iSTT INTERNATIONAL SOCIETY FOR TRENCHLESS TECHNOLOGY	**TRENCHLESS TECHNOLOGY RESOURCE CENTRE**	
	TRENCHLESS TECHNOLOGY GUIDELINES	THIRD EDITION
	SITE SURVEY, INVESTIGATION AND PREPARATION	LAST UPDATED JULY 2009

1. OVERVIEW

This section of the TRC provides information on techniques and systems used before and after the rehabilitation work. The proper use of these techniques is as important to success as the correct selection and installation of the rehabilitation system. The techniques are summarised in the table below.

TASK	DESCRIPTION	PURPOSE	TECHNIQUES
SITE SURVEY AND BURIED INFRASTRUCTURE LOCATION	LOCATION OF PIPES TO BE REHBILITATED	ESSENTIAL FIRST STEP	AS BUILT DRAWINGS TRIAL HOLES ELECTROMAGNETIC DETECTION GROUND PROBING RADAR
	LOCATION OF ADJACENT UTILITIES	AVOIDANCE OF COLLATERAL DAMAGE	
	ACCESS POINTS	CONFIRM LOCATION OF EXISTING ACCESS AND/OR SELECT NEW LOCATIONS	VISUAL INSPECTION
PIPE CLEANING AND PRE REHABILITATION INSPECTION	PRE REHABILITATION INSPECTION	CONFIRM PIPE CONDITION AND LOCATION OF LATERALS, JUNCTIONS BENDS ETC	CCTV SURVEYS
	REMOVAL OF LOOSE DEBRIS AND OBSTRUCTIONS	ALLOW SAFE LINER INSERTION	JETTING AND FLUSHING
	REMOVAL OF SURFACE DEPOSITS	MAXIMISE BORE ACHIEVE REQUIRED SURFACE CONDITION	SCRAPING RACK FEED BORING HP WATER JETTING PIGGING
	REMOVE ROOTS		SPECIALIST EQUIPMENT
MAINTAINING SERVICE AVAILBILITY	BYPASSING SEWER FLOWS	MAINTAIN SEWER SERVICE DURING REHAB	OVERPUMPING
	PROVIDING ALTERNATIVE WATER SUPPLY	MAINTAIN SERVICE TO CUSTOMERS	TEMPORARY SURFACE MAINS
POST REHABILITATION ASSESMENT	LINING INSPECTION		CCTV SURVEY
	PERFORMANCE TESTS		PRESSURE TEST
SAFETY ASPECTS OF ACCESSING PIPE	PUBLIC SAFETY OPERATOR SAFETY	MINIMISE SAFETY HAZARDS	SIGNING AND SAFETY BARRIERS OPERATOR SAFETY TRAINING

SITE SURVEY AND BURIED INFRASTRUCTURE LOCATION

The first task for the rehabilitation contractor when he arrives on site is to find and arrange access to the sections of pipe included in the rehabilitation contract. These are normally identified on a set of as built drawings which show the location of the pipeline in relation to defined surface features. However traditionally, such drawings have been found to be inaccurate and/or incomplete, and most contracts have put the responsibility for verification of this information firmly in the hands of the contractor.

The contractor must also assess the potential impact of the planned rehabilitation activities on adjacent utilities and other buried infrastructure. This is particularly important in the case of technologies, such as pipe bursting, to be conducted in the vicinity of high sensitivity utilities such as gas, power and fibre optics. In spite of the growth of central utility record systems of the "one call" type, the contractor is ultimately responsible for the prevention/remediation of collateral damage to existing infrastructure.

The costs, and inconvenience, of collateral damage have increased dramatically over the past few years, and they are a major cause for concern. The disruption associated with this type of damage affects all parties and contract stakeholders irrespective of the legal allocation of responsibility in the contract documents. This has lead to the development of an alternative approach to the problem which has been given the acronym SUE (Subsurface Utility Engineering) and is discussed in detail in Section 1 of these Guidelines. This is based on the use of modern geophysical techniques to locate all the buried assets in the site area followed by use of trial excavations to confirm the data. The information is then displayed on comprehensive plans drawn with the aid of Global Positioning Systems. The SUE process defines the accuracy of the information and hence allows the identification and pricing of risks

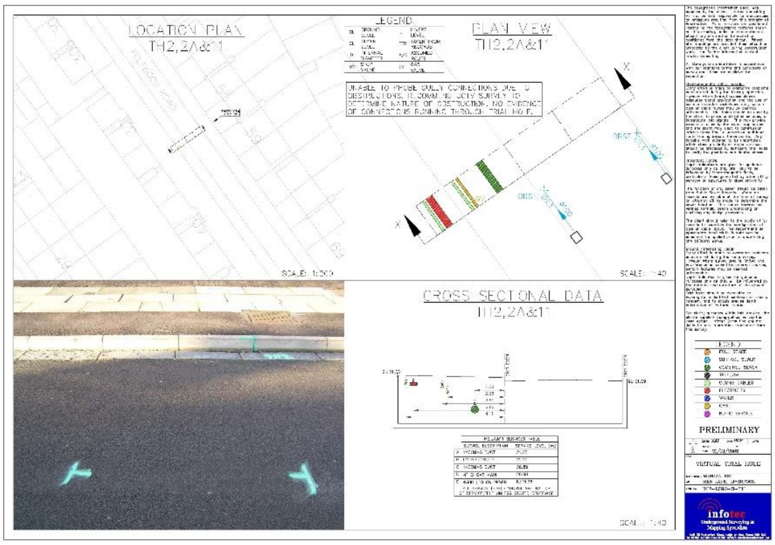
The renovation of sewers by lining is the least problematic situation in terms of location, due to the use of existing manholes and remote lateral reinstatement techniques. The use of pipe bursting for sewer replacement does involve the risk of collateral damage, although, the greater depth of the sewers reduces the risk of damaging water and gas mains. However, both pipe bursting and conventional sliplining require accurate location of laterals for disconnection and reinstatement via local excavation.

Pressure pipes, such as water mains, offer a much greater challenge because there are seldom any useful existing surface access points, and the various utilities are frequently installed very close to each other. In these circumstances the use of pipe bursting may involve a high risk of collateral damage, and hence increases the need for accurate location and identification of buried pipes.

The easiest and most direct way for the contractor to verify the location of the pipe, and adjacent utilities, is by a series of small excavations termed "trial holes", which are usually located at key points identified from the as built drawings. If the excavations confirm the information on the as built drawings, the contractor can proceed to the next. If there are large discrepancies, between them either more trial holes must be dug, or alternative location techniques must be used such as those described in Section 1. The excavation and reinstatement of trial holes can be expensive, time consuming and potentially disruptive, and can itself be a cause of collateral damage. The use of vacuum excavation methods, described in Section 9, can help to reduce the costs, risks, and disruption of the trial hole procedure.

Trail Holing using vacuum excavation techniques. *Picture courtesy of U Mole/Infotec*.

A recent modern twist to the trial hole way of working has been the development of the 'Virtual Trial Hole'. This technique in no digging but utilises remote sensing techniques such as EM location, ground probing radar etc to conduct a limited location survey, generally a cross section across say a roadway, to establish the positions of utilities beneath that particular road section. By comparing this small section or 'virtual trial hole' to the existing plans any discrepancies can be highlighted which may lead to the need for further investigation. If no discrepancies are found it can be assumed the existing plans are accurate. By completing a number virtual trial holes over an area of proposed work will enable the level of accuracy to be established whilst minimising the effort and cost as compared to completing a full remote sensing survey or actually digging actual trial holes and creating the disruptions they can bring with them.



Typical output from a Virtual Trail Hole survey. *Picture courtesy of Infotec Consulting*.

ACCESS POINTS AND SURFACE ACTIVITIES

Although all of the Technologies featured in these Guidelines are described as Trenchless, in practice, all require some excavation to allow access to the pipe. The only exception is the renovation of Sewers using some types of close fit lining technologies. In some cases all necessary access to the pipe is via existing manholes, and intermediate connections can be reinstated robotically from within the main pipe. However, other types of Sewer Renovation using close fit liners require enlargement of existing manholes and/or excavation of additional pits

Pressure Pipes such as gas and water mains are not normally equipped with manholes or other types of usable surface access points. Therefore some excavation is always required to create access points for liner installation and termination and to allow reinstatement of service connections and accommodation of in line equipment such as valves and junctions

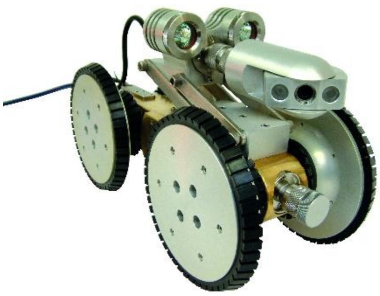
Each Rehabilitation Technology has its own particular set of requirements for the magnitude and location of excavations. Such requirements must be taken into account in Project Planning as discussed below. In addition to the location of excavations it is also necessary to consider the location and site footprint of all surface equipment and materials used in the Rehabilitation Process. Careful planning of these features prior to contract commencement can help to minimise traffic disruption and environmental impacts and reduce safety hazards to the workforce and the general public. Safety is considered in more detail in Section 9 of these Guidelines.

PRE REHABILITATION INSPECTION

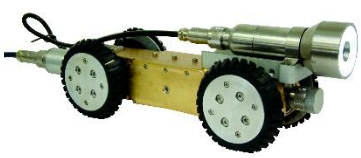
Where the existing pipe is being utilised in the rehabilitation either as a convenient route for new pipe installation or as a vehicle for renovation, it is essential to inspect it just prior to commencement of the project. If the existing pipe is being used as a route for a replacement line by, for example, conventional sliplining, the inspection ensures that there are no obstructions to insertion of the liner. Where sewers and other pipelines are being renovated, using a close fit liner, the inspection checks the following.

A. The pipe has not deteriorated significantly since the original assessment. was carried out and the selected renovation technique is still valid
B. There is no debris, surface deposits, roots and/or protruding fittings and other obstacles which might prevent or seriously impair liner installation.
C. That the exact position and orientation of manholes and side connections has been accurately recorded and verified
D. That the location, type and exact geometry of diameter changes and vertical and horizontal bends has been determined
E. That the pipe inner surface has been cleaned to the standard required by the specific rehab technology

In man entry size pipes, the inspection can be achieved by walking or crawling through the line and recording the necessary data. In non man entry pipes CCTV survey is used. In the case of pressure pipe liners, the suitability of the pipe for liner insertion may also be assessed by pulling a proving pig through the line. It is common practice for the client to be given the results of these inspections prior to commencement of the work so that any necessary remedial actions and/or changes in installation procedures can be advised.



Typical CCTV camera systems used for non man entry pipeline surveys. *Pictures courtesy of AM Industrial.*



CLEANING

Pipeline cleaning is an essential precursor to renovation and may even be classed as a renovation technique in its own right provided that the pipe being cleaned is basically structurally sound and in good working order apart from the need for cleaning. The main purposes of cleaning include

A. Removal of materials such as silt and fats

B. Removal of surface deposits such as corrosion products to maximise the existing free bore and create a surface appropriate to the renovation method to be used. This is particularly critical where a good bond is required between the liner and the pipe wall.

A wide range of cleaning techniques is available for both gravity(sewer) and pressure pipes.

SEWERS

Various hydraulic and mechanical methods are available for main line sewer cleaning. Hydraulic cleaning methods include equipment that uses water and water velocity to clean the invert and walls of the sewer pipe. Mechanical cleaning methods use equipment to physically remove the material from the walls and invert of the sewer pipe.

Hydraulic Cleaning

High-Velocity Cleaners: High-velocity cleaners are very efficient machines that provide the most flexibility with the least personnel required. A high-pressure stream of water is aimed at the surface to be cleaned. High-velocity cleaners (also known as Water Jet cleaners) can either be truck mounted or trailer mounted. In either case, they are designed as self-contained units for maximum efficiency. All tools required to route traffic, remove manhole covers, and for safety of the job site are carried on the truck, as are the various nozzles and hoses required for proper operation.

A van-mounted High Velocity (or Water Jet) cleaning unit. *Picture courtesy of Flowplant*.

The removal of debris from the sewer usually requires two operators on the normal high-velocity machine, but some agencies operate with a one-person crew in certain situations. Under these circumstances, additional crew members should be available nearby if needed.

An enhancement to the high-velocity machine is the addition of a vacuum unit for removal of debris from the manhole. When sand, silt, and other material are brought back to the manhole, it can be removed easily with the vacuum unit instead of manually removing it. When a vacuum unit is combined with a high-velocity cleaner on the same vehicle, it is frequently referred to as a combination machine.

Another advantage of larger high-velocity cleaners is the availability of root cutters. Which involve attachment of a flat blade to the end of the nozzle. Pressure from the high-velocity stream of water spins the cutting blade causing it to cut through roots as it passes through the sewer. With the addition of root cutters, high-velocity cleaners are capable of cleaning every type of debris from a sewer main. High-velocity cleaners are the most frequently used equipment for sewer maintenance.

It is important to remove sand and gravel at the nearest downstream manhole as flushing progresses. If it is washed downstream, it can create even greater problems at pumping stations and treatment plants.

There are other devices (balls, kites, bags, parachutes, scooters, etc.) that can be used to improve performance of hydraulic cleaners, particularly in large gravity sewers where high-velocity cleaners are not as effective. These devices use water pressure behind the tool to develop hydraulic water pressure and scour the pipe as the tool moves through the pipe.

Most small to medium size systems and many larger systems subcontract cleaning and televising to specialists who have the proper tools and training to not only clean and CCTV, but seal and grout leaks and cut off protruding service connections.

Mechanical Cleaning

Rodders: Mechanical cleaning means the use of some type of physical device that scrapes, cuts, or pulls material from the main line gravity sewer. The original method, called hand rodding, is the oldest and most labor-intensive method of mechanical cleaning. Small engine-powered rodding machines are now available. These machines are very inexpensive and provide a very effective method of cleaning in smaller systems and also in remote easements or right-of-way areas where large equipment cannot gain access.

Larger mechanical power rodders are equipped with a reel to carry the steel rods and an engine to provide the force to rotate, push, and pull the steel rods. Power rodders are available in both truck-mounted and trailer-mounted models and a variety of different engine sizes are available for each type of unit.

Truck-mounted rodders can travel more quickly than trailer-mounted rodders, which must be towed to the work location. Also, truck-mounted units have the advantage of offering power takeoff capability. Some disadvantages of truck-mounted units are their limited maneuverability and the fact that if the rodder breaks down, the truck cannot be used for any other purpose while repairs are made. With a trailer-mounted unit, the truck can be used for other purposes when the power rodder is not in use. Also, the trailer-mounted unit costs less.

Power rodders can clear most obstructions in a sewer main. The rodder is effective in cleaning roots and grease as well as cleaning or opening stoppages in the main line. The power rodder is not as effective when working with deposits of solids such as sand or gravel because the tools do not have the ability to move the material. The tools are designed to cut or scrape materials from the pipe walls and are most effective on hardened grease and roots.

Power rodders are usually less expensive than high-velocity or combination machines. However, power rodders do involve more setup time than high-velocity cleaners. Power rodders normally must have drivable surfaces to operate efficiently; in extreme cases, a trailer-mounted unit can be hauled into off-road situations by using a backhoe to pull it along. Both the power rodder and the high-velocity cleaner must have well-trained operators. Either machine can seriously injure operators or damage the sewer main if it is not operated properly.

Bucket Machine: Power bucket machines are another type of mechanical cleaning device; and are used to remove debris, roots, grease, or sediments from main line sewers. A bucket machine is equipped with a set of specialised winches that pull a special bucket through a pipe to collect debris. The captured materials are then physically removed from the pipe.

These machines are very powerful and offer the best cleaning product with the least opportunity for operator error that could affect the results. Since a full-size cutter and brush can be pulled through the line, each cleaning should be thorough and no

PRESSURE PIPES

When pipes are severely scaled or suffer from tuberculation, as is the case with many water mains, a more aggressive cleaning technique is sometimes required. Scraping is a commonly used technique, which relies on a pipeline being open sufficiently, to pass a winch wire through it. Once in place a scraper head, normally a circular rubber or metal device, in the form of a wire brush or metal sheet or rubber shape that may or may not have some form of serration on the cutting edge, is attached to the wire and pulled through the pipe. The scraper dislodges any build-up of material and, as it is normally designed to match the internal diameter of the pipe, it pulls the debris to end of the pipeline into the winching access pit. Where necessary the static scraper head can b replaced by a flail attached to a rotating rod. The flail dislodges any unwanted material and it falls into the invert of the pipe. Jetting or flushing may then be used to remove the debris.

A selection scraper devices for pipeline cleaning. *Picture courtesy of Pipe Equipment Ltd.*

Where the pipe is heavily tuberculated it may not be possible to insert the winch wire and a system such as Rack Feed Boring must be used. This uses a boring head rotated and advanced through a series of drive rods. The system is pushed into the pipe, and water flushed in the opposite direction, to clear the debris. In some cases, the utility will insist that the contaminated flushing water is disposed of by tanker.

When all else fails, the pipe can be cleaned by using water jets, operated at very high pressure, and this technique is generally used with renovation techniques which depend on a good bond. A major disadvantage of these aggressive cleaning techniques is the potential for damage to the host pipe under renovation. It has, at times, been known to cause so much damage that the renovation technique employed, has had to be changed, because the original choice becomes unsuitable for the new problems created.

PIGGING

Where the main cleaning work has been successful, sometimes a pipe requires a final inner wall surface clean. To achieve this, a pipe 'pig' can be employed. A pig is often a foam or plastic cylindrical plug that fit tightly, but not too tightly, in the internal diameter of a pipeline. The pig is pushed through the pipe,

A selection of foam pigs. *Picture courtesy of Pipeline Pigging Products Inc.*

using compressed air or water pressure to remove any remaining fine silts or particles that may interfere with a renovation process.

On some pipeline, 'pigging' can be used as the main cleaning technique, and is regularly used in the cleaning of plastic pipelines.

Pigs used for the main cleaning action can have smooth outer skins or can be manufactured with a variety of external designs for removing debris from the pipe wall and transporting it out of the pipe.

MAINTAINING SERVICE AVAILABILITY

In many circumstances, even with the use of Trenchless Technology, there is a requirement to take sections of a service offline during the course of the replacement or rehabilitation work. In the case of sewers this often means that, unless the storage capacity upstream of the worksite is sufficient, a flow Bypass/over-pumping system has to be established to ensure continuing sewer services to customers.

In terms of water or gas supply, unless the work downtime is very short, there is frequently a need to establish a temporary supply service to affected customers. Power and telecommunications cables are not generally affected by this type of interruption since it is normal to install a new cable before the supply switch occurs, a move that is normally planned to be of short duration.

In both the sewer bypass and the temporary service supply scenarios, the requirement and the cost of providing temporary services may have a significant impact on the selection of the replacement or renovation technique that will be used,. The cost of such a service provision must be taken fully into account when comparing the cost of alternative rehabilitation technologies.

Sewer Bypass

Sewer Bypass/over-pumping systems are generally required where the work is likely to take longer than the storage capacity of the pipeline remaining in service can handle. More often than not the bypass set up for any particular job works on the adage that the bigger the sewer, the bigger the operation and therefore the bigger the likely need for over-pumping.

Flow monitoring undertaken during the investigation and analysis of a pipeline will indicate the levels of flow likely to be encountered and therefore the level of over-pumping capacity required. If this information was not obtained at the during the condition assessment of the pipeline it will need to be established accurately before any system can be adequately designed.

The general layout of a bypass system requires the section to be renovated/ replaced to be isolated from the remainder of the system, which will continue to operate normally. This would be achieved with adequate sealing techniques or stoppers in the pipelines at either side of the work site, probably at least one manhole further upstream and downstream of the work site.

A typical large-capacity bypass pumping system working from an existing manhole. *Picture courtesy of Hampton Roads Sanitation District, Virginia, USA.*

An adequate pumping system is then installed at the final operating manhole on the upstream side of the site to raise the flows out of the manhole and pass them to the first available operating manhole on the downstream side of the work site via the bypass pipeline.

Adequate supervision and maintenance, fuel/power supplies, noise regulation, site access, traffic control and disruption to the local area of such a pumping system are all aspects of the temporary system that are vital to control correctly during the operation as it is likely to have to work 24 hours per day for as long as the work site is open. Positioning the pumping system and its pipelines correctly will not only make life easier for the contractor but also reduce the likelihood of complaints for local residences and businesses.

Where expected flows are relatively small the bypass pipe may be able to be placed in the open across the work site with some form of protection shield to prevent damage/leakage. If the system is to operate for a significant length of time or where the over-pumping main crosses working highways there may be a need to find a way/route along which it could run to ensure continued uninterrupted operation.

If the sewer under renovation or replacement has significant inflow into it under the normal course of operation which is outside of the storage capacity of the lateral connections, bypass arrangements for these lateral connections may also have to be put into place during the course of the main works. This may involve one or more smaller pumping systems taking flows from laterals and feeding to a downstream manhole.

Maintenance of Service Supply

Where supply main replacement or renovation is being undertaken there is often a need to establish a temporary supply, which may cover either water or gas supplies, in order to keep the customers effected by the works 'on line'.

With temporary supply pipelines, more often than not a connection is made at a convenient position either side of the work site. As the service is normally pressurised, connection to a surface laid temporary pipe that is directly connected to the customer's service pipe will allow continued supplies to be maintained.

The main disadvantage to this of course is that the service pipes have to be exposed to allow this connection to be made and unmade at the beginning and at the end of the main work programme. The temporary supply pipe is also often found running along surface in the street. Covers prevent damage and therefore the potential for leakage but often this also makes for poor pavement surfaces, which can limit access to many, particularly the less able. Therefore routing of these services has to be carefully planned and executed. The contractor must also maintain large stocks of the pipe used for temporary mains, and must be able to provide 24 hour monitoring and maintenance.

POST REHABILITATION ASSESSMENT

When rehabilitation work is complete, acceptance by the client is normally subject to agreed assessment criteria. In the case of sewer renovation, the assessment normally consists of a CCTV survey of the lined pipe. This is used to check the general appearance of the liner, the presence of any obvious defects, such as wrinkles, and the quality of lateral reinstatement.

The acceptance of lined pressure pipes is often based on a combination of CCTV survey and pressure tests. It should be noted that a lined pipe behaves differently to the original pipeline, when pressure tested. As the internal pressure is applied, the liner will expand until any micro annulus is eliminated. This occurs over a period of time, during which, additional water must be added, to maintain the test pressure. This could be interpreted as a test failure, in terms of standard pressure tests .and is normally accommodated by using a timed pressurisation cycle which allows time for the liner to expand and stabilise at lower pressures

If the liner is designed to be semi structural, then the test pressure should be carefully selected, to reflect the current structural condition of the host pipe.

SITE SAFETY AND ACCESS

General site safety is always a concern to buried service operators, and the specifics of site safety arrangements guidelines, and regulations, differ from country to country, and so are far too numerous to cover in detail here. Although it should be stressed that safety is of the utmost importance wherever you may be in the world and that local regulations should be adhered to stringently for the safety of all.

One of the main arguments for the use of trenchless technology for the past 30 years has been its ability to reduce disruption to local communities and businesses. More often than not this has been achieved in one of two ways. First the work sites tend to be there for less time, so reducing the impact of the works in terms of time, and secondly, the technologies tend to utilise much smaller footprints in terms of operating space. This latter ‘advantage’ does carry with it some provisos however.

Confined space access requires the correct equipment and training. *Picture courtesy of CAS Ltd, UK.*

With generally smaller openings and accesses, trenchless technologies do offer a smaller ‘vision’ target, so it is very important that signing and fencing are of a high standard, wherever they may be. This in turn leads to the argument that positioning of access pits, shafts, working areas must be taken into account in laying out a project. This involves both public, and workforce safety, and also the requirement for significant vehicular access. Such access is needed for everything from continual delivery and removal equipment (pipe delivery to a microtunnel for example where storage space in minimal) through active participation of equipment in the trenchless process (boilers for water-based CIPP lining for example). The limitations this access will place on others, such as business / residential access (if placed close to industrial site gates etc), must also be considered.

As well as positioning, the access to the shafts/pits etc should be made as difficult as possible out of working hours, and even during working hours where open pits may be left for some time unattended, with not only sufficient fencing but also top covers where necessary. Signing and lighting may also be required.

As well as preventing access to unauthorised personnel there is a general requirement for safe working practice according to national regulations, which should be rigorously adhered to. In specific circumstances with certain trenchless technologies where chemical or other hazardous potential exists, personnel should be issued with the relevant safety clothing and equipment and the training necessary to use this equipment correctly.

Where man-entry is required into confined spaces, the relevant Nationally-recognised Training should have been completed by all necessary personnel and Certification achieved as required. This should include not only the use of access equipment but also site ventilation, breathing apparatus, communications and monitoring systems, such as gas detectors, and rescue systems where necessary.

SUMMARY

1. Site survey and investigation pre- and post trenchless operation is as important in many instances as the work itself.
2. Various techniques are available to achieve a successful site investigation for most given circumstances including Trial Holes, CCTV and GPR.
3. Cleaning can also be as important a part of the operation as the trenchless process itself, with a variety of tools to aid the contractor being available.
4. Maintenance of services around the work programme can play a significant role in the success of a project not least by way of maintaining public support. Bypass and temporary service installations should be planned in advance and positioned with a view to least disruption to everyday traffic and life
5. Safety is paramount in all situations not just for the protection of the workforce but also the general public which will come into contact with projects operating in their locality.
6. Access should be designed to limit the possibility of public entry whilst maintaining the facility to get equipment and materials in and out with the minimum of disruption.