506 776926 / 07774479863
Email address:	graeme.hedger@westlothian.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes



#7

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 10:16:38 AM
Last Modified: Thursday, September 17, 2015 10:45:15 AM
Time Spent: 00:28:36
IP Address: 212.219.240.201

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Occasionally
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Occasionally
Magnetometry	Never
RFID Detection	Occasionally
Vibration Acoustic	Occasionally
Excavation	Frequently
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	A specialist surveying contractor
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	A specialist surveying contractor
Magnetometry	Don't use
RFID Detection	A specialist surveying contractor
Vibration Acoustic	A specialist surveying contractor
Excavation	"In house" resources
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	8
Drain tracing dye	5
Gyro Based Pipe Logging	9
RFID Detection	8
Vibration Acoustic	7
Excavation	10

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	8
Drain tracing dye	10
Gyro Based Pipe Logging	9
RFID Detection	8
Vibration Acoustic	7
Excavation	10

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

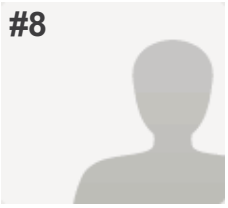
CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Limited specification
Drain tracing dye	Limited specification
Gyro Based Pipe Logging	Poor knowledge of how to use it
RFID Detection	Lack of confidence in output
Vibration Acoustic	Limited specification
Excavation	Poor knowledge of how to use it

Q8: In your experience, what is the most common limitation?

Dealing with different strata's at different depths

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A lot
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident major improvements can be made

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	David Macpherson
Authority	EAC
Job Title	Flooding Officer
In this role do you have a need to detect / survey drainage apparatus?	occasionally
Telephone	Not given
Email address:	david.macpherson@ayrshireroadsalliance.org
Q14: Would you be happy to be contacted to provide further information?	Yes



#8

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 11:37:34 AM
Last Modified: Thursday, September 17, 2015 11:47:25 AM
Time Spent: 00:09:50
IP Address: 212.219.208.1

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Occasionally
Other	Never
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	"In house" resources
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Other techniques	Don't use
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	7
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	9

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	Don't know
Drain tracing dye	3
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	Don't know

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

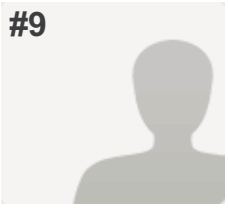
CCTV Camera Surveys	Poor/out of condition equipment
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Poor knowledge of how to use it
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it

Q8: In your experience, what is the most common limitation?

Equipment failure (CCTV) and costs

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years? No

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have never heard of it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	Steven
Authority	Orkney Islands Council
Job Title	Civil Engineer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01856 873535
Email address:	steven.miller@orkney.gov.uk
Q14: Would you be happy to be contacted to provide further information?	Yes



#9

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 12:00:14 PM
Last Modified: Thursday, September 17, 2015 12:32:35 PM
Time Spent: 00:32:20
IP Address: 212.219.208.1

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Frequently
Other	Occasionally
Please list all other techniques you use for drainage detecton surveys.	Water diviners rarely then confirmed by excavation. Plans and historical data when available

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	"In house" resources
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Other techniques	A specialist surveying contractor

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	Yes

Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.

Contractor & contact details	Lanes for Drains, Aberdeen
Technique	Jetting and de-silting then camera. Improving access points on network making managable sections at sensible locations.

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	5
Other techniques	6
Other (please specify)	Scottish water records, Local Authority records, local knowledge.

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	3
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	9
Other techniques	7
Other (please specify)	Cable tracer and sonde on a set of rods.

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Poor/out of condition equipment
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Other
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Limited specification
Other techniques	Limited specification
Other (please specify)	Drain tracing dye - proves connectivity but not route or condition. Rods and sonde - basic but effective so long as accessible. Condition not assessed.

Q8: In your experience, what is the most common limitation?

Poor access into the system to trace. Other utility blockages preventing survey or inspection.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

A little,

Please provide reasons for your answer
CCTV has improved as has cable detection but unless access into the system is made possible and utility obstructions removed survey is still difficult. Sharing of Scottish water records has been poor for us and records not very accurate.

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Confident that some improvements can be made ,

Please provide reasons for your answer
Flooding legislation forcing compliance and action.

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

I have never heard of it

Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Respondent skipped this question

Q13: Finally, about you:

Name	W Johnstone
Authority	Orkney Islands Council
Job Title	Roads Ops Manager
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01856872311
Email address:	billy.johnstone@orkney.gov.uk

Q14: Would you be happy to be contacted to provide further information?	No

#10

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 17, 2015 12:12:12 PM
Last Modified: Thursday, September 17, 2015 12:56:02 PM
Time Spent: 00:43:50
IP Address: 194.83.173.62

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Occasionally
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Occasionally
Please list all other techniques you use for drainage detecton surveys.	Ground Radar
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Other techniques	A specialist surveying contractor
Other (please specify)	Ground Radar
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	9
Other techniques	8
Other (please specify)	Ground Radar

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	Don't know
Drain tracing dye	7
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	7
Other techniques	6
Other (please specify)	Ground Radar

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Lack of confidence in output
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Lack of confidence in output
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Limited specification
Other techniques	Limited specification
Other (please specify)	Ground radar

Q8: In your experience, what is the most common limitation?

Time /speed of getting a result and cost

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

A little,

Please provide reasons for your answer
Technical techniques are expensive and not quick enough. Resort to old ways (excavation and dye) as it is usually in-house and under your control with an reasonably quick result

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Have little confidence that improvements can be made ,

Please provide reasons for your answer
Funding is currently a major problem with local authorities and significant commitment would be required to change from the old ways.

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

I have heard about it, but not used it

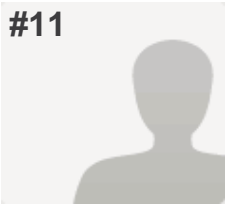
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

I recognise the need to know where your assets are. We are currently trawling through old drowings of road re-alignments to produce a GIS map of roads drainage. We know our gully locations for cleaning cycles. For flooding we need to know where water can/should drain to. After desktop work we will tie collection ito all Drainage Investigation works and log new findings. It is a start.

Q13: Finally, about you:

Name	Ian Young
Authority	Stirling Council
Job Title	Team Leader Bridge nad Flood Maintenance
In this role do you have a need to detect / survey drainage apparatus?	yes
Telephone	01786237645
Email address:	youngi@stirling.gov.uk

Q14: Would you be happy to be contacted to provide further information?	No



#11

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Monday, September 21, 2015 9:55:32 AM
Last Modified: Monday, September 21, 2015 10:04:35 AM
Time Spent: 00:09:02
IP Address: 194.83.172.50

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Occasionally
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	"In house" resources
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	6

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	Don't know
Drain tracing dye	5
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	5

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Lack of confidence in output
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Lack of confidence in output

Q8: In your experience, what is the most common limitation?

Resource and time to carry out assessments

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A lot, Please provide reasons for your answer No doubt technology available has improved significantly, but a lack of resources of the authorities charged with ownership of the apparatus and a lack of co-ordination across parties makes delivering a sufficiently accurate data base of reliable information difficult.
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident major improvements can be made, Please provide reasons for your answer No doubt technology will improve further, but costs are a major limiting factor.
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q13: Finally, about you:

Name	Stuart Cullen
Authority	Clackmannanshire Council
Job Title	Principal Roads and Flooding Officer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01259 452593
Email address:	scullen@clacks.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes

#12

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 24, 2015 8:57:35 AM
Last Modified: Thursday, September 24, 2015 9:04:51 AM
Time Spent: 00:07:15
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Drain tracing dye	Occasionally
Excavation	Occasionally

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Drain tracing dye	"In house" resources
Excavation	A specialist surveying contractor

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	9
Drain tracing dye	4
Excavation	6

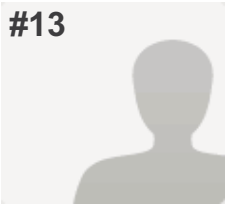
Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	8
Drain tracing dye	3
Excavation	3

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Poor/out of condition equipment
Drain tracing dye	Limited specification
Excavation	Limited specification

Q8: In your experience, what is the most common limitation?	*Respondent skipped this question*
Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A little
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have never heard of it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	Mark Barbour
Authority	South Lanarkshire
Job Title	Assistant Engineering Officer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698 455196
Email address:	mark.barbour@southlanarkshire.gov.uk
Q14: Would you be happy to be contacted to provide further information?	No



#13

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 24, 2015 8:57:40 AM
Last Modified: Thursday, September 24, 2015 9:14:55 AM
Time Spent: 00:17:14
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Frequently
Drain tracing dye	Frequently
Excavation	Frequently
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Drain tracing dye	"In house" resources
Excavation	A specialist surveying contractor
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*
Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:	
CCTV Camera Surveys	9
Acoustic Transmission - sounding	3
Drain tracing dye	7
Gyro Based Pipe Logging	3
Magnetometry	3
RFID Detection	3
Vibration Acoustic	3
Excavation	8

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	3
Drain tracing dye	5
Gyro Based Pipe Logging	3
Magnetometry	3
RFID Detection	3
Vibration Acoustic	3
Excavation	6

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Acoustic Transmission - sounding	Lack of confidence in output
Drain tracing dye	Lack of confidence in output
Gyro Based Pipe Logging	Lack of confidence in output
Magnetometry	Lack of confidence in output
RFID Detection	Lack of confidence in output
Vibration Acoustic	Lack of confidence in output
Excavation	Lack of confidence in output

Q8: In your experience, what is the most common limitation?

Steerable cameras

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

A little,

Please provide reasons for your answer
Stability of cctv cameras within pipes is still an issue, preventing operators continuing surveys in systems with debris, or traction in pipes with silt.

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Confident that some improvements can be made ,

Please provide reasons for your answer
If we can land rovers on Mars and operate them over different terrain, it seems likely that the ability to traverse through pipes could be improved.

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

I have never heard of it

Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

No

Q13: Finally, about you:

Name	Scott MacDonald
Authority	South Lanarkshire Council
Job Title	Engineering Officer (Flooding)
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698455206
Email address:	scott.macdonald@southlanarkshire.gov.uk

Q14: Would you be happy to be contacted to provide further information? Yes

#14

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Wednesday, August 26, 2015 4:38:08 PM
Last Modified: Thursday, September 24, 2015 9:20:00 AM
Time Spent: Over a week
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Occasionally
Drain tracing dye	Frequently
Excavation	Occasionally
Please list all other techniques you use for drainage detecton surveys.	Use of historical plans and as-built drawings can be useful where available

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	"In house" resources
Drain tracing dye	"In house" resources
Excavation	"In house" resources
Other (please specify)	We have a small diameter push camera for use in pipes up to 300mm dia and approx 50m length. Anything greater than this, or where Traffic Management is reuqired we employ specialsit survey contractor to use a larger CCTV crawler unit, or if required a walkthrough survey in large diameter pipes.

Q3: Is there a particular combination of contractor and technique you find to be particularly effective? No

Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5. *Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	7
Acoustic Transmission - sounding	6
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	8
Other techniques	Don't know

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	5
Acoustic Transmission - sounding	5
Drain tracing dye	5
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	3

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Other
Acoustic Transmission - sounding	Other
Drain tracing dye	Other
Excavation	Other
Other (please specify)	Effectiveness of CCTV surveys is that a blockage in the pipe could limit the progress of the equioment along the pipe, therefore its difficult to locate anytghing beyond the nit. Alss the use of CAT tool are required to find the location of the unit below ground, the accuracy of this can be poor unless skilled in its use. My experience of sounding pipes works if you have both ends, however it tells you nothing of what is in between these points. My experience of drain tracing is it works if you have both ends, however it tells you nothing of what is in between these points. Excavation is can be hit or miss, and is usualy backed up with other surveys eg CCTV survey has encountered a blockage and cannot progress.

Q8: In your experience, what is the most common limitation?

Unable to progress CCTV surveys past blockages. If there can be a better way to progress a survey through a pipe then the turns and gradient changes etc can be interpreted to the surface more effectively. The presence of clay in our area, and the depth of some pipes often limits the use of other technologies and the outputs can be worthless.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?

No,

Please provide reasons for your answer
We are still utilsing the sma etechniques and the new developments such as GPR etc don't seem to work very well in our experience. Our most common approach is still dye trace, CCTV survey with sonde and CAT, and then excavations where the CCTV unit cannot progress.

Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?

Confident major improvements can be made,

Please provide reasons for your answer
The presence of underground apparatus is widespeard across various industries, and it is envisaged that more effective and efficient techniques must have been developed for use in these fields that can be transposed into our own field of work.

Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?

I have heard about it, but not used it

Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Respondent skipped this question

Q13: Finally, about you:

Name	David Molloy
Authority	South Lanarkshire Council
Job Title	Flood Risk Management - Team Leader
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698 453615
Email address:	david.molloy@southlanarkshire.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes

#15

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 24, 2015 9:19:01 AM
Last Modified: Thursday, September 24, 2015 9:29:30 AM
Time Spent: 00:10:29
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Drain tracing dye	Frequently
Excavation	Occasionally

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Drain tracing dye	A specialist surveying contractor
Excavation	A specialist surveying contractor

Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Drain tracing dye	7
Excavation	8

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	8
Drain tracing dye	8
Excavation	8

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Limited specification
Drain tracing dye	Limited specification

Q8: In your experience, what is the most common limitation?	*Respondent skipped this question*
Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	No, Please provide reasons for your answer Equipment being used by the contractors has changed very little in the past ten years
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made , Please provide reasons for your answer New technologies should ensure some improvement in the coming years
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have never heard of it
Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	Robert Falconer
Authority	SLC
Job Title	Assistant Engineering Officer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698453797
Email address:	robert.falconer@southlanarkshire.gov.uk
Q14: Would you be happy to be contacted to provide further information?	No

#16

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 24, 2015 9:52:51 AM
Last Modified: Thursday, September 24, 2015 9:58:27 AM
Time Spent: 00:05:36
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.

CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Occasionally

Q2: Who normally carries out these surveys?

CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	Don't use
Drain tracing dye	"In house" resources
Gyro Based Pipe Logging	Don't use
Magnetometry	Don't use
RFID Detection	Don't use
Vibration Acoustic	Don't use
Excavation	A specialist surveying contractor
Other techniques	Don't use

Q3: Is there a particular combination of contractor and technique you find to be particularly effective? Yes

Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.

Contractor & contact details	Underground inspection Services
Technique	CCTV and small Civils works

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	9

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	Don't know
Drain tracing dye	10
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

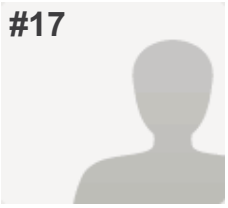
CCTV Camera Surveys	Other

Q8: In your experience, what is the most common limitation?

Colllapsed or out of alignment drainage pipes

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A lot
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Confident that some improvements can be made , Please provide reasons for your answer Research is being carried out all the time with any improvements becoming common practice in the future
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have never heard of it

Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*
Q13: Finally, about you:	
Name	Jim Logan
Authority	South Lanarkshire Council
Job Title	Engineering Officer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698 453635
Email address:	james.logan@southlanarkshire.gov.uk
Q14: Would you be happy to be contacted to provide further information?	No



#17

COMPLETE

Collector: Web Link 1 (Web Link)
Started: Thursday, September 24, 2015 12:34:43 PM
Last Modified: Thursday, September 24, 2015 1:13:00 PM
Time Spent: 00:38:17
IP Address: 212.219.209.199

PAGE 1: Survey of Local Authority Highway Drainage Specialists

Q1: When undertaking drainage detection surveys, which of the following techniques do you use?Please tick all that are applicable.	
CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Frequently
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Occasionally
RFID Detection	Occasionally
Vibration Acoustic	Never
Excavation	Frequently
Please list all other techniques you use for drainage detecton surveys.	A desk top study is essential before starting, there may be plans availableshowing the drainage arrangement.
Q2: Who normally carries out these surveys?	
CCTV Camera Surveys	A specialist surveying contractor
Acoustic Transmission - sounding	A specialist surveying contractor
Drain tracing dye	"In house" resources
Excavation	Other
Other (please specify)	Usually a civil engineering contractor would be used for excavation work. Dye tracing and basic CCTV work can be carried out in-house.
Q3: Is there a particular combination of contractor and technique you find to be particularly effective?	No
Q4: If answer to Q3 was "Yes", please provide details below. If "No", skip to Q5.	*Respondent skipped this question*

Q5: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the effectiveness of each technique is in identifying the presence of the underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	8
Drain tracing dye	9
Gyro Based Pipe Logging	3
Magnetometry	3
RFID Detection	3
Vibration Acoustic	Don't know
Excavation	10

Q6: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of each technique in identifying underground drainage apparatus:

CCTV Camera Surveys	9
Acoustic Transmission - sounding	7
Drain tracing dye	6
Gyro Based Pipe Logging	3
Magnetometry	3
RFID Detection	3
Vibration Acoustic	Don't know
Excavation	10

Q7: There are clearly factors which limit the effectiveness of different detection methods. Please indicate how these apply to the different techniques.

CCTV Camera Surveys	Lack of confidence in output
Acoustic Transmission - sounding	Poor knowledge of how to use it
Drain tracing dye	Lack of confidence in output
Gyro Based Pipe Logging	Poor knowledge of how to use it
Magnetometry	Poor knowledge of how to use it
RFID Detection	Poor knowledge of how to use it
Vibration Acoustic	Poor knowledge of how to use it
Excavation	Limited specification

Q8: In your experience, what is the most common limitation?

Lack of record drawings is a limitation. Accessing he exact location can be limiting. The defective apparatus may be located underneath something which is not easily moved or excavated.

Q9: In your view has the detection of underground drainage apparatus been significantly improved over the last 10 years?	A little, Please provide reasons for your answer CCTV, Sonar probes, dye tracing and excavation. These are the options available when investigating / repairing a drainage problem. It has been that way for as long as I can remember. In last few years robot cutting and patch lining has been handy on occasion.
Q10: Looking ahead how optimistic are you that improvements can be made in underground drainage detection techniques used by local authorities?	Have little confidence that improvements can be made , Please provide reasons for your answer I think intelligent robotics could be the way ahead in this area, perhaps the R&D is too expensive with no guarantee of a return. I would like to see new technology change the way we do our business. The main contractors we use for investigation / repair works do not offer much more than the standard fayre; CCTV dye tracing etc.
Q11: Are you aware of the document PAS128:2014 "Specification for Underground Utility Detection, Verification and Location"?	I have heard about it, but not used it

Q12: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Historic sandstone drains are very difficult to survey/repair. Some sort of mechanical device which can gain access, record images, take measurements, remove debris and carry out repairs would be too good to be true.

Q13: Finally, about you:

Name	David Beaton
Authority	South Lanarkshire Council
Job Title	Engineering Officer
In this role do you have a need to detect / survey drainage apparatus?	Yes
Telephone	01698 453687
Email address:	david.beaton@southlanarkshire.gov.uk

Q14: Would you be happy to be contacted to provide further information?	Yes

Appendix E. Survey Contractor Questionnaire

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Research into Underground Drainage Detection Techniques

Survey for Drainage Specialist Contractors

Atkins Limited is undertaking research for the Society of Chief Officers of Tranportation in Scotland (SCOTS) to determine best practice in the detection of underground drainage apparatus. The aim is to identify if there are methods in use in other countries or other industries which could be applied in Scotland so as to minimise the need to carry out excavations which both damage roads and delay travellers.

To enable us to establish best practice in use across the industry we would appreciate it if you could complete this short questionnaire on the underground utility detection services you provide.

If you wish to discuss any aspect of this research please feel free to contact:
Sarah Munn (telephone: 0141 220 2191 or by email: Sarah.Munn@atkinsglobal.com)

Thank you.

1. When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

	Frequently	Occasionally	Never
Ground Penetrating Radar	○	○	○
Electromagnetic Location	○	○	○
CCTV Camera Surveys	○	○	○
Acoustic Transmission - sounding	○	○	○
Drain tracing dye	○	○	○
Gyro Based Pipe Logging	○	○	○
Magnetometry	○	○	○
RFID Detection	○	○	○
Vibration Acoustic	○	○	○
Excavation	○	○	○

Other (please specify)

2. On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

	Don't know	1	2	3	4	5	6	7	8	9	10
Ground Penetrating Radar	○	○	○	○	○	○	○	○	○	○	○
Electromagnetic Location	○	○	○	○	○	○	○	○	○	○	○
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

3. On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

	Don't know	1	2	3	4	5	6	7	8	9	10
Ground Penetrating Radar	○	○	○	○	○	○	○	○	○	○	○
Electromagnetic Location	○	○	○	○	○	○	○	○	○	○	○
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

4. Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

	Don't know	1	2	3	4	5	6	7	8	9	10
Ground Penetrating Radar	○	○	○	○	○	○	○	○	○	○	○
Electromagnetic Location	○	○	○	○	○	○	○	○	○	○	○
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

5. Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

	Don't know	1	2	3	4	5	6	7	8	9	10
Ground Penetrating Radar	○	○	○	○	○	○	○	○	○	○	○
Electromagnetic Location	○	○	○	○	○	○	○	○	○	○	○
CCTV Camera Surveys	○	○	○	○	○	○	○	○	○	○	○
Acoustic Transmission - sounding	○	○	○	○	○	○	○	○	○	○	○
Drain tracing dye	○	○	○	○	○	○	○	○	○	○	○
Gyro Based Pipe Logging	○	○	○	○	○	○	○	○	○	○	○
Magnetometry	○	○	○	○	○	○	○	○	○	○	○
RFID Detection	○	○	○	○	○	○	○	○	○	○	○
Vibration Acoustic	○	○	○	○	○	○	○	○	○	○	○
Excavation	○	○	○	○	○	○	○	○	○	○	○
Other techniques	○	○	○	○	○	○	○	○	○	○	○

Other (please specify)

6. In your view has the detection of underground utilities significantly improved over the last 10 years?

- ○ No
- ○ A little
- ○ A lot
- ○ Totally transformed

Please provide any additional comments:

7. Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?

- ◯ Confident major improvements can be made
- ◯ Confident that some improvements can be made
- ◯ Have little confidence that improvements can be made
- ◯ Do not think any improvements can be made

Please give your reasons for your answer:

8. "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?

- ◯ Yes
- ◯ No
- ◯ Not sure

If answer is yes, please share your views below:

9. Does your company comply with PAS128:2014 "Specific for Underground Utility Detection, Verification and Location"?

- ◯ All services are provided on the basis of PAS128:2014
- ◯ We can meet the requirements of PAS128:2014, if requested by a client
- ◯ Not at present but we are moving towards compliance with PAS128:2014
- ◯ We are reviewing our status in respect of PAS128:2014
- ◯ I am not aware of PAS128:2014
- ◯ We have no plans to adopt PAS128:2014

10. Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

* 11. Finally about you:

Name:	
Company:	
Job title:	
Telephone:	
Email Address:	

* 12. Would you be happy to be contacted to provide further information?

Appendix F. Survey Contractor Participants

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Survey Participants - Contractors

ID Number	Company Name	Individual's Name	Contact Email	Contact Number
1	**Subscan Tech**	John Robinson (Managing Director)	J.Robinson@subscantech.co.uk	T: 01788 550017 M: 07860 833641
2	**EEG**	Stephen Docherty (Project Manager)	Steven.Docherty@eeg.uk.com	T: 0845 555 555 9
3	**L & M Surveys**	Peter Webster (Utilities Manager)	PeterWebster@lmsurveys.co.uk	T: 01563 533368 T: 01563 533309 M: 07824 874340
4	**Aspect Ltd**	Steven Scott	sscott@aspect surveys.com	T: 01294 313399
5	**Malcolm Hughes Land Surveyors**	Lynday Clark	Lyndsay.clark@mhls.co.uk	T: 01506 467 910
6*	**SUMO Services Ltd**	Peter Marsh (Operations Manager)	Peter.Marsh@sumoservices.com	T: 02392 415028 M: 07747 792529

Note: * No response received to questioniare but he did respond to other consultation especially with regard to PAS 128 :2014 and Mapping the Underworld.

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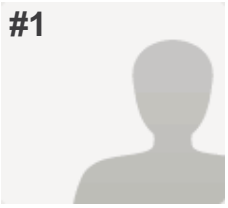
Appendix G. Survey Contractor Responses



COMPLETE

Collector: Email Invitation 1 (Email)
Started: Wednesday, October 07, 2015 4:54:58 PM
Last Modified: Wednesday, October 07, 2015 5:07:20 PM
Time Spent: 00:12:21
Email: J.Robinson@subscantech.co.uk
Custom Data: None
IP Address: 94.185.244.58

PAGE 1: Survey for Drainage Specialist Contractors

Q1: When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Ground Penetrating Radar	Frequently
Electromagnetic Location	Frequently
CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Frequently
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Occasionally
Magnetometry	Never
RFID Detection	Occasionally
Vibration Acoustic	Occasionally
Excavation	Occasionally

Q2: On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Ground Penetrating Radar	7
Electromagnetic Location	9
CCTV Camera Surveys	8
Acoustic Transmission - sounding	7
Drain tracing dye	8
Gyro Based Pipe Logging	9
Magnetometry	Don't know
RFID Detection	6
Vibration Acoustic	4
Excavation	9
Other techniques	Don't know

Q3: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

Ground Penetrating Radar	8
Electromagnetic Location	8
CCTV Camera Surveys	5
Acoustic Transmission - sounding	7
Drain tracing dye	8
Gyro Based Pipe Logging	10
Magnetometry	Don't know
RFID Detection	5
Vibration Acoustic	4
Excavation	10
Other techniques	Don't know
Other (please specify)	Remember its not just the techniques involved, its using a robust methodology like PAS128 and trained surveyors with QCF qualifications that matter more.

Q4: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Ground Penetrating Radar	6
Electromagnetic Location	9
CCTV Camera Surveys	9
Acoustic Transmission - sounding	5
Drain tracing dye	7
Gyro Based Pipe Logging	10
Magnetometry	Don't know
RFID Detection	5
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q5: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

Ground Penetrating Radar	8
Electromagnetic Location	9
CCTV Camera Surveys	9
Acoustic Transmission - sounding	6
Drain tracing dye	7
Gyro Based Pipe Logging	10
Magnetometry	Don't know
RFID Detection	5
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q6: In your view has the detection of underground utilities significantly improved over the last 10 years?

Totally transformed,

Please provide any additional comments:
The use of multi- array GPR, post processing and QCF training units for surveyors has transformed the industry. PAS128 has given us the first ever robust and accountable specification to work from. Still work to be done with accreditation for survey companies and client education.

Q7: Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?

Confident major improvements can be made,

Please give your reasons for your answer:
Post PAS128, there has been more collaboration and investment in the utility survey industry than in the previous 20 years. Survey companies and manufacturers' are now thinking about 3d deliverables and BIM. Still work to be done to professionalise the industry and make site survey staff educated and accountable.

Q8: "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?

Yes,

If answer is yes, please share your views below:
Yes, and we have been major collaborators for many years.

Q9: Does your company comply with PAS128:2014 "Specific for Underground Utility Detection, Verification and Location"?

All services are provided on the basis of PAS128:2014

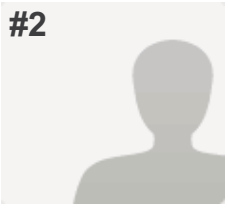
Q10: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

I am one of the four authors of PAS128 and passionate about its implementation. Happy to discuss this at length if required.

Q11: Finally about you:

Name:	John Robinson
Company:	Subscan Technology Ltd
Job title:	Managing Director
Telephone:	01788 550017
Email Address:	j.robinson@subscantech.co.uk

Q12: Would you be happy to be contacted to provide further information?	Yes



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Collector: Email Invitation 1 (Email)
Started: Wednesday, October 07, 2015 10:02:16 PM
Last Modified: Wednesday, October 07, 2015 10:07:00 PM
Time Spent: 00:04:43
Email: Steven.Docherty@eeg.uk.com
Custom Data: None
IP Address: 213.205.252.100

PAGE 1: Survey for Drainage Specialist Contractors

Q1: When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Ground Penetrating Radar	Never
Electromagnetic Location	Frequently
CCTV Camera Surveys	Frequently
Acoustic Transmission - sounding	Frequently
Drain tracing dye	Occasionally
Gyro Based Pipe Logging	Never
RFID Detection	Occasionally
Vibration Acoustic	Occasionally
Excavation	Occasionally

Q2: On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Ground Penetrating Radar	6
Electromagnetic Location	7
CCTV Camera Surveys	7
Acoustic Transmission - sounding	5
Drain tracing dye	6
Gyro Based Pipe Logging	5
Magnetometry	4
RFID Detection	5
Excavation	8
Other techniques	Don't know

Q3: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

Ground Penetrating Radar	5
Electromagnetic Location	5
CCTV Camera Surveys	5
Acoustic Transmission - sounding	5
Drain tracing dye	5
Gyro Based Pipe Logging	5
Magnetometry	5
RFID Detection	5
Vibration Acoustic	5
Excavation	5
Other techniques	5

Q4: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Ground Penetrating Radar	7
Electromagnetic Location	6
CCTV Camera Surveys	7
Acoustic Transmission - sounding	8
Drain tracing dye	7
Gyro Based Pipe Logging	7
Magnetometry	7
RFID Detection	7
Vibration Acoustic	7
Excavation	7
Other techniques	7

Q5: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

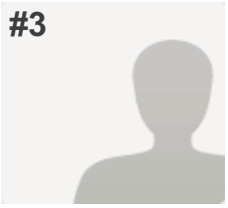
Ground Penetrating Radar	6
Electromagnetic Location	5
CCTV Camera Surveys	7
Acoustic Transmission - sounding	5
Drain tracing dye	7
Gyro Based Pipe Logging	5
Magnetometry	6
RFID Detection	6
Vibration Acoustic	5
Excavation	6
Other techniques	7

Q6: In your view has the detection of underground utilities significantly improved over the last 10 years?	A lot
Q7: Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?	Confident that some improvements can be made
Q8: "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?	No
Q9: Does your company comply with PAS128:2014 "Specific for Underground Utility Detection, Verification and Location"?	I am not aware of PAS128:2014
Q10: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q11: Finally about you:

Name:	Steven Docherty
Company:	EEG
Job title:	Project Manager
Telephone:	07951595007
Email Address:	Steven.docherty@eeg.uk.com

Q12: Would you be happy to be contacted to provide further information?	Yes



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Email: PeterWebster@lmsurveys.co.uk
Custom Data: None
IP Address: 78.25.225.49

PAGE 1: Survey for Drainage Specialist Contractors

Q1: When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Ground Penetrating Radar	Frequently
Electromagnetic Location	Frequently
CCTV Camera Surveys	Occasionally
Acoustic Transmission - sounding	Never
Drain tracing dye	Frequently
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Never
Other (please specify)	Flexitrace and sonde locating

Q2: On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Ground Penetrating Radar	7
Electromagnetic Location	8
CCTV Camera Surveys	8
Acoustic Transmission - sounding	Don't know
Drain tracing dye	10
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	Don't know
Other techniques	10

Q3: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

Ground Penetrating Radar	7
Electromagnetic Location	9
CCTV Camera Surveys	10
Acoustic Transmission - sounding	Don't know
Drain tracing dye	10
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	Don't know
Other techniques	10

Q4: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Ground Penetrating Radar	3
Electromagnetic Location	1
CCTV Camera Surveys	10
Acoustic Transmission - sounding	Don't know
Drain tracing dye	10
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	Don't know
Other techniques	10

Q5: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

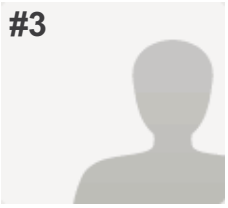
Ground Penetrating Radar	7
Electromagnetic Location	8
CCTV Camera Surveys	10
Acoustic Transmission - sounding	Don't know
Drain tracing dye	10
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	Don't know
Other techniques	10

Q6: In your view has the detection of underground utilities significantly improved over the last 10 years?	A little
Q7: Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?	Have little confidence that improvements can be made
Q8: "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?	Yes
Q9: Does your company comply with PAS128:2014 "Specific for Underground Utility Detection, Verification and Location"?	All services are provided on the basis of PAS128:2014
Q10: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q11: Finally about you:

Name:	Peter Webster
Company:	L&M Survey Services
Job title:	Utility Manager
Telephone:	01563 531625
Email Address:	peterwebster@lmsurveys.co.uk

Q12: Would you be happy to be contacted to provide further information?	Yes



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Time Spent: 00:52:10
Email: SScott@aspectsurveys.com
Custom Data: None
IP Address: 81.138.0.8

PAGE 1: Survey for Drainage Specialist Contractors

Q1: When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Ground Penetrating Radar	Frequently
Electromagnetic Location	Frequently
CCTV Camera Surveys	Never
Acoustic Transmission - sounding	Occasionally
Drain tracing dye	Occasionally
Gyro Based Pipe Logging	Never
Magnetometry	Occasionally
RFID Detection	Never
Vibration Acoustic	Occasionally
Excavation	Never

Q2: On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Ground Penetrating Radar	8
Electromagnetic Location	9
CCTV Camera Surveys	7
Acoustic Transmission - sounding	6
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	7
RFID Detection	1
Vibration Acoustic	4
Excavation	10

Q4: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

Ground Penetrating Radar	8
Electromagnetic Location	9
CCTV Camera Surveys	8
Acoustic Transmission - sounding	6
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	7
RFID Detection	Don't know
Vibration Acoustic	5
Excavation	10

Q3: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Ground Penetrating Radar	8
Electromagnetic Location	6
CCTV Camera Surveys	8
Acoustic Transmission - sounding	6
Drain tracing dye	6
Gyro Based Pipe Logging	Don't know
Magnetometry	2
RFID Detection	1
Vibration Acoustic	5
Excavation	10

Q5: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

Ground Penetrating Radar	7
Electromagnetic Location	9
CCTV Camera Surveys	9
Acoustic Transmission - sounding	6
Drain tracing dye	7
Gyro Based Pipe Logging	Don't know
Magnetometry	8
RFID Detection	Don't know
Vibration Acoustic	6
Excavation	10

Q6: In your view has the detection of underground utilities significantly improved over the last 10 years?	A lot
Q7: Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?	Confident major improvements can be made, Please give your reasons for your answer: If the way ahead is utilising a combination of geophysical techniques within the one device, then "Yes". Multiple sensors all geo-referenced, new deliverables for clients, it can only be good for the industry.
Q8: "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?	Yes, If answer is yes, please share your views below: Concerns on cost (hardware & software), practicality and accuracy, but great interest in the potential of such a system. Like all new original data collection systems, some stumbling blocks to come, but if successful it could transform the detection of utilities for years to come. Keen to know more on potential user-interface. This system opens the door to far more complex survey techniques than GPR/Electromagnetic. The system requires the input of GNSS strings/inertial systems, a host of new sensors. Luckily we have experience of such but it will be a steep learning curve for the surveyor/company with little knowledge or experience? Wondering if there is any industry backing (MALA, RD, and Vivax etc). Looking forward to following the development of the system.
Q9: Does your company comply with PAS128:2013 "Specific for Underground Utility Detection, Verification and Location"?	All services are provided on the basis of PAS128:2014

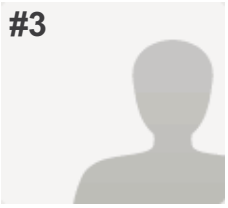
Q10: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.

Disappointed not to see Glasgow, Nottingham or Newcastle Universities involved in real cutting edge research when they have such well established Geomatics departments.

Q11: Finally about you:

Name:	Stephen Scott
Company:	Aspect Land & Hydrographic Surveys
Job title:	Senior Land Surveyor
Telephone:	01294 313399
Email Address:	sscott@aspectsurveys.com

Q12: Would you be happy to be contacted to provide further information?	Yes



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Last Modified: Tuesday, October 13, 2015 1:22:33 PM
Time Spent: 00:08:20
Email: Lyndsay.clark@mhls.co.uk
Custom Data: None
IP Address: 87.127.122.57

PAGE 1: Survey for Drainage Specialist Contractors

Q1: When undertaking any underground utility detection surveys (not only for drainage), which of the following techniques does your company use? Please select all that are applicable.

Ground Penetrating Radar	Frequently
Electromagnetic Location	Frequently
CCTV Camera Surveys	Never
Acoustic Transmission - sounding	Frequently
Drain tracing dye	Never
Gyro Based Pipe Logging	Never
Magnetometry	Never
RFID Detection	Never
Vibration Acoustic	Never
Excavation	Never

Q2: On a scale of 1 to 10 (1 being not very effective and 10 being very extremely effective) how would you rate the following techniques in detecting the presence of underground utilities?

Ground Penetrating Radar	7
Electromagnetic Location	7
CCTV Camera Surveys	Don't know
Acoustic Transmission - sounding	7
Drain tracing dye	8
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q4: On a scale of 1 to 10 (1 being very poor and 10 being excellent) how would you rate the accuracy of the following techniques in locating underground utilities:

Ground Penetrating Radar	5
Electromagnetic Location	8
CCTV Camera Surveys	Don't know
Acoustic Transmission - sounding	4
Drain tracing dye	5
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q5: Now thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being not very effective and 10 being extremely effective) how would you rate the following techniques?

Ground Penetrating Radar	4
Electromagnetic Location	2
CCTV Camera Surveys	6
Acoustic Transmission - sounding	4
Drain tracing dye	5
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	Don't know
Other techniques	Don't know

Q3: 5ow thinking specifically about detecting underground drainage apparatus, on a scale of 1 to 10 (1 being poor and 10 being very accurate) how would you rate the accuracy of the following techniques?

Ground Penetrating Radar	Don't know
Electromagnetic Location	Don't know
CCTV Camera Surveys	Don't know
Acoustic Transmission - sounding	Don't know
Drain tracing dye	Don't know
Gyro Based Pipe Logging	Don't know
Magnetometry	Don't know
RFID Detection	Don't know
Vibration Acoustic	Don't know
Excavation	10
Other techniques	Don't know

Q6: In your view has the detection of underground utilities significantly improved over the last 10 years?	A little
Q7: Looking ahead how optimistic are you that improvements can be made in underground utility detection techniques?	Confident that some improvements can be made
Q8: "Mapping the Underworld" is an industry initiative which aims to reduce the number of excavations made in the road each year, by establishing a multi-sensor utility detection device, which uses a combination of geophysical techniques. Are you aware of this initiative?	No
Q9: Does your company comply with PAS128:201N "Specific for Underground Utility Detection, Verification and Location"?	All services are provided on the basis of PAS128:2014
Q10: Do you have any other information, thoughts, or ideas which you think may be helpful to our research? Please detail below.	*Respondent skipped this question*

Q11: Finally about you:

Name:	Lyndsay Clark
Company:	Malcolm Hughes Land Surveyors
Job title:	Processing Manager
Telephone:	01506 467910
Email Address:	lyndsay.clark@mhls.co.uk

Q12: Would you be happy to be contacted to provide further information?	Yes

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Philip Mendelsohn
Atkins
200 Broomielaw
Glasgow
G1 4RU

philip.mendelsohn@atkinsglobal.com
0141 220 2205