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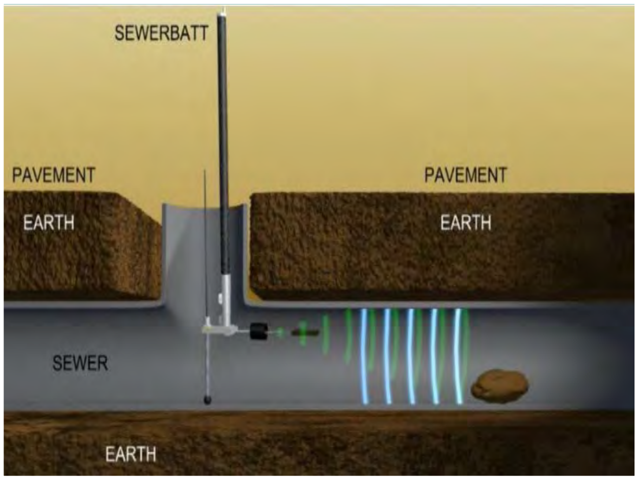
Demonstration of Innovative Sewer System Inspection Technology SewerBatt™



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Demonstration of Innovative Sewer System Inspection Technology SewerBatt™

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Disclaimer

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Abbreviations/Acronyms

3-D	Three-dimension
ADS	ADS Environmental Services
ALSA	ALSA Tech LLC
ASTL	Acoustic Sensing Technology Ltd (United Kingdom)
ATV	All Terrain Vehicle
BC	Brown and Caldwell
CCTV	Closed-Circuit Television
CIP	Cast Iron Pipe
CMOM	Capacity, Management, Operation and Maintenance
DAQ	Data Acquisition (electronic data communication module)
DE	Dissipation Energy
DIP	Ductile Iron Pipe
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
HD	High-Definition
IBAK	Ingenieur Büro Atlas, Kiel (manufacturer of RapidView and PANORAMO (CCTV))
I&I	Infiltration and Inflow
LC	Lateral Connection
MCR	MATLAB Compiler Runtime
MSDGC	Metropolitan Sewer District of Greater Cincinnati
NASSCO	National Association of Sewer Service Contractors
NRMRL	National Risk Management Research Laboratory
O&M	Operation and Maintenance
ORD	Office of Research and Development
OSHA	Occupational Safety & Health Administration
PACP	Pipeline Assessment and Certification Program
PC	Personal Computer
PE	Pipe End
POTW	Publicly Owned Treatment Works
PTSI	Pegasus Technical Services, Inc.
PVC	Poly-vinyl Chloride
QAPP	Quality Assurance Project Plan
RAG	Red, Amber and Green (summary pipe conditions)
RCP	Reinforced Concrete Pipe
RF	Radio Frequencies
SD	secure digital (data storage card)
SL-RAT	Sewer Line – Rapid Assessment Tool
SSO	Sanitary Sewer Overflow
USB	Universal Serial Bus
VCP	Vitrified Clay Pipe
WERF	Water Environment Research Foundation
WSWRD	Water Supply and Water Resources Division

Abstract

The overall objective of this EPA-funded study was to demonstrate innovative a sewer line assessment technology that is designed for rapid deployment using portable equipment. This study focused on demonstration of a technology that is suitable for smaller diameter pipes (less than 12-inch diameter). The recently developed and commercially-available acoustic-based sewer pipe assessment technology demonstrated during this study was the SewerBatt^{TM} manufactured by Acoustic Sensing Technology LTD (ASTL), based in the United Kingdom.

This technology can provide a rapid assessment of the need for pipe cleaning and to detect obstructions and defects in sewer pipes. Acoustic technologies require a minimal amount of equipment when compared to traditional closed-circuit television (CCTV) inspection systems. This acoustic based technology has the potential to provide information in a matter of minutes to assist an operator in determining whether a sewer pipe might be partially or fully blocked and require cleaning or renewal. The speed of the assessment, using minimal equipment, has the potential to result in significant cost-savings compared to traditional methods, such as CCTV inspection. It is generally known that smaller diameter pipes (i.e., less than or equal to 12-inch diameter) contribute to over 90 percent of the sewer main backups reported in a typical city (Sprague, J., 2007). This study hence focused on the demonstration of an acoustic technology that is suited for smaller diameter pipes.

This collaborative field demonstration of the SewerBatt was led by EPA's National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio. EPA worked with the Metropolitan Sewer District of Greater Cincinnati (MSDGC) as a collaborative research partner to identify study locations, provide access to the study area sewer lines and to perform the related field work. Specifically, the data and information obtained from the following technologies were used in this demonstration project: SewerBatt; Pan-Tilt-Zooming pole-mounted camera (aka "camera on a stick") manufactured by Envirosight Quickview; and HD-digital scanning CCTV or the PANORAMO 3D Optical Pipeline Scanner manufactured by RapidView-IBAK.

The results of this demonstration of the SewerBatt show promise for the application of this technology as a tool for cost-effective, pre-cleaning assessment, post-cleaning quality assurance and quick condition assessment screening. The application of this technology in an overall collection system O&M program should enable wastewater utilities to optimize their sewer cleaning efforts and free up valuable resources to more effectively implement critical CMOM and asset management programs. Also, with further development, SewerBatt has the potential to provide very useful sewer defect identification and location capability.

Executive Summary

The focus on condition assessment of gravity wastewater collection systems (sewers) continues to broaden. Traditionally, the main focus of condition assessment of sewers has been directed at operational issues related to the collection and conveyance of flows to a facility for treatment and disposal. To address operational issues, attention has tended to concentrate on maintenance activities associated with the cleaning and removal of debris and foreign materials from collection system pipes. The combination of debris and extraneous wet-weather induced flows can result in less than desired levels of customer service and possibly cause raw sewage to overflow from the collection system or to result in basement backups.

Cleaning and inspecting sewer pipes is essential for utilities to operate and maintain a properly functioning system and minimize SSOs. The routine maintenance of a sewer system often includes sewer system cleaning, root removal/treatment, and cleaning/clearing of sewer mainline blockages. However, understanding where and when to perform cleaning activities in the most effective manner is not necessarily a straight forward task. In an attempt to direct maintenance staff and cleaning equipment to those pipes in a sewer system that require attention, some agencies identify cleaning needs by conducting inspection of the sewers prior to cleaning. Rapid assessment approaches and tools provide an avenue to significant pre-cleaning inspection cost savings that could be achieved through reduced inspection and non-productive cleaning costs.

The overall objective of this EPA funded study was to demonstrate a recently developed innovative acoustic-based sewer line assessment technology that is designed for rapid deployment using portable equipment. This technology can provide a rapid assessment of the need for pipe cleaning and an overall pipe-condition assessment. Acoustic technologies require a minimal amount of equipment when compared to closed-circuit television (CCTV) inspection systems. These acoustic based technologies have the potential to provide information in a matter of minutes to assist a utility in determining whether a sewer pipe might be partially or fully blocked and require cleaning or renewal.

Innovative inspection approaches are now emerging that take advantage of the advances in newly available observation and detection technologies and deployment strategies, such as acoustic- (sonic, ultrasonic) and light- (laser, infrared) based devices that have not traditionally been applied to sewer system investigation. These technologies are designed for rapid deployment using portable equipment and do not necessarily require a robotic transporter in order to capture data for the entire length of the pipe. The deployment of these non-traditional technologies, supported by emerging digital, modular, and robotics technologies has the potential to greatly expand the "reach" of sewer system inspection techniques, while reducing the overall cost of sewer inspections.

One commercially available line of emerging technology for the rapid assessment of gravity sewer lines is acoustic-based technology for sewer inspection. Acoustic energy naturally follows a pipe's curvature. Obstructions within the pipe will cause a portion of the acoustic energy to be reflected and absorbed. In addition, unless the obstruction is significantly dense, a portion of the acoustic energy also passes through. These inherent physical properties of acoustics within pipes provide the mechanisms for evaluating a pipe's condition. Based on these mechanisms, acoustic inspection technology may be capable of quickly evaluating the presence of blockages, features, and defects in the interior of sewer pipes and provide informed decisions relating to the need for cleaning or further inspection using other available technologies.

The SewerBatt is a portable, battery-operated, acoustic sewer inspection tool that consists of an acoustic sensor head that is mounted on a pole (similar to a pole-mounted camera device) which is lowered into the manhole and inserted into the pipe being inspected. The sensor head contains a sound source (speaker) that transmits an acoustic excitation signal into the pipe. Simultaneously, the acoustic signal response from the pip is captured by an array of microphones that are also contained in the sensor head. The captured signal responses, along with the user inputs related to the pipe section being inspected, are used to assess the pipe condition.

After the device is inserted into the pipe and the user inputs are completed, the user can click on the "run" button to run an inspection test. Typically, the signal transmission and response recording process is completed in less than a minute. Features (such as lateral connections and the pipe end) and defects (such as broken pipes and sedimentation) affect the acoustic excitation signal either by reflecting a part of it back to the SewerBatt sensor, or by absorbing the sound energy. These pipe segment features (or defects) are presented as "bumps" in the acoustic signal response plots. By comparing these response bumps recorded with a library of known signal responses, the system provides an assessment. For rapid assessment, an automated condition assessment module that reviews the acoustic signal response, makes allowance for the energy loss from the pipe-ends and lateral connections, and then grades the pipe. The final pipe condition or grading is simply in the form of a colored traffic light indicator providing a red, amber (yellow), or green (RAG) grade. A red grade assessment indicates the need for further inspection or cleaning. An amber grade assessment is cautionary, indicating that there may be some blockage issues, but not sufficient to block the flow. A green assessment indicates the pipe is free of any significant blockages and no further evaluations are necessary.

MSDGC is responsible for the operation and maintenance of over 3,000 miles of sewer, with approximately 600 miles of those sewers being "off-road." These off-road sewers are typically inspected every 8 – 10 years and are difficult to access, and expensive to inspect. In addition to these "off-road" sewers, MSDGC also inspects and cleans on-road sewers on a proactive basis. For the purposes of this study, the following three Greater Cincinnati-area locations were identified and selected for this demonstration:

- Hunt Road – off-road sewers (see Appendix B for a detailed figure)
- Galia Drive – off-road sewers (see Appendix B for a detailed figure)
- Greenhills – on-road sewers (see Appendix B for a detailed figure)

These locations include a range of pipe sizes and a variety of pipe materials and were scheduled for cleaning and inspection during the study year. The selected study areas have sewer pipes ranging from 6- to 12-inch diameters. The SewerBatt system deployed in this evaluation is designed to work optimally in this pipe size range. For optimal evaluation of larger diameter pipes, the acoustic unit would require retrofitting with larger sized and more powerful electronic hardware coupled with adjustments to the algorithm software.

A project-specific EPA required Quality Assurance Project Plan (QAPP) was developed and implemented by the project team. Each sewer pipe-segment was to be examined and assessed using selected acoustic methods, pole mounted camera, and CCTV prior to cleaning. If cleaning was considered necessary based on the inspections, the sewer segments were to be cleaned, examined, and assessed again after cleaning. Per the project's QAPP, the following strategy was specified for conducting the inspections. Sewer line branches were to be inspected by starting at the furthest downstream pipe segment, with the inspection regime systematically conducted to the furthest upstream pipe segment. This procedure was specified to ensure that if any material (or debris) was dislodged during testing, the material would flow downstream and not impact subsequent testing in the upstream pipe segments.

Besides providing a pipe condition and blockage assessment, the key advantage of implementing technologies such as SewerBatt is the rapid deployment feature using portable equipment that can result in significant cost savings to utilities. As mentioned previously, the Greenhills area within MSDGC was selected to evaluate the time it takes to conduct an acoustic assessment campaign using SewerBatt. As the goal of this study area was to evaluate the time required to perform the acoustic inspections, advanced planning and preparation was conducted to help mitigate issues associated with traffic control and location of manholes. This sub-study involved sixty-two (62) SewerBatt measurements at pipe-segments covering approximately 10,000 linear feet of pipe in the Greenhills study area with pipe sizes of 8" and 10" diameters.

The emergence of acoustic sewer inspection technologies (e.g., SewerBatt) as rapid deployment, low-cost, reliable, pre-cleaning assessment tools is focusing growing attention on the potential for more cost-effective sewer cleaning programs. Through the ease of deployment, reduction of cost, increases in reliability of these inspection approaches, combined with the potential for reducing the "cleaning of clean pipes," significant cost savings are attainable. As utilities apply these new inspection technologies, they can move towards implementing sewer cleaning programs that consist of planned directed and quick response cleaning. Also, these cost savings can be realized while improving collection system performance and achieving the protection of public health and water quality.

The results of this demonstration project reveal the potential for more cost-effective sewer cleaning programs. The site specific pre-cleaning assessment inspection costs resulting from this project and MSDGC's historic practices for CCTV (on-road), CCTV (off-road), and SewerBatt (on- and off-road) are $1.68/ft., $2.03/ft., and $0.13/ft., respectively. Thus, for pre-cleaning assessment, the application of the SewerBatt can reduce MSDGC's costs by $1.55/ft. for on-road sewers and $1.90/ft. for off-road sewers. In addition, by moving to a sewer cleaning program predominated by planned directed cleaning, MSDGC can save $2.00/ft. by reducing its "cleaning of clean pipe." In total, when costs of conventional CCTV inspection and cleaning are combined, for each pipe segment that is deemed "clean" using the SewerBatt, MSDGC can save $3.55/ft. for on-road sewers and $3.90/ft. for off-road sewers.

The results of this demonstration of the SewerBatt show promise for its application as a tool for cost-effective, pre-cleaning assessment, post-cleaning quality assurance and quick condition assessment screening. The application of the SewerBatt in an overall collection system O&M program should enable wastewater utilities to optimize their sewer cleaning efforts and free up valuable resources to more effectively implement critical CMOM and asset management programs. Also, with further development, SewerBatt has the potential to provide a very useful sewer defect identification and location capability.

1.0 Introduction

The focus on condition assessment of gravity wastewater collection systems (sewers) continues to broaden. As sewer system networks age, the risk of deterioration, blockages, and collapses becomes increasingly of concern. The consequences of these events and conditions can negatively impact a community's social, environmental and financial well-being. As a result, sewer system owners and operators worldwide are taking proactive measures to better maintain and improve the performance levels of their sewer systems. Sewer system owners and operators are progressively addressing operational issues prior to their occurrence, when possible, and obtaining information concerning the condition of their sewer system assets.

Traditionally, the main focus of condition assessment of sewers has been directed at operational issues related to the collection and conveyance of flows to a facility for treatment and disposal. To address operational issues, attention has tended to concentrate on maintenance activities associated with the cleaning and removal of debris and foreign materials from collection system pipes. The presence of debris and foreign material in sewer pipes reduces capacity and inhibits sewage from flowing through the system to the treatment facilities as intended. Additionally, attention has been directed towards the reduction of excessive hydraulic loading of sewers due to wet-weather induced infiltration and inflow (I&I) entering and over burdening the hydraulic capacity of the sewers and wastewater treatment plants. The combination of debris and extraneous wet-weather induced flows can result in less than desired levels of customer service and possibly cause raw sewage to overflow from the collection system or result in basement backups. Unintended overflows from a wastewater collection system are commonly referred to as sanitary sewer overflows (SSOs).

Occasional unintentional discharges of raw sewage (i.e., SSOs) from municipal sanitary sewers occur in almost every system. SSOs result from a variety of causes, including but not limited to line blockages, line breaks, and sewer defects that allow storm water and groundwater to overload the system; lapses in sewer system operation and maintenance; power failures; inadequate sewer design; and vandalism. The U.S. Environmental Protection Agency (EPA) estimates that there are at least 23,000 - 75,000 SSOs per year (not including the sewage backups into buildings). The untreated sewage from these overflows can contaminate the nation's water resources, causing serious water quality problems. Sewage can also backup into basements, causing property damage and threatening public health (EPA, 2012).

1.1 Maintenance of Sanitary Sewers

Many avoidable SSOs are caused by inadequate operation or maintenance, inadequate system capacity, and improper system design and construction. These SSOs can be reduced or eliminated by the following practices (EPA, 2012):

- Sewer system cleaning and maintenance
- Reducing I&I through system rehabilitation, repairing broken or leaking service lines, and removing illicit direct inflow connections from the private sector.
- Increasing or upgrading sewer, pump station, or sewage treatment plant capacity and reliability

- Construction of wet-weather storage and high-rate treatment facilities to treat excess flows

Cleaning and inspecting sewer pipes is essential for utilities to operate and maintain a properly functioning system and minimize SSOs; these activities further a community's reinvestment in wastewater infrastructure (EPA, 1999). For many utilities, sewer cleaning and inspection programs are generally part of larger umbrella programs. These programs are commonly referred to by the utilities and regulatory agencies as capacity, management, operation and maintenance (CMOM) and asset management programs. Effective operation and maintenance (O&M) of a collection system is an essential element of any CMOM and asset management program (EPA, 2005).

The routine maintenance of a sewer system often includes sewer system cleaning, root removal/treatment, and cleaning/clearing of sewer mainline blockages. However, understanding where and when to perform cleaning activities in the most effective manner is not necessarily a straight-forward task. Some agencies clean their sewer system as a matter of course without knowing in advance whether the system or portions of the system require cleaning. Pipes with blockages receive the same attention and resources as those with no actual cleaning needs. The use of staff and equipment is not optimized in this approach, with the result that staff time and resources which could be directed to other more productive O&M activities are lost.

In an attempt to direct maintenance staff and cleaning equipment to those pipes in a sewer system that require attention, some agencies identify cleaning needs by conducting inspection of the sewers prior to cleaning. These pre-cleaning inspections are conducted using various approaches and equipment with varying degrees of success, efficiency and speed.
The speed and cost associated with traditional methods for pre-cleaning inspections vary greatly. The rapid assessment of sewers to determine the need for cleaning and to possibly identify defects is an approach that is capturing wide attention at many wastewater utilities. Rapid assessment approaches and tools provide an avenue to significant pre-cleaning inspection cost savings that could be achieved through reduced inspection and non-productive cleaning costs.

The overall objective of this EPA-funded study was to demonstrate a recently developed innovative acoustic-based sewer line assessment technology that is designed for rapid deployment using portable equipment. This technology can provide a rapid assessment of the need for pipe cleaning and an overall pipe-condition assessment. Acoustic technologies require a minimal amount of equipment when compared to closed-circuit television (CCTV) inspection systems. These acoustic-based technologies have the potential to provide information in a matter of minutes to assist a utility in determining whether a sewer pipe might be partially or fully blocked and require cleaning or renewal. The speed of the assessment, using minimal equipment, has the potential to result in significant cost-savings compared to traditional methods, such as CCTV inspection. It is generally known that smaller diameter pipes (i.e., less than or equal to 12-inch diameter) contribute to over 90 percent of the sewer main backups reported in a typical city (Sprague, J., 2007). This study therefore focused on the demonstration of an acoustic technology that is suited for smaller diameter pipes.

1.2 Sewer Line Inspection Techniques

The traditional sewer system inspection methodologies used for pre-cleaning assessment and inspection-based condition assessment are generally based on visual observations. Most inspections of sewer lines are performed primarily by one or more of the following established inspection techniques:

- Visual (historical)
- Lamping (historical)
- Pole/Stick Mounted Zooming Cameras
- CCTV
- Laser profiling
- Sonar assessment

The historical approaches to visually examining sewers have been used to varying degrees of success. In the past, before camera and robotic equipment were widely available, workers often entered a maintenance access point (manhole) and visually examined the pipes. This method of pipeline inspection is rarely used today due to worker safety considerations, limitations inherent to the inspection method, and the introduction of technologies that allow for remote, non-entry, camera-based inspections.

Workers have long used light sources lowered into sewer access structures or manholes in an attempt at illuminating the interior of a pipe. A second worker positioned at grade at an adjacent manhole then attempts to see if the light has reached the adjacent manhole. If light is observed, the pipe is assumed to be relatively free of obstructions. If light is not observed, the pipe is assumed to have a blockage that also obstructs flow. The pipe would then typically be cleaned in an attempt to remove the blockage. Inspection of a pipe in this manner has been referred to as lamping of lines or simply lamping. Many older sewer systems have lamp holes constructed in the sewers to facilitate this type of inspection. The fundamental issue with lamping of lines is that the entire inspection relies on whether light can visibly be seen from one access structure to the next. The inspectors cannot directly see whether a sewer pipe requires cleaning or if a structural defect exists. Such structural defects might include conditions such as misalignment of the pipeline, sags, protruding taps or a collapsed pipe. A variation of line lamping that has been used extensively is for a worker to enter a manhole and shine a bright light and view the pipe condition using a mirror or direct observation. This approach can be effective but only a small percentage of the line can be inspected.

More recently, cameras have been mounted on poles, much like a painter’s extension pole commonly referred to as cameras on a stick or pole-mounted cameras. A pole-mounted camera is lowered into the manhole by an operator standing at street level, and the camera operator directs the camera’s view into the pipes connected to the manhole. On an integrated monitor, the equipment operator remotely views at street level what the camera observes in the pipe. These cameras are now commonly equipped with operator-controlled lighting and camera focus/zooming capabilities to augment the inspection in an attempt to view and inspect the entire pipe length between access structures.

Pole-mounted zooming cameras are a significant advancement over lamping of lines. However, issues with lighting the entire length of the pipe between access structures and the ability to focus the camera lens at significant distances in poor lighting conditions are limitations of these tools. Furthermore, the effectiveness of this tool is further diminished, if the pipe is misaligned, water vapor is present, or obstructions such as roots or other matter are present.

Robotic platforms, mounted with camera-based technologies, have been in use for sewer inspections for more than 50 years. These robotic systems allow for CCTV camera equipment to be remotely operated, controlled, and monitored from ground level. The inspection images can be viewed immediately and transferred to data storage devices for viewing and evaluation at a later time. Advances in technology include self-propelled equipment, digital imaging and 360-degree field of view. The cameras are transported into the length of sewer pipes for direct visual inspection via the camera. These CCTV systems are now widely used and, over the course of the past 20 to 30 years, become the current industry standard for direct visual inspection of sewer pipes. A majority of utilities own and operate CCTV systems or have contract(s) for the provision of CCTV services.

The most common type of robotic CCTV inspection systems in use for inspection of public sewers requires vans, trucks, or similar vehicles for their operation. If sewers are located off-road, all wheel drive or four wheel drive vehicles may be required to access the manhole structures. A new vehicle equipped with a CCTV inspection system will typically cost between $100,000 and $200,000, and require a minimum crew of two persons. Custom off-road vehicles equipped with CCTV systems are even more expensive to own and operate. Figure 1-1 shows a custom off-road CCTV camera tractor owned and operated by the Metropolitan Sewer District of Greater Cincinnati (MSDGC).

Figure 1-1. Custom Off-road CCTV Camera Tractor (Courtesy: MSDGC)

The use of laser and sonar profiling technologies for the inspection and condition assessment of sewers has been introduced in recent years (EPA, 2009). Laser profiling technology is increasingly being used to inspect sewers. Laser profiling goes beyond visual inspection and allows for geometric measurements to be obtained. However, the adoption of laser profiling for pre-cleaning inspection is of limited added value to what CCTV can provide.

Unlike CCTV and laser technologies, sonar profiling equipment requires that the sensing apparatus be completely submerged and only provides an assessment of the pipe condition under the water level. Therefore, the equipment is often coupled with CCTV equipment so that the pipe above and below the water level can be inspected. Sonar assessment is useful in locating and mapping debris especially in large diameter pipes with significant base-flow, water filled siphons and pressurized force mains.

1.3 Industry Standard Sewer Inspection Methodology

The National Association of Sewer Service Contractors (NASSCO) has established “de-facto” industry standards for the use of CCTV systems in sewers. The standards include acceptable operating parameters as well as observation and defect coding standards for sewer inspection. NASSCO offers the Pipeline Assessment and Certification Program (PACP) for CCTV operators and those who analyze and interpret CCTV data. The NASSCO PACP system provides for the standardization of the description of defects within the industry.

Inspections performed in compliance with the NASSCO PACP require that CCTV inspections be conducted at a pace of no more than 30 feet per minute for camera transporter travel. PACP compliant inspections also require that the system operator stop and view observed pipe defects and features. Advanced technologies using high-definition (HD) digital scanning and imaging CCTV systems are capable of traveling at a faster pace without the need to stop and view observed pipe defects and features, while maintaining visual clarity and gaining high resolution, enhanced defect, and feature observation. The capture of data from these scanning systems allows for virtual pan, tilt zoom operations and post-inspection coding of defects and features. Use of these scanning systems is acceptable under the NASSCO PACP system if image quality is adequate and meets minimum PACP standards.

Typical average daily CCTV inspection production rates vary from operator-to-operator and from site-to-site. A multitude of factors affect the typical average daily production rates. Such factors include the availability of system access locations (e.g., manholes), distance between access locations, pipe diameter, pipe materials, flow depth and velocity in the pipes, presence of debris, number of defects, number of features, CCTV system cable length, transporter weight, and other factors. An average daily production rate between 1,000 feet to 4,000 feet can be expected.

CCTV has revolutionized the manner in which sewer systems are operated, maintained, and inspected, thus making sewer pipe inspection relatively safe when compared to previous methods of inspection. Its greatest strength is its ability to visually examine and inspect the entire length of a pipe. It’s limitation, however, is that the CCTV system must travel the entire length of a pipe to complete an inspection. Significant blockages, defects, or lack of available access denies its ability to inspect the sewer in part or total.

1.4 Innovative Sewer Inspection Methodologies

Multi-sensor robotic transporter platforms have been developed and introduced to the industry that allow for the coupling of laser and sonar profiling technologies onto a remotely operated and controlled CCTV inspection system. These systems provide for significant advancements in the ability to inspect a sewer system. These technologies are typically integrated with the CCTV camera transporter (increasing the overall cost), but providing additional insights into the condition of the sewer.

Innovative inspection approaches are now emerging that take advantage of the advances in newly available observation and detection technologies and deployment strategies, such as acoustic- (sonic, ultrasonic) and light- (laser, infrared) based devices that have not traditionally been applied to sewer system investigation. These technologies are designed for rapid deployment using portable equipment and do not necessarily require a robotic transporter in order to capture data for the entire length of the pipe. The deployment of these non-traditional technologies, supported by emerging digital, modular, and robotics technologies has the potential to greatly expand the “reach” of sewer system inspection techniques, while reducing the overall cost of sewer inspections.

One commercially available line of emerging technology for the rapid assessment of gravity sewer lines is acoustic-based technology for sewer inspection. This technology provides for the acoustic “lamping” of lines rather than using a light source to illuminate the lines. The major difference in operating methods between light lamping of lines versus acoustical monitoring is that the acoustic signal bends along the pipe; unless the pipe has significant blockage, a portion of the signal passes through. In addition, a portion of the transmitted signal will be reflected when obstructions, features, or defects are encountered whereas light is absorbed and/or blocked by those same conditions. The acoustic inspection technology may be capable of quickly evaluating the presence of blockages, features, and defects in the interior of sewer pipes and provide informed decisions relating to the need for cleaning or further inspection using other available technologies.

CCTV sewer inspections, especially in “off road” conditions, generally require special equipment, such as a highly customized vehicle equipped with an on-site generator, remotely operated transporter, tether cable and spool system, operator control hardware, a computer system, specialized software, and various other tools. Acoustic sewer inspections require much less supporting equipment and the inspection equipment is portable, allowing for easier access to remote sites.

Sewer inspections with acoustic-based technology have the potential of being performed in a fraction of the time in which CCTV inspections are performed, thus increasing the rate of productivity of the inspections and reducing the cost of the inspections.

A portable acoustic inspection system can assist in making a quick diagnostic determination whether a sewer line needs to be cleaned or if it needs to be investigated further using CCTV inspection. These diagnostic determinations will allow the utility to more cost-effectively deploy their limited resources to areas that require cleaning or further investigation. It will optimize the deployment of the special equipment and crews required for CCTV inspection to locations where they are most needed, thus increasing the cost-effectiveness of the CCTV inspection program.

1.5 Study Objective

The overall objective of this EPA-funded study was to demonstrate innovative sewer line assessment technologies that are designed for rapid deployment using portable equipment. This study focused on demonstration of technologies that are suitable for smaller diameter pipes (less than 12-inch diameter). One commercially-available acoustic-based sewer pipe assessment technology is the SewerBatt™ manufactured by Acoustic Sensing Technology Ltd (ASTL), based in United Kingdom. This report summarizes the collaborative demonstration of the SewerBatt in a study area consisting of sewer lines operated by MSDGC in the Greater Cincinnati area.

1.6 SewerBatt Equipment Overview

SewerBatt uses acoustic technology to detect obstructions in sewer pipes. The SewerBatt is a portable, battery-operated system that consists of an acoustic sensor head that is mounted on a pole (similar to a pole-mounted camera device) which is lowered into the manhole and inserted into the pipe being inspected. The sensor head contains a sound source (speaker) that transmits an acoustic excitation signal into the pipe. Simultaneously, the acoustic signal response from the pipe is captured by an array of microphones that are also contained in the sensor head. The captured signal responses, along with the user inputs related to pipe section being inspected, are used to assess the pipe condition. Figure 1-2 shows the SewerBatt's conceptual deployment for blockage assessment.

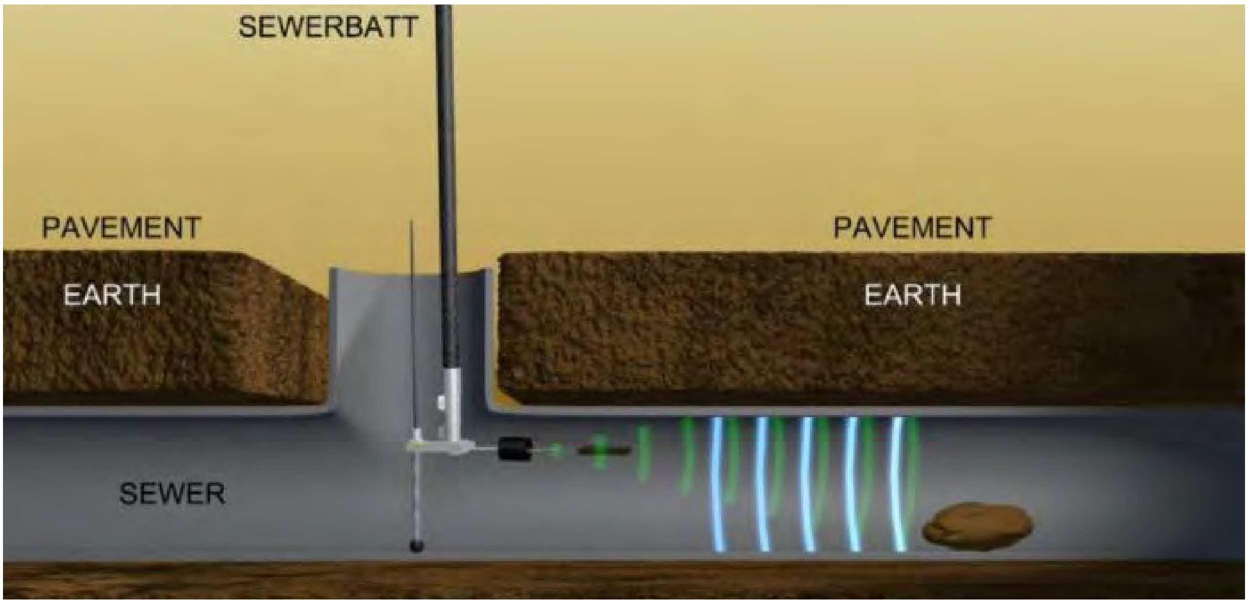

Figure 1-2. SewerBatt Conceptual Deployment

Figure 1-3 schematically illustrates the SewerBatt system used during this demonstration study, including its components and their connectivity. Figure 1-4 shows the SewerBatt system demonstrated during this project.

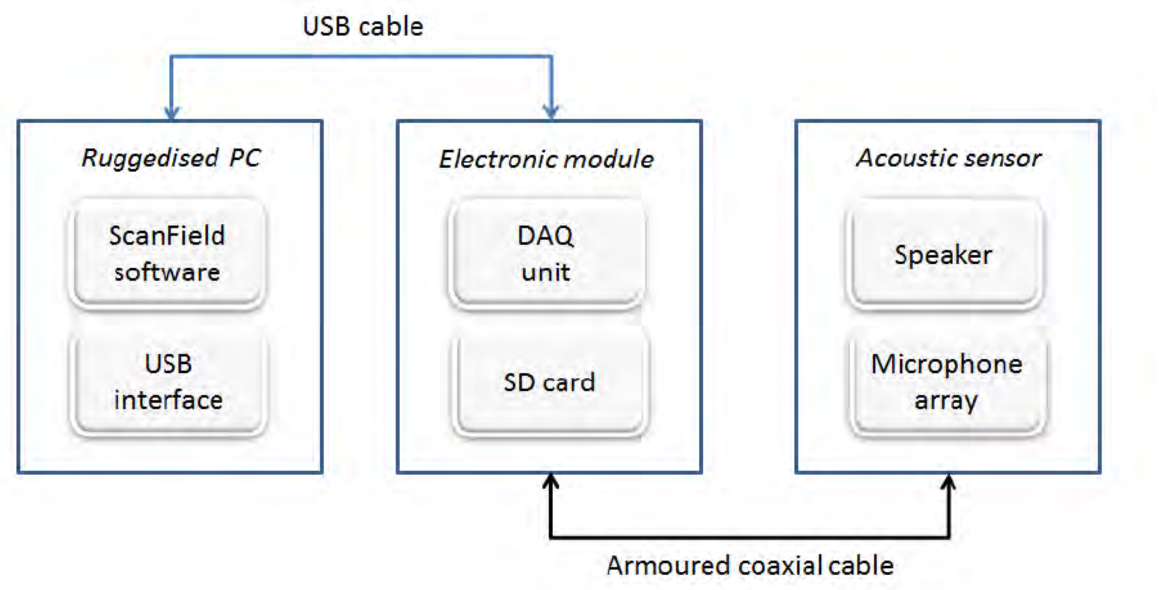

Figure 1-3. SewerBatt System Components and Connectivity

Figure 1-4. SewerBatt System

The main components of the SewerBatt system are briefly described below:

Acoustic Sensor Head – As mentioned previously, the sensor head contains a speaker unit that transmits an acoustic signal and an array of microphones that capture the acoustic signal response from the pipe. Currently, the SewerBatt sensor head is available in two sizes: small (for pipes up to 9-inches in diameter) and large (for pipes up to 18-inches in diameter). Upon request, ASTL can produce a custom sensor head for inspecting pipes of diameter larger than 18-inches. The excitation acoustic signal strength and the associated signal processing hardware are matched to the sensor head-size. As shown in Figure 1-2, the acoustic sensor head is mounted on a pole for insertion into the sewer pipe and is connected to an above ground electronic module via a shielded waterproof cable (note: the electronic module and connecting cable are not shown in Figure 1-2).

Electronic Module - The above-ground electronic module is a small, weather-proof sealed plastic box that contains a data acquisition (DAQ) board and a secure digital (SD) card for data storage. The connection interface to the sensor head and the universal serial bus (USB) connection to the PC are on the outside of this box. The electronic module communicates with a Microsoft Windows-based laptop or a personal computer (PC) via the USB interface. The separate electronic module has been merged with the sensor head in the newer version of the equipment.

Scanfield Software - The acoustic signal response is evaluated and the individual pipe-segment condition is assessed using ASTL's proprietary Scanfield[1] software that communicates with the hardware via the USB interface and serves as the user interface. The Scanfield software comes with a MATLAB Compiler Runtime (MCR)[2] which enables the execution of Scanfield software. Prior to transmitting an acoustic signal, the software requires the user to input basic pipe-segment related information that is used to perform some of the computations. The user input software dialog box is presented as Figure 1-5.

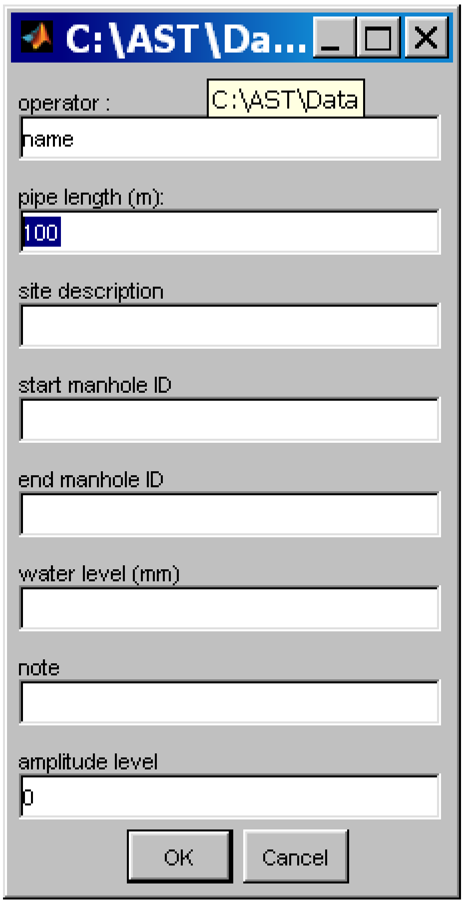

Figure 1-5. SewerBatt User Input Dialog Box

[1] Scanfield Version 1.4.1 was used for development of this report.
[2] MathWorks, Natick, Massachusetts, USA.

A full description of the Scanfield software features is beyond the scope of this document. However, for the purposes of understanding the results presented in Section 3.0, a brief overview of the pipe evaluation procedure is presented in the following section.

1.7 SewerBatt Pipe Condition Assessment Overview

After the device is inserted into the pipe and the user inputs shown in Figure 1-5 are completed, the user can click on the "run" button to run an inspection test. Typically, the signal transmission and response recording process is completed in less than a minute. Figure 1-6 shows SewerBatt's acoustic response "lines" plot output using the Scanfield software for one of the pipe segments (1705013 – 1705012) that was inspected during this demonstration.

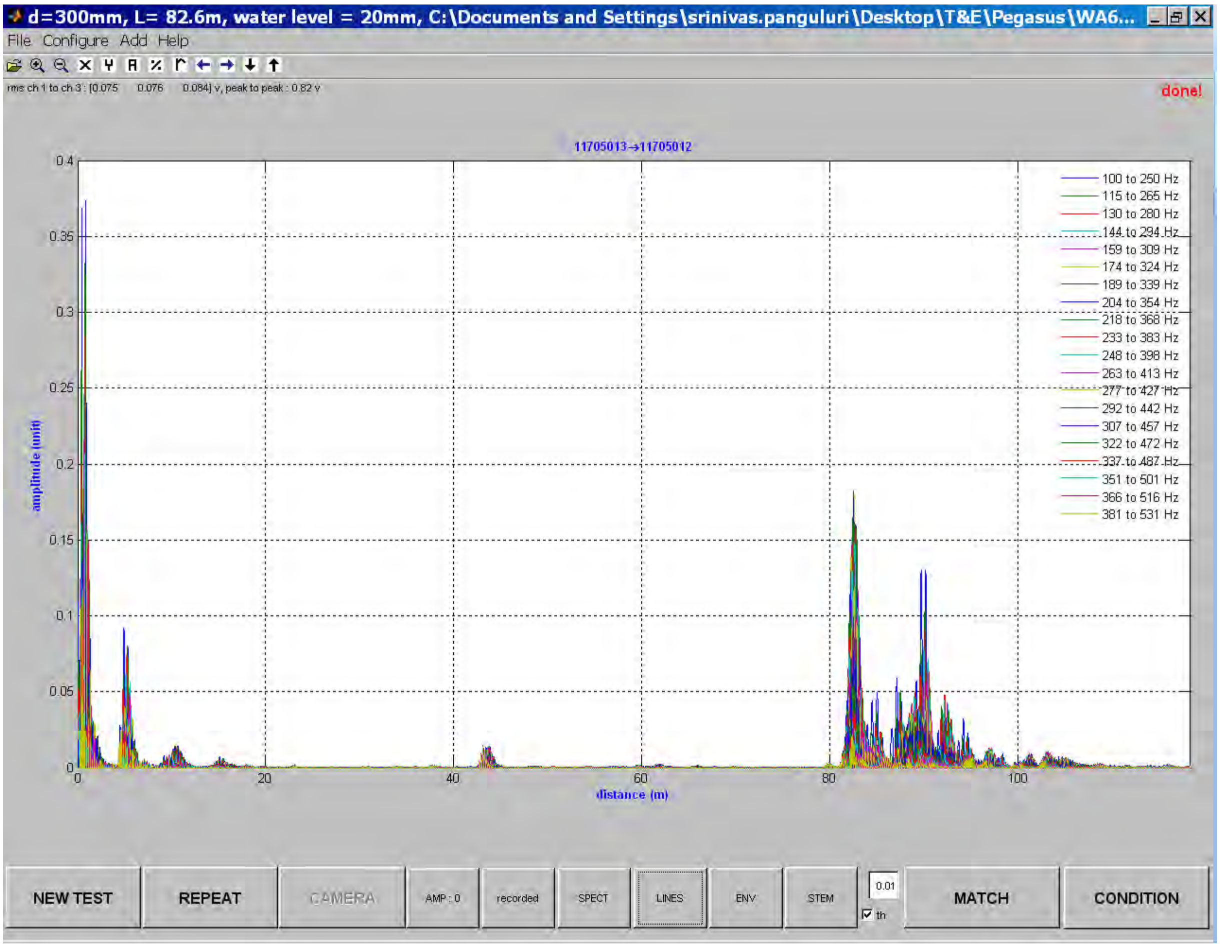

Figure 1-6. SewerBatt Acoustic Response Lines Plot

Features (such as lateral connections and the pipe end) and defects (such as broken pipes and sedimentation) affect the acoustic excitation signal either by reflecting a part of it back to the SewerBatt sensor, or by absorbing the sound energy. These pipe segment features (or defects) are presented as "bumps" in the acoustic signal response plot above. By comparing these response bumps recorded with a library of known signal responses, the system provides an assessment.

A review of the "Lines" plot presented above as Figure 1-6, indicates an initial "bump" or response (at the manhole insertion point) and other responses at approximately 5m, 10m, 44m and 82m (and beyond). The colored lines in this plot indicate the range of frequencies and the relative amplitude of the frequency-specific response from the pipe. Also, the level of detail or “bumps” presented in the plot depends upon the set threshold. The threshold used to generate the “Lines” plot presented in Figure 1-6 was 0.01. This plot can be further reviewed by using the “Envelope” plot option in the Scanfield software presented as Figure 1-7. The level of signal response detail presented in this plot also depends upon the set threshold. For the purposes of discussion, to only highlight features of interest with high amplitude signal response, a different threshold level (0.039) was used to generate the “Envelope” plot presented as Figure 1-7.

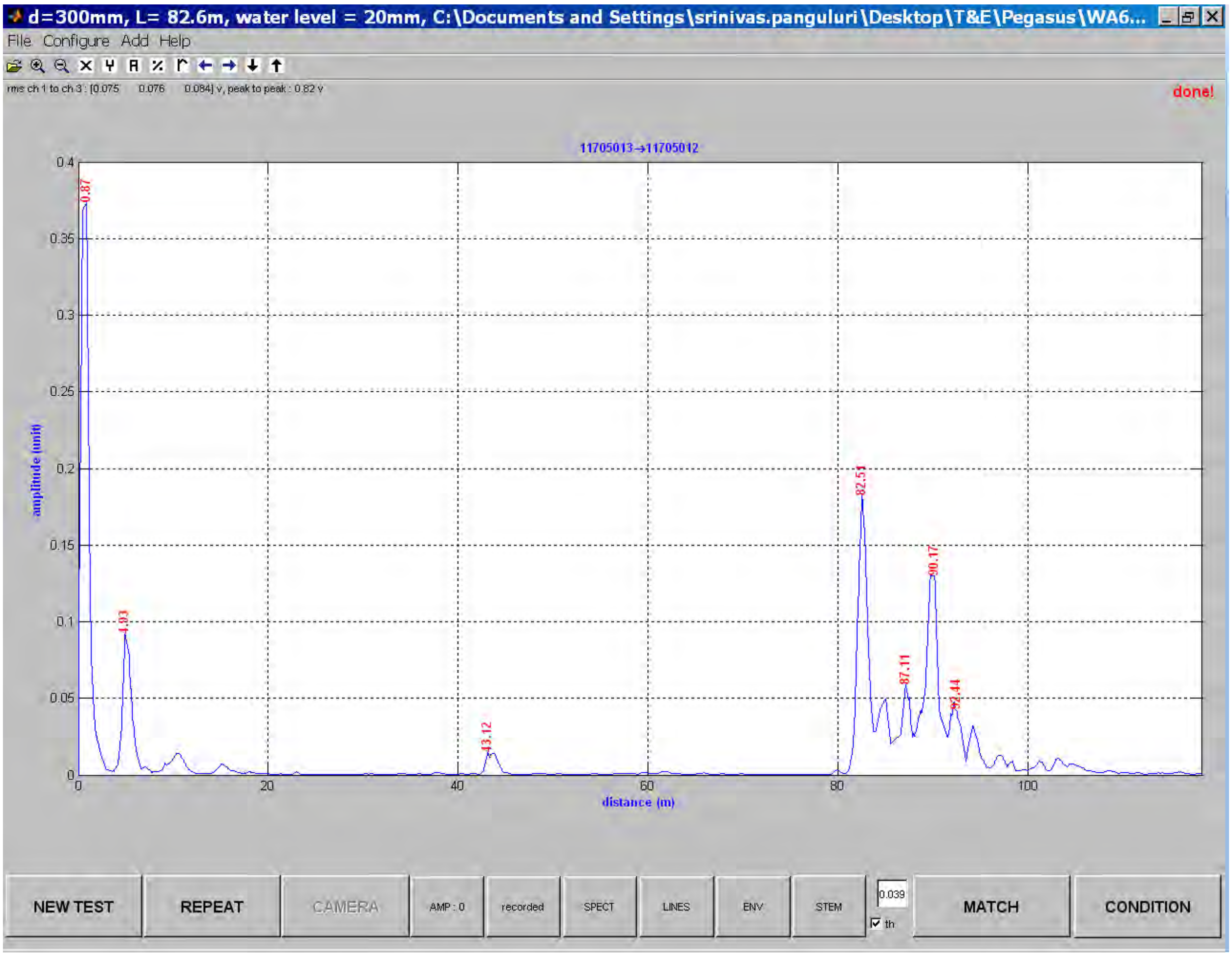

Figure 1-7. SewerBatt Acoustic Response Envelope Plot

At the set threshold-level for this pipe segment (1705013 – 1705012), the SewerBatt identified an initial response from the device insertion point (0.87m), some obstructions at 4.93m and 43.12m and the end of pipe response at 82.51m (the distances are indicated in the plot in red). In this case, the end-of-pipe acoustic response distance (~82 m) is matched based on known pipe length data from MSDGC’s Geographic Information System (GIS) database. When the match button is selected, based on the limited site specific acoustic match library, the software generates the impulse response “Match” plot presented as Figure 1-8.

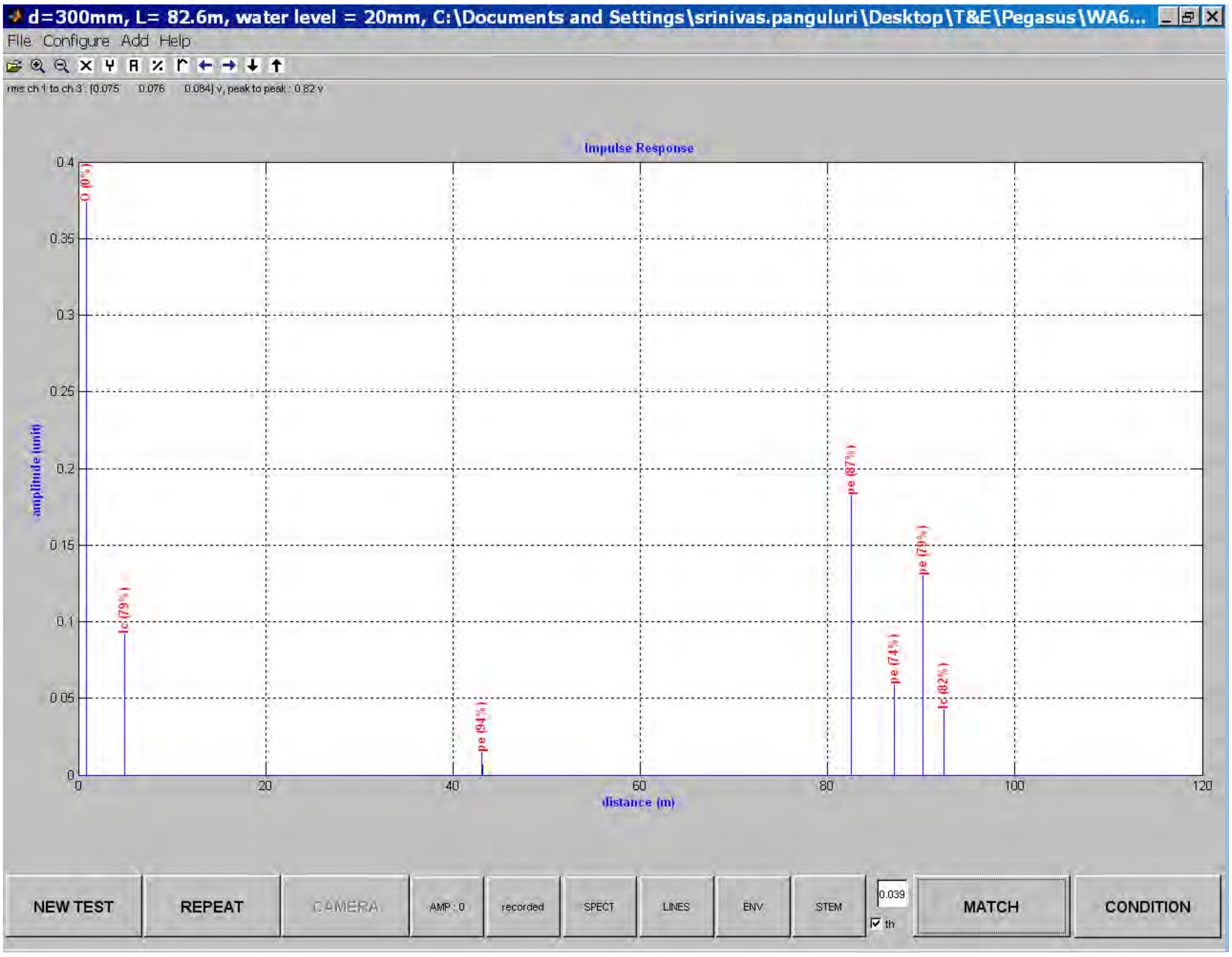

Figure 1-8. SewerBatt Acoustic Response Match Plot

The “Match” plot indicates that the response at the initial 4.93m obstruction is likely a lateral connection (lc), and the later responses at the 43.12m and 82.51m locations are likely pipe ends (pe). Although the SewerBatt system is designed to identify such discrete features/defects along the sewer pipe, additional effort and time will be necessary to build a substantial acoustic signal response signature library. Therefore, for the purposes of this technology demonstration project, ASTL developed a rapid assessment feature. A more detailed overview of the SewerBatt’s discrete defect identification capability is available in Romanova et al., 2013.

For rapid assessment, the Scanfield software includes an automated condition assessment module[3] that reviews the acoustic signal response, makes allowance for the energy loss from the pipe-ends and lateral connections, and then grades the pipe. The final pipe condition or grading is simply in the form of a colored traffic light indicator providing a red, amber (yellow), or green (RAG) grade. A red grade assessment indicates the need for further inspection or cleaning. An amber grade assessment is cautionary, indicating that there maybe some blockage issues, but not sufficient to block the flow. A green assessment indicates the pipe is free of any significant blockages and no further evaluations are necessary. The reflected energy set levels for the RAG assessment are user definable. For the purposes of

[3] An “alpha” or test version of this module was provided by ASTL for use in this demonstration study.

this demonstration, it was determined that pipes in good condition (green) generally had a reflected energy value of less than 70 (a dimensionless number based on the ratio of the strength of the reflected energy compared to the strength of the excitation signal). Pipes in poor condition were generally observed to have a reflected energy level of more than 90. Thus, the RAG classification was set to the following reflected energy levels: green – energy < 70, amber – energy 70 to 90, and red – energy > 90. Furthermore, if the RAG algorithm determines a green or amber value based on the reflected energy value, the system also calculates the strength of the biggest feature/defect response and compares it with the strength of the response calculated for the pipe end (pe) to calculate a value designated as dissipation energy (DE) ratio in the software output. If the DE ratio is less than 0.33, the initial RAG classification is not changed; for a DE ratio value between 0.33 and 0.66, the initial green RAG value is elevated to amber and finally for a value more than 0.66, the RAG is set to red irrespective of its initial classification.

Figure 1-9 depicts an example RAG condition assessment output for the pipe segment (1705013 – 1705012), using acoustic data previously presented in Figures 1-6, 1-7, and 1-8.

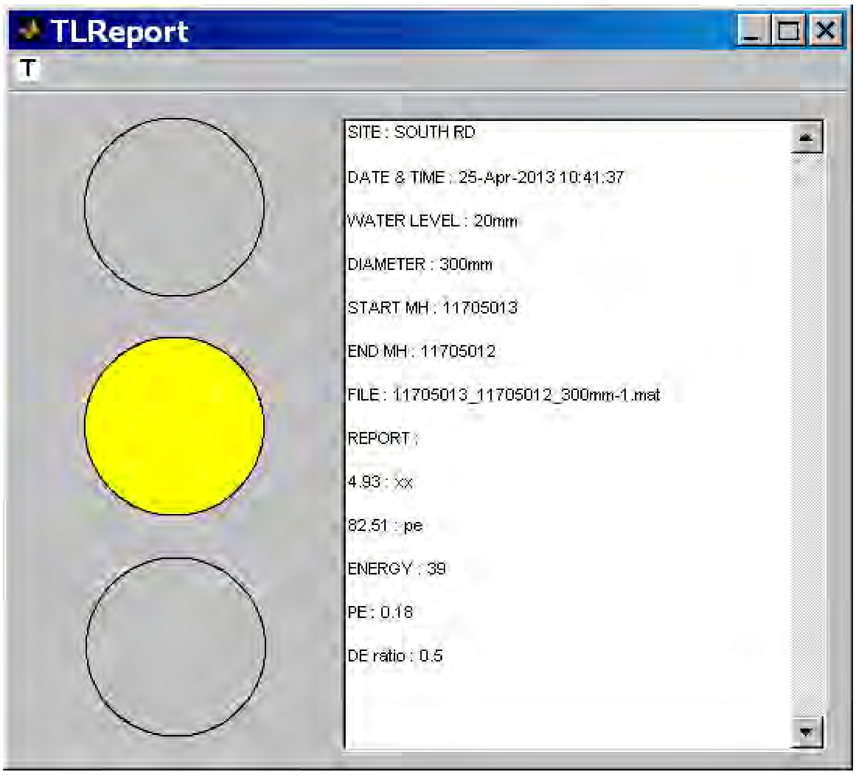

Figure 1-9. SewerBatt Condition Assessment (RAG) Response

This assessment was performed by clicking the “condition” button, which asked the user to confirm the pipe end location and if the acoustic responses at the 4.93m and 43.12m locations were related to pipe ends or lateral connections. Because the current signature library was limited, the decision was made to reject those identified assessments. Although the energy level was in the green range, the RAG algorithm comes up with a summary assessment of an elevated value or amber because of the DE ratio 0.5 (0.09/0.18) for blockage response at 4.93m (as shown in Figure 1-9). A more detailed discussion of this pipe segment is presented in Section 3.0, where the CCTV findings indicate the presence of 15% medium roots at 4.93m (~16 feet) and 30% medium roots at about 44m (~147 feet). Appendix A contains a more detailed report from ASTL that provides additional details on the SewerBatt methodology and overall results from the MSDGC assessments during the Greater Cincinnati trials.

Overall, the SewerBatt system setup and analysis is quick (taking only a few minutes) and gives some indication of defect type and location. Therefore, the main practical advantage of this method over traditional inspection methods, such as CCTV, is the speed of measurement and the ability to measure from the manhole without traversing the pipe. If necessary, the acoustic inspection can be performed by a single operator as the equipment is lightweight and no personnel entry is required.

1.8 Project Team

This collaborative field demonstration of the SewerBatt was led by EPA's National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio. EPA engaged MSDGC as a collaborative research partner to provide access to the study area (see Section 2.0) sewer lines and to perform the related field work. For coordinating and performing this demonstration, EPA issued a work assignment to Pegasus Technical Services, Inc. (PTSI) under EPA Contract No: EP-C-11-006. Shaw Environmental & Infrastructure, Inc. (Shaw - a team subcontractor to PTSI) served as the project lead to assist in the selection of technology vendors, obtain the equipment through lease, coordinate the field efforts with MSDGC, evaluate the data generated, and produce this report with the project team.

To perform these tasks, Shaw subcontracted with Brown and Caldwell (BC) and ALSA Tech LLC (ALSA) to serve as industry experts/consultants in this demonstration. In addition, Shaw contacted selected technology vendors (e.g., ASTL) to arrange for the lease of the SewerBatt device. The members of this project team included:

- EPA – Dan Murray, Patrick Clark and John Olszewski
- MSDGC – Jerry Weimer, Eric Withers, Eric Schneider, Dustin Prue, and Mike Pittinger
- Shaw – Srinivas Panguluri and Don Schupp
- BC – Gary Skipper and Steve Donovan
- ALSA – Abraham Chen
- ASTL – Richard Long, Nick Hawkins, Andrej Fedotov and Kirill Horoshenkov

The EPA and Shaw project team participated in this collaborative field demonstration mainly as neutral observers during the field activity-phase of this study. The project team's main objective was to compile the data collected by MSDGC and perform the evaluation contained in this report. The project team members periodically accompanied MSDGC personnel while they deployed the equipment and assessed the condition of sewers in the Cincinnati area using both a conventional CCTV camera-based inspection system and the SewerBatt. Specifically, the results obtained from the following technologies will be discussed in this report:

- SewerBatt manufactured by ASTL.
- Pan-Tilt-Zooming pole-mounted camera (aka "camera on a stick") manufactured by Envirosight Quickview.
- HD-digital scanning CCTV.

Although the PANORAMO 3D Optical Pipeline Scanner (manufactured by RapidView-IBAK) was slated for use during this study, the equipment had to be serviced and was not available for use during the SewerBatt portion of this demonstration.

2.0 Study Area Description and Evaluation Parameters

MSDGC is responsible for the operation and maintenance of over 3,000 miles of sewers, with approximately 600 miles of those sewers being "off-road." These off-road sewers are typically inspected every 8 to 10 years and are difficult and expensive to access and inspect. In addition to these "off-road" sewers, MSDGC also inspects and cleans on-road sewers on a proactive basis. For the purposes of this study, the following three Greater Cincinnati-area locations were identified and selected for the demonstration:

- Hunt Road – off-road sewers (see Appendix B for a detailed figure)
- Galia Drive – off-road sewers (see Appendix B for a detailed figure)
- Greenhills – on-road sewers (see Appendix B for a detailed figure)

These locations include a range of pipe sizes and a variety of pipe materials and were scheduled for cleaning and inspection during the study year. Tables 2-1 and 2-2 summarize the total number of pipe segments by size and material type selected for this study.

Pipe Size (in)	No. of Segments
6	1
8	97
10	1
12	56
Total	**155**

Table 2-1. Hunt Road, Galia Drive, and Greenhills Pipe Segment Size Summary

Pipe Material	No. of Segments
Concrete (RCP)	75
Ductile Iron Pipe (DIP)	2
Cast Iron Pipe (CIP)	1
Vitrified Clay Pipe (VCP)	60
Poly-Vinyl Chloride (PVC)	1
Slip-lined	5
Unknown	11

Table 2-2. Hunt Road, Galia Drive, and Greenhills Pipe Segment Material Summary

As summarized in Table 2-1, the selected study areas have sewer pipes ranging from 6- to 12-inches diameter. The SewerBatt system deployed in this evaluation is designed to work optimally in this pipe size range. For optimal evaluation of larger diameter pipes, the acoustic unit would require retrofitting with larger sized and more powerful electronic hardware coupled with adjustments to the algorithm software.

2.1 Test Conditions

A project-specific EPA required Quality Assurance Project Plan (QAPP) was developed and implemented by the project team (EPA, 2012b). As part of the QAPP, the inspections were to be conducted during times when the water level in the sewer was below 40 percent of pipe diameter and there were no significant changes to the water levels between the technology deployments. Each sewer pipe-segment was to be examined and assessed using selected acoustic methods, pole mounted camera, and CCTV prior to cleaning. If cleaning was considered necessary based on the inspections, the sewer segments were to be cleaned, examined, and assessed again after cleaning. Figure 2-1 depicts the overall test procedure that MSDGC was to follow during this study. Figure 2-2 shows the inspection test procedure, and Figure 2-3 shows the mainline CCTV test procedure. As indicated in Figure 2-1, another acoustic inspection technology the Sewer Line – Rapid Assessment Tool (SL-RAT) was also evaluated during this demonstration study with results contained in a separate EPA report. Both acoustic inspection technologies were evaluated using the same underlying CCTV-based PACP assessments.

2.2 Condition Assessment/Inspection Strategy

The SewerBatt representatives from ASTL visited Cincinnati in April 2013 to train all project personnel on the appropriate techniques for deployment and use of the SewerBatt equipment. Thereafter, the vendor representatives and Shaw/EPA/BC personnel accompanied the MSDGC crew periodically to observe the condition assessment and data collection process.

Each subsection of the sewer segments were tested from the furthest downstream section to the upstream section to ensure that if any material was dislodged during testing, the material would flow downstream and not impact the upstream sections. Each segment was examined using the following technologies:

- SewerBatt
- Pole/Stick Mounted Camera
- CCTV or PANORAMO Pipeline Scanner

As mentioned previously in Section 1.8, the PANORAMO 3D Optical Pipeline Scanner (manufactured by RapidView-IBAK) was slated for use in this study. However, the equipment had to be serviced and was not available for use during the SewerBatt evaluations.

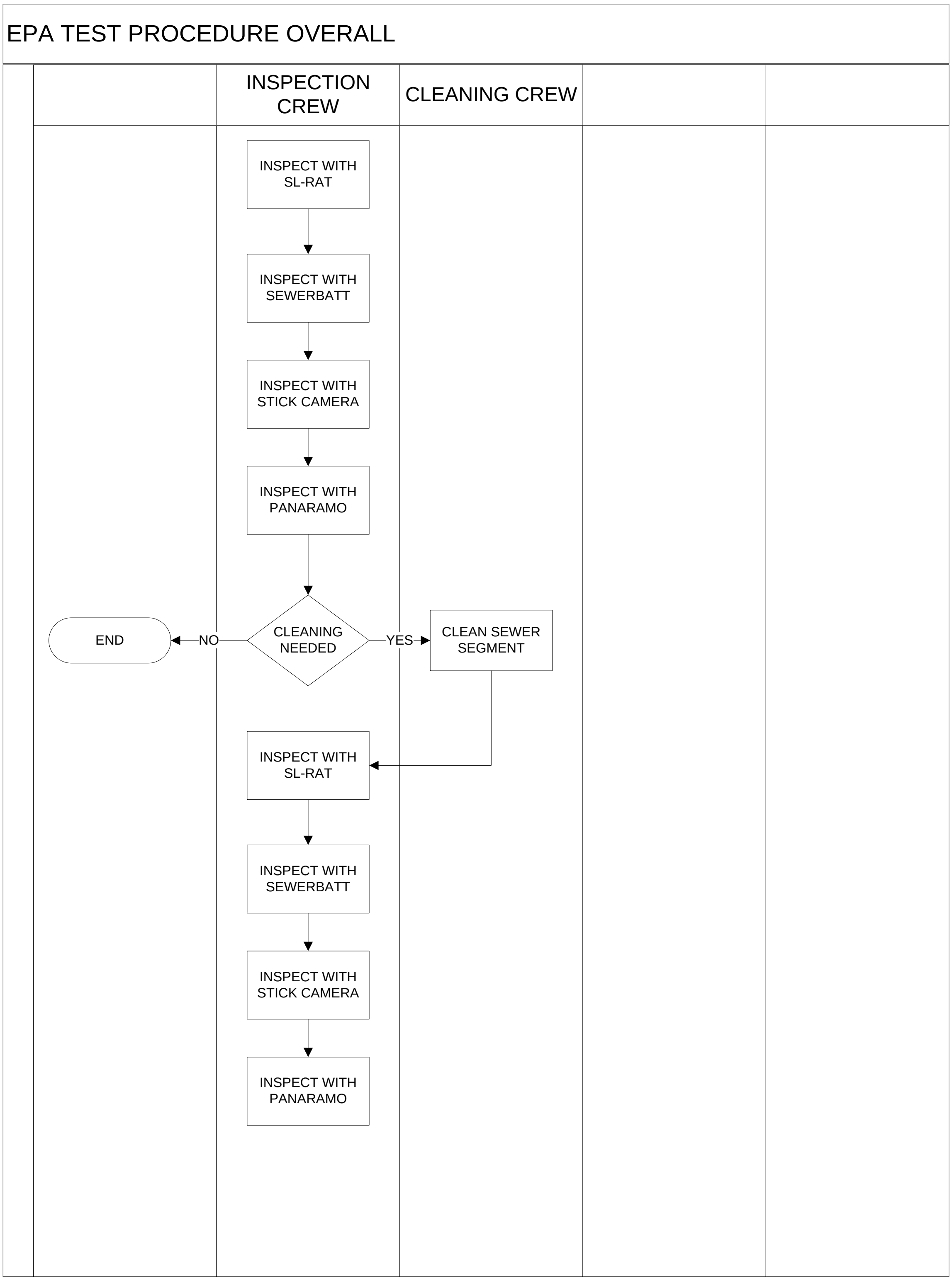

Figure 2-1. Overall Test Procedure

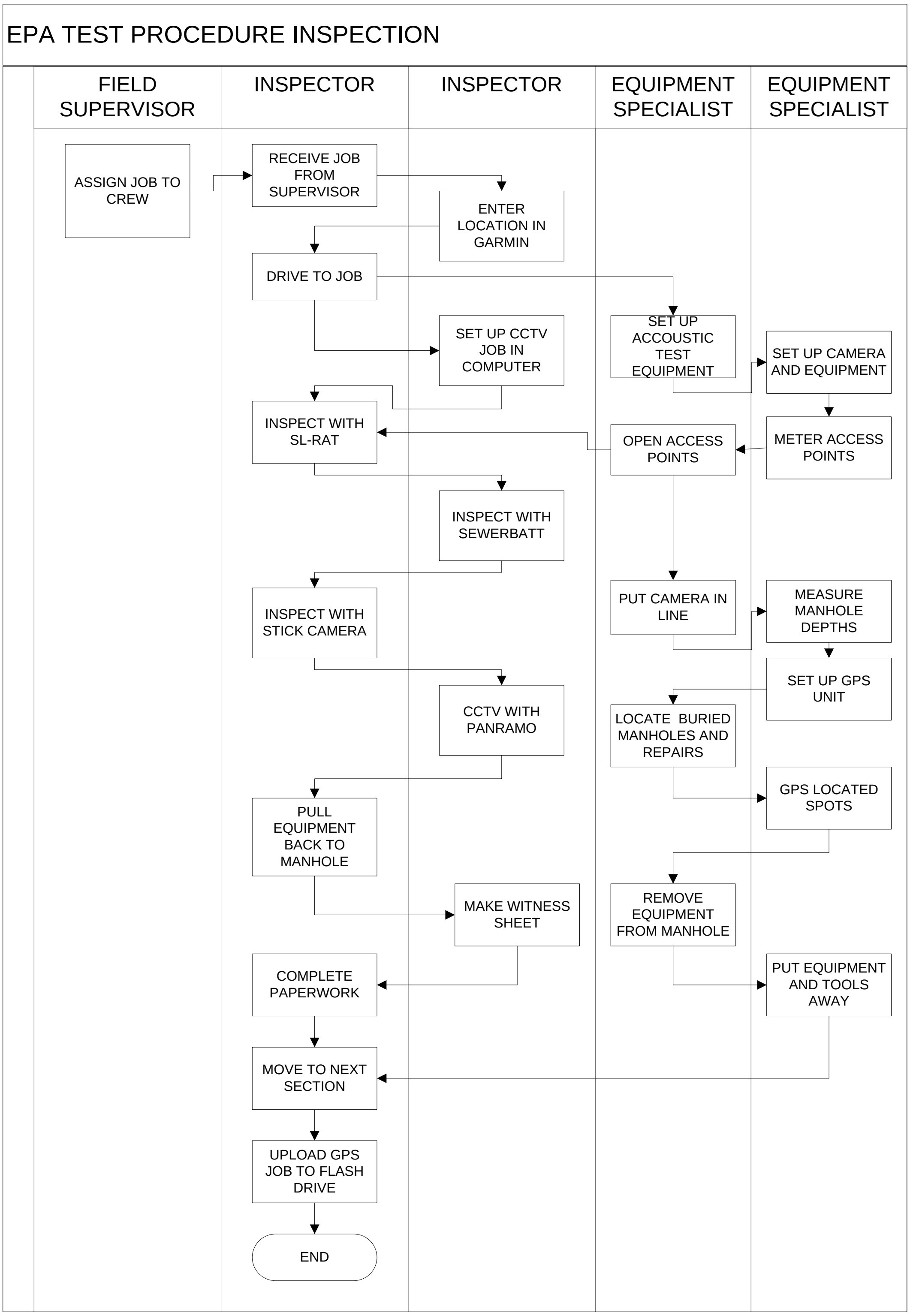

Figure 2-2. Inspection Test Procedure

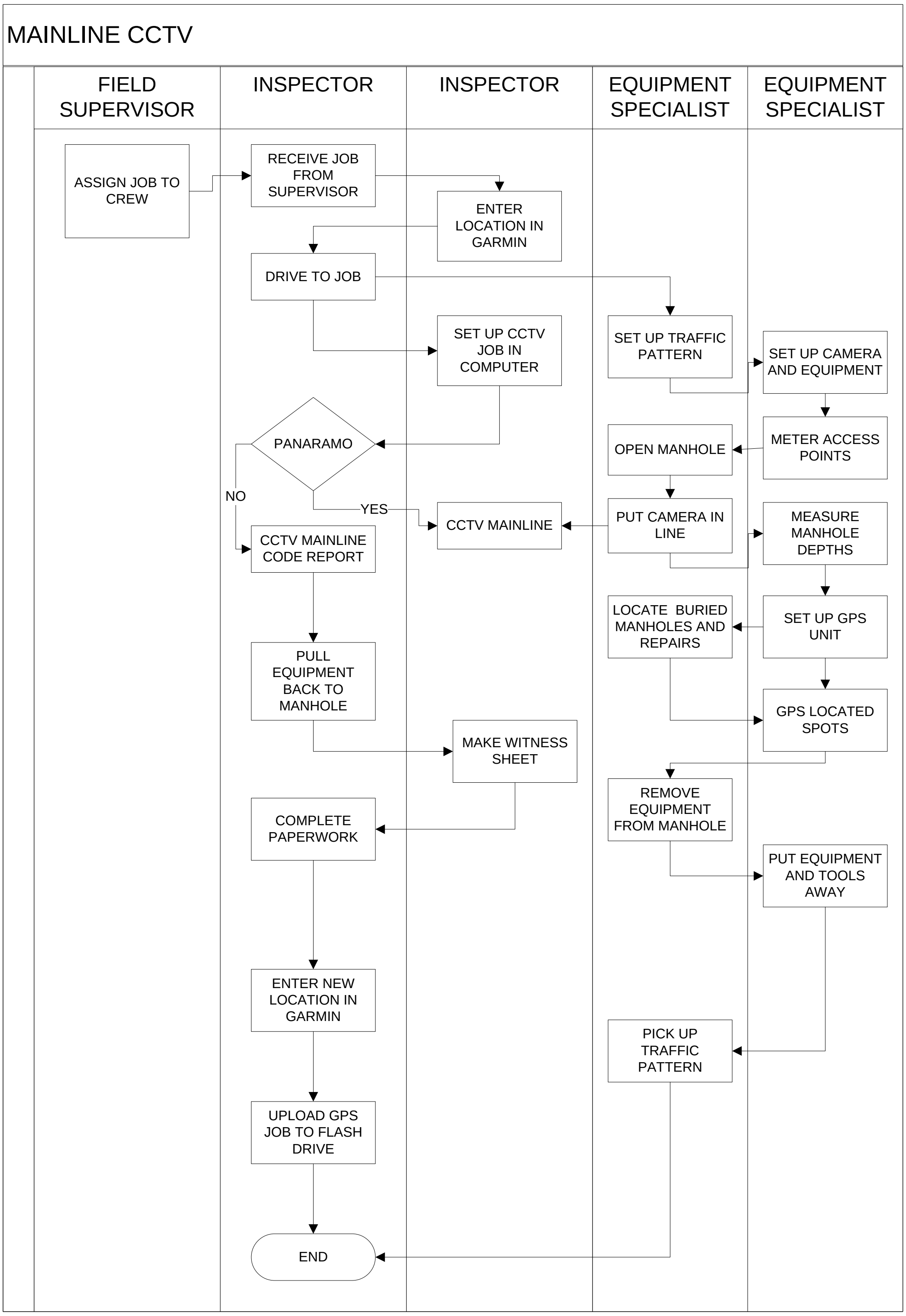

Figure 2-3. CCTV Test Procedure

2.3 CCTV and Pole Mounted Zooming Camera Data Evaluation Procedure

As indicated in the previous sections, two camera-based technologies were specified in the QAPP to be used as part of the inspection regime for each pipe segment evaluated. The two specific camera technologies used during the project were:

- Envirosight Quickview (Pole/Stick Mounted Camera) –handheld pole mounted zooming camera used to visually inspect and assess the sewer condition.
- HD CCTV – robotic CCTV which utilizes high-definition camera lenses to capture video. The video recording can be assessed in real time or at a later date. The system permits computer-aided measurement of the positions and sizes of objects or pipe defects.

For both camera-based technologies, the condition assessment of the sewer segments was based on the NASSCO PACP methodology. The PACP provides a standard method for coding each defect, based on a visual assessment of the type and extent of the observed defect within a pipe segment. The PACP methodology stipulates a mapping between defect codes to a numeric pipe condition grade. The general assignment of pipe condition grades are:

- Grade 5 – Pipe segment has failed or will likely fail within the next five years. Pipe segment requires immediate attention.
- Grade 4 – Pipe segment has severe defects with the risk of failure within the next five to ten years. Pipe condition is generally poor and will likely become Grade 5 in near future.
- Grade 3 – Pipe segment has moderate defects and the condition is fair to moderate. Deterioration may continue, but not for ten to twenty years.
- Grade 2 – Pipe segment has minor defect, but generally good and has not begun to deteriorate. Pipe is unlikely to fail for at least 20 years.
- Grade 1 – Pipe segment may have minor defects, but otherwise in excellent condition. Failure is unlikely in the foreseeable future.

For the purposes of this report, the sewer condition assessment performed by the mainline CCTV was coded and rated using the NASSCO PACP method. However, the numerical PACP codes were not directly comparable to the SewerBatt outputs. Therefore, the video outputs from the CCTV inspections were compared to the outputs generated by the SewerBatt in Section 3.0 of this document.

2.4 Rapid Deployment Evaluation Procedure

Besides providing a pipe condition and blockage assessment, the key advantage of implementing technologies such as SewerBatt is the rapid deployment feature using portable equipment that can result in significant cost savings to utilities. As mentioned previously, the Greenhills area within MSDGC was selected to evaluate the time it takes to conduct an acoustic assessment campaign using SewerBatt. As the goal of this study area was to evaluate the time required to perform the acoustic inspections, advanced planning and preparation was conducted to help mitigate issues associated with traffic control and location of manholes. All manholes were pre-marked, and motorized All Terrain Vehicles (ATVs) were used to conduct this campaign. This sub-study involved sixty-two (62) SewerBatt measurements at pipe-segments covering over 10,000 linear feet of pipe in the Greenhills study area with pipe sizes of 8 and 10 inches in diameter. It should be noted that the NASSCO-PACP CCTV assessments were performed only for four of the pipe-segments in the Greenhills study area.

3.0 Technology Demonstration Results

The inspection test procedure shown previously in Figure 2-2 and the CCTV test procedure depicted in Figure 2-3 were not accomplished for every pipe segment during the course of the project. This was due to a variety of reasons including access limitations, wet-weather rain events that interrupted the schedule, unscheduled CCTV tractor repairs, and the unforeseen periodic need for the MSDGC crew to address system issues requiring immediate attention. Therefore, for some of the data/results presented in the following sections, only factual field findings are reported without a detailed interpretation. For the purposes of this report, the data obtained from the pole/stick mounted camera was found to be of little use in terms of discussing the SewerBatt results when compared to the more detailed data obtained from the CCTV; hence, it has not been included in this document.

Furthermore, the SewerBatt equipment was expected to arrive in January 2013 and was originally designated to be tested concurrently with the SL-RAT device (as presented previously in the test procedures Figures 2-1 and 2-2). However, there were some unforeseen delays related to the formation of ASTL as a "spin-off" company from the University of Bradford (United Kingdom), the organization that had developed the original non-commercialized SewerBatt product. Subsequently, the SewerBatt representatives from ASTL arrived in Cincinnati during April 2013 to train all project personnel on the appropriate techniques to deploy and use the SewerBatt equipment. However, by that time, the Galia Drive inspections using the SL-RAT, CCTV and associated cleaning had already been completed. Although SewerBatt inspections were conducted at the Galia Drive location (presented below in Section 3.1), the results are separated in time and are interpreted accordingly.

The version of the SewerBatt system used in this study uses metric units in the acoustic signal processing functions that are performed during its deployment. Although the option to display results in U.S. customary units (e.g., distances in feet) is provided in the interface, the internal calculations function only with metric units. For this reason, this report uses metric units when presenting the SewerBatt results. According to ASTL, the option to run the software in U.S. customary units will be included in a later release. Appropriate conversion factors should be applied where necessary while interpreting the results (e.g., for distances, multiply meters by 3.281 to convert to feet).

3.1 Galia Drive Study Area CCTV/SewerBatt Assessment Summary

The Galia Drive evaluation area consists mainly of off-road sewers, through a wooded area serving several residential subdivisions. The terrain has very steep slopes and access to the manholes is provided by an unpaved path cut through the area. The alignment of the sewer along the path is above a steep ravine that leads to an unnamed creek in the Muddy Creek watershed. All of the inspections listed in this section were performed between April 2013 and June 2013.

Of the fifty-four (54) sewer pipe-segments originally identified for inclusion in the Galia study Drive area, a total of thirty-four (34) SewerBatt assessments were performed in this study area. Also, no CCTV data was available for three (3) of the thirty four (34) SewerBatt assessed pipe-segments for comparison purposes. Therefore, only thirty one (31) individual pipe-segments have CCTV data to support the SewerBatt inspections. Furthermore, several of these segments had been inspected earlier in the year; for the purposes of this analysis, the most recent CCTV data was used.

Table 3-1 (below) summarizes the SewerBatt test results and associated CCTV inspection findings for the Galia Drive study area.

Segment ID	CCTV Date	CCTV Findings	SewerBatt Date	SewerBatt RAG Grade (Initial/Revised)	SewerBatt Comments from Envelope Plot Review
11702001-11702002	4/30/2013	Light grease	04/29/13	G/G	Minor responses at 16' and 105'
11702003-11702012	1/29/2013	No issues	04/29/13	G/G	No responses
11705009-11706007	5/2/2013	No issues	04/29/13	G/G	Medium responses between 16' and 33'
11705011-11705010	5/2/2013	Fine roots	04/25/13	G/G	Slight response at 14'
11705013-11705012	5/3/2013	Roots Med	04/25/13	G/A	Responses at 16', 33', 50' and 147'
11706002-11707005	4/30/2013	Roots Med – 15% roots seen at 156' and small root ball at 206'	04/29/13	G/A	Response at 13'
11706003-11706002	4/30/2013	Root Ball at end of pipe	04/29/13	G/G	No response
11706004-11706003	4/30/2013	Roots fine	04/29/13	G/A	No response
11706006-11706005	4/30/2013	Roots Med at 173'	04/29/13	G/A	No sharp response
11706006-11706005	4/30/2013	Slight structural overall very clear	04/29/13	G/G	Response at 16'
11706007-11706006	5/2/2013	Overall very clear	04/29/13	G/G	No response
11707005-11702001	4/30/2013	Root Ball at 114', offset joint w/ roots at 54'	04/29/13	G/A	Strong response at 139' and 199'
11711001-11706006	4/30/2013	No issues	04/29/13	G/G	Slight response at 16'
11712001-11711001	4/30/13	Light O&M	04/29/13	G/A	Responses at 16' and 102'
11712002-11712001	4/30/13	Roots fine	04/29/13	G/G	Responses at 13' and 23'
11712003-11712002	4/30/13	Roots fine	04/29/13	G/G	Response at 20'
11712004-11712003	5/1/13	Light deposits	04/25/13	G/G	Response at 23'

Segment ID	CCTV Date	CCTV Findings	SewerBatt Date	SewerBatt RAG Grade (Initial/Revised)	SewerBatt Comments from Envelope Plot Review
11712005-11712004	5/1/13	Light deposits	04/25/13	G/G	Response at 20’
11712006-11712005	5/1/13	No issues	04/25/13	G/G	No responses
11713001-11712006	5/1/13	Minor issues	04/25/13	G/G	Response at 15’
11713002-11713001	5/1/13	Minor Issues	04/25/13	G/G	Response at 13’
11713003-11713002	5/1/13	Gusher, light deposits, grease throughout the line	04/25/13	G/A	No responses
11713004-11713003	5/1/13	Sideline splash at starting manhole, deposits (5%) throughout	04/25/13	G/A	No responses with low end of pipe response
11713005-11713006	5/3/13	Minor issues, tap at 244’, 2 taps 2’ from target manhole	04/29/13	R/R	Responses at 20’, 244’, 280’ and 290’
11713006-11712006	5/3/13	No issues	04/29/13	G/G	Slight response at 23’
11713007-11713006	5/3/13	Minor deposits, tap at 59’, 2 taps 2’ from target manhole	04/29/13	R/R	Responses at 16’ and 194’
11713014-11713018	5/3/13	Tap at 6’, 15.6’ and 39.9‘, beyond 40’ camera “jumped” over several joints	04/29/13	R/R	Numerous responses, peaks at 16’, 46’, 56’, and 73’
11713018-11713003	5/3/13	No issues	04/25/13	G/G	No responses
15016001-11713004	5/1/13	Light deposits	04/25/13	G/A	Slight responses at 40’ and 80’, more noticeable from 198’-264’
15016002-15016001	5/3/13	Grease starts at 173’, TF at 33.5’	04/25/13	G/A	Responses at 23’, 36’, 43’, and 191’

Table 3-1. Summary of SewerBatt and CCTV Results for Galia Drive

Of the thirty-one (31) SewerBatt assessments supported by CCTV, twenty-eight (28) received an auto condition grade of green, and three received an auto condition grade of red. The data were also provided to ASTL representatives for a detailed evaluation. The ASTL team recommended a manual override of ten (10) of the Galia road segments from green to amber (See Appendix A for a detailed discussion). These sections were on the threshold of the cutoff value between green and amber, and in most cases they were downgraded due to a lower than expected pipe-end acoustic response. The conservative assumption here was that the unidentified conditions that decreased the acoustic response at the pipe-end and the manual override of the quick assessment recommends further investigation. It should be noted that no major structural defects were found during the CCTV inspections (e.g., no PACP Structural Grades of 4 or 5) in this area. However, numerous minor PACP O&M defects were identified and are included in Table 3-1.

Based on the relatively consistent SewerBatt response, a sub-sample (twelve segments) across the various automated condition grade categories (red/amber/green including the manual override for this study area) was selected for a more detailed discussion. These selected pipe-segments include the following consideration: all three (3) segments that had a final condition grade of red; seven (7) of the ten (10) sections that had an automatic grade of green, but were manually overridden to amber; and two (2) of twenty (20) sections that had a final condition grade of green.

Green Condition Grade Discussion - Of the two green graded pipe sections selected for further discussion, one (11705010-11705009) was selected because SewerBatt indicated a response, but the CCTV log did not indicate any issue in the pipe. For the other pipe-segment (11706003-11706002), the CCTV log showed a root ball in the pipe and was evaluated to ascertain why the SewerBatt condition rating remained green.

The first selected pipe-segment (11705010-11705009) was assessed from the downstream manhole (i.e., from manhole ID 11705009) and showed a SewerBatt response at 6.1m. This location is equivalent to 127 feet (distance compensated for reverse setup of the SewerBatt vs. the CCTV) on the CCTV inspection. The pipe-end response is correctly indicated at 44.87 m (~147 feet), and no major defects were found; however, a noticeable hydraulic jump was seen at the 127 feet joint on the CCTV footage. Figure 3-1 shows the CCTV response image for the exact location where a SewerBatt response (6.1 m) was noted for this segment.

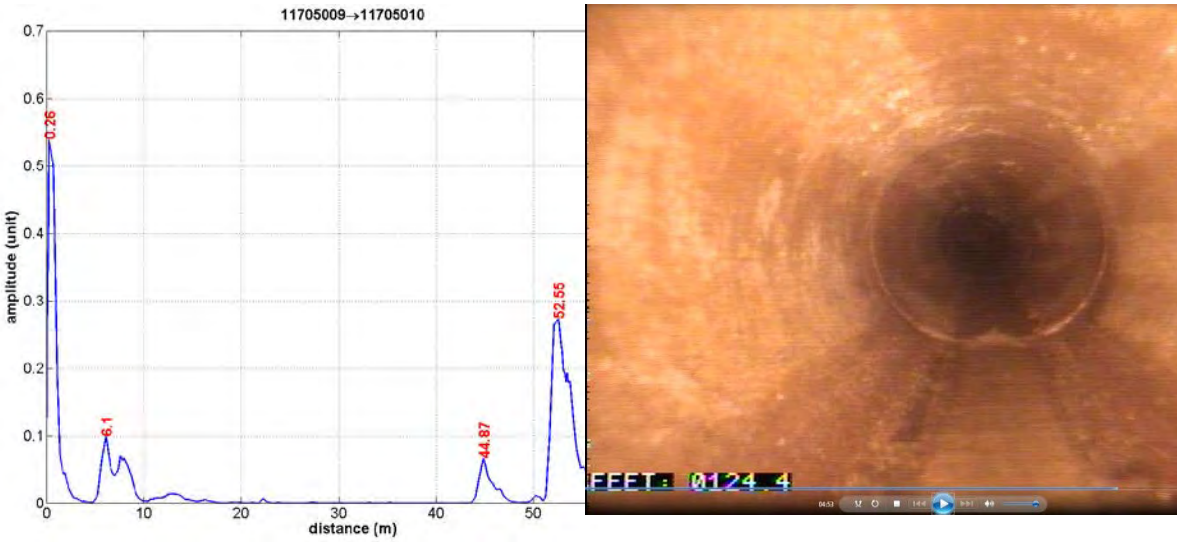

Figure 3-1. SewerBatt/CCTV Response Comparison (Segment ID 11705010-11705009)

For the second pipe-segment (11706003-11706002), a root ball filling 80% of pipe was found at 3 feet from the upstream manhole. However, since the SewerBatt deployment was from the downstream manhole (in reverse from manhole ID 11706002), it appears that any response from the root ball was masked by the pipe-end response at the target manhole.

Amber Condition Grade Discussion – As mentioned previously, there were no automated amber condition grades. However, ten (10) sections were manually downgraded from green to amber by the ASTL team. Seven (7) of these locations were evaluated in more detail to determine if conditions were identified in the CCTV inspection that could explain the manual re-grading to amber.

For segment 1705013–1705012, the SewerBatt identified responses, seen in Figure 3-2, at 4.93m (16’) and at about 44m (147’) which were consistent with roots seen with CCTV. A downgrade to amber is considered appropriate.

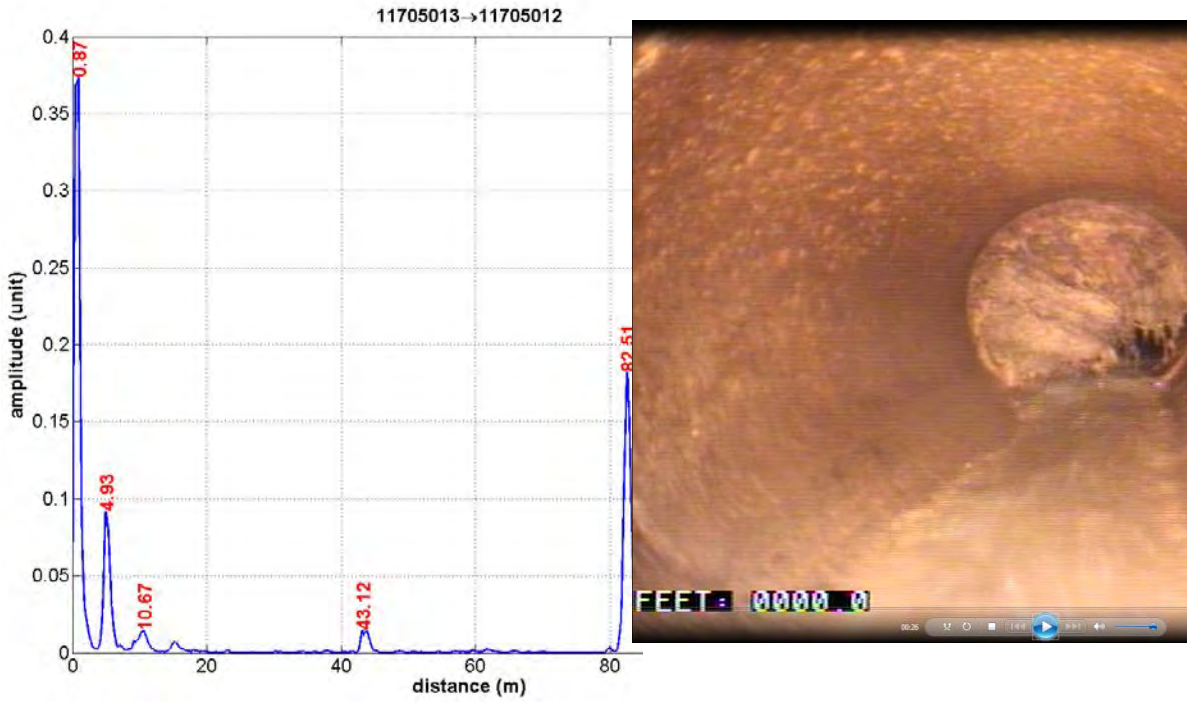

Figure 3-2. SewerBatt/CCTV Response Comparison (Segment ID 11705013-11705012)

Similarly, two (2) other pipe-segments downgraded to amber also were verified for root intrusion at discrete locations in the pipe as identified by SewerBatt. The remaining four (4) pipe-segments had either fine roots, grease deposits or encrustation throughout the entire line which likely affected the overall energy value resulting in an amber downgrade.

Red Condition Grade Discussion – The three (3) pipe segments, with a final condition grade of red, also reported an automatic condition of red. During review of the CCTV investigations, no significant defects were found in the pipe. However, each of these sections contained lateral connections in the pipe which resulted in significant energy loss and a low-level response from the target manhole (or pipe-end). A review of the peaks on the SewerBatt output graph identified most of the lateral connections noted during the assessment. A summary of these pipe feature/defect identifications is presented in Appendix A.

3.2 Hunt Road Area CCTV/SewerBatt Assessment Summary

The Hunt Road Evaluation area consists mainly of off-road sewers, through a wooded area serving several residential subdivisions. The terrain on the periphery has very steep slopes and access to the manholes is provided by an unpaved path cut through the area from the downstream location. The alignment of the sewer is along the path which is adjacent to an unnamed creek in the East Branch of the Mill Creek watershed.

In this study area, the SewerBatt operation and inspections were performed between May 2013 and June 2013. A total of twenty-six (26) sections were inspected using CCTV and only twenty (20) of those were assessed with SewerBatt. No sewer segments were found in need of cleaning and two (2) segments were found with structural issues, neither of which resulted in obstruction of the pipe. Table 3-2 presents the SewerBatt test results and the correlating CCTV inspection findings of the pipe segments at the Hunt Road site.

Segment ID	CCTV Date	CCTV Findings	SewerBatt Date	SewerBatt RAG Grade (Initial/Revised)	SewerBatt Comments from Envelope Plot Review
44705005-44705004	5/28/13	Minor deposits throughout, pipe end at 65’	05/29/13	R/R	No pipe end, strong responses at 64’ and 90’ and many lower responses past 64’
44706004-44707026	6/12/13	Deposits, water level 25%	05/29/13	G/A	Response at 16’
44706008-44706009	6/12/13	No issues	06/04/13	A/A	No responses
44706009-44706010	6/12/13	No issues	06/04/13	G/G	Slight response at 23’
44706010-44706004	6/12/13	Minor deposits throughout	05/29/13	R/R	Response at 20’
44706012-44706011	6/12/13	No issues	06/04/13	R/R	Low responses 10’ through 66’
44706013-44706010	6/12/13	Deposits at joint 3’ from manhole	05/29/13	G/A	No responses
44706014-44706013	5/28/13	Minor structural issues, significant cracked pipe and possible shape loss in the first 33’, deposit at 72’	05/29/13	R/R	Response at 13’ and 23’
44706015-44706014	5/28/13	Minor grease	05/29/23	G/G	Response at 13’
44712001-44705005	5/28/13	Minor O&M	05/29/13	G/A	No responses, pe response low
44712002-44712001	5/28/13	Minor grease and deposits, grease throughout, starts at 14’, a little heavier at 20’	05/29/13	R/R	Response at 23, pipe end response low
44712007-44712002	5/28/13	Minor structural issues, cracked pipe w/ deposits 90’-126’, non-laminar flow first 33’ from deployment manhole	05/29/13	G/G	No responses
44712008-44712007	5/28/13	Minor deposits, hydraulic jumps at joints	05/29/13	A/G	Minor responses at 16’ and 33’

Segment ID	CCTV Date	CCTV Findings	SewerBatt Date	SewerBatt RAG Grade (Initial/Revised)	SewerBatt Comments from Envelope Plot Review
48209013-44712008	5/28/13	Minor deposits	06/03/13	G/G	No responses
48209014-48209013	6/10/13	Minor O&M	06/03/13	G/G	No responses
48209015-48209014	6/10/13	No issues	06/03/13	G/G	Response at 145’
48209016-48209015	6/10/13	No issues, water level 50% at target manhole, 2 break in taps at 126’ and 133’	06/03/13	G/G	Responses at 96’ and 102’
48209017-48209016	6/10/13	Minor grease	06/03/13	G/G	No response
48209018-48209017	6/10/13	Minor deposits	06/04/13	A/A	Response at 26’, lower responses throughout

Table 3-2. Summary of SewerBatt and CCTV Results for Hunt Road

Similar to the extended discussion for the Galia Drive area, ten (10) sewer segments were selected for a detailed comparative discussion. Once again, the pipe segments selected included a sampling across the various SewerBatt condition grade categories (red/amber/green, including the manual override for this study area). The selected ten (10) pipe segments include the following considerations: all five (5) segments that had a final condition grade of red; one (1) pipe-segment that had an automatic and final condition grade of amber; one (1) segment that reported an automatic grade of amber, but was manually overridden to green; one (1) segment that had an automatic grade of green, but was downgraded to amber; and two (2) segments that were evaluated had an automatic and final condition grade of green.

Green Condition Grade Discussion - Of the selected locations, two (2) locations had final condition grades of green. One pipe segment (44712007-44712002) was assessed from the upstream manhole using SewerBatt, but was CCTV’d upstream or with a reverse setup. The SewerBatt inspection Envelope plot shows a slight response in the first 20 meters (end of pipe response is at 55.04m and beyond) and the CCTV inspection showed non-laminar flow and some cracked pipe with minor deposits (See Figure 3-3).

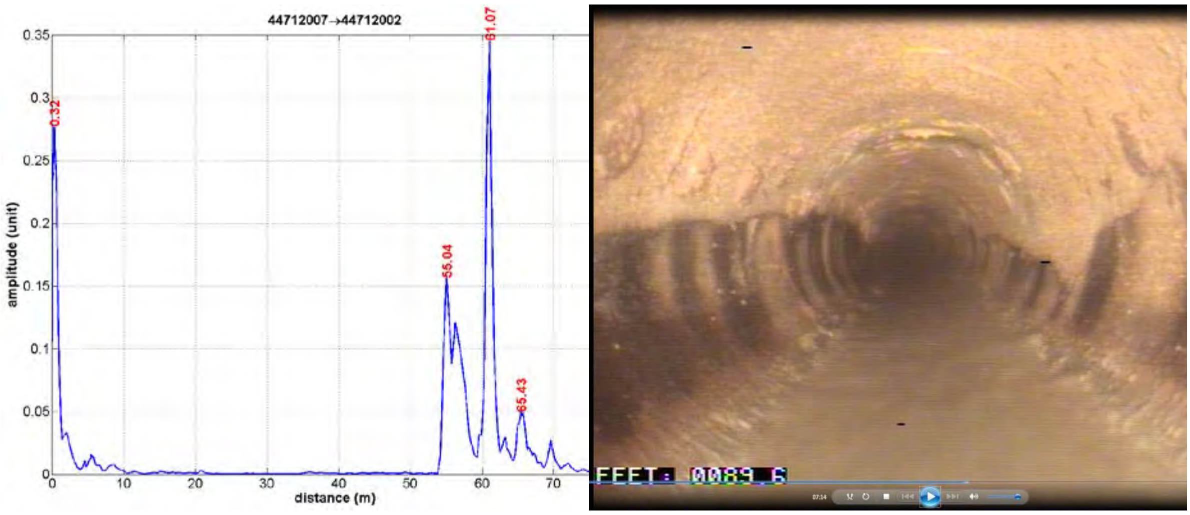

Figure 3-3. SewerBatt/CCTV Response Comparison (Segment ID 44712007-44712002)

At the second segment 48209015-48209016, SewerBatt responded in the vicinity of two (2) break-in taps identified by CCTV at about 30 meters (See Figure 3-4). No other issues were found with this pipe; therefore the green rating was appropriate.

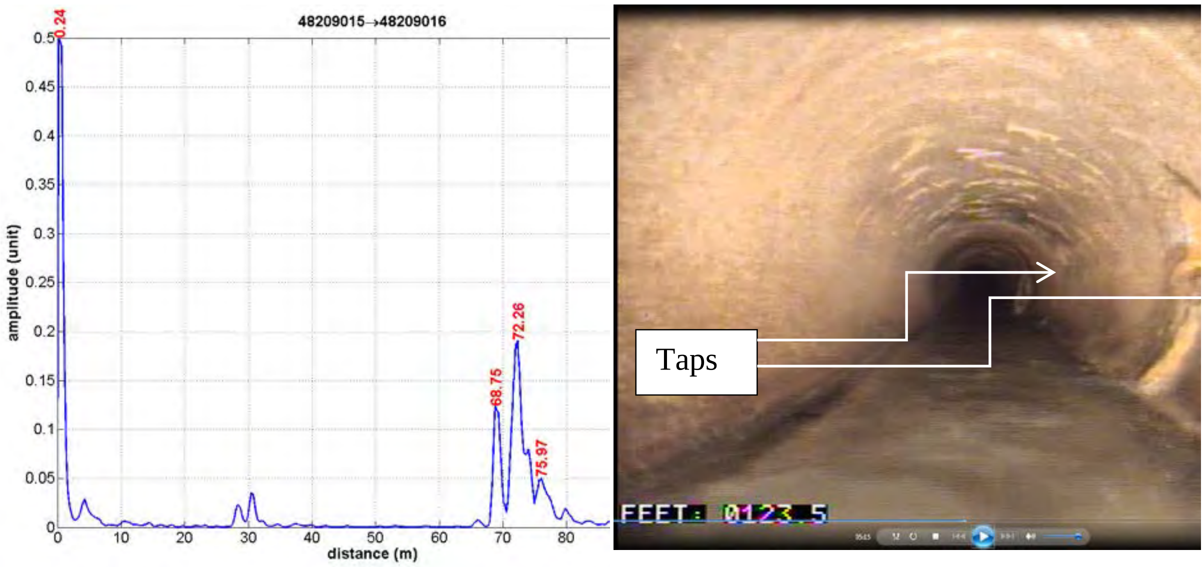

Figure 3-4. SewerBatt/CCTV Response Comparison (Segment ID 48209015-48209016)

Amber Condition Grade Discussion –Two (2) amber pipe segments were selected for further evaluations. One was manually adjusted and the second one was not. The segment (44706008-44706009) which returned an automatic amber condition grade (and not manually adjusted) was likely due to the energy loss from an outside drop at the deployment manhole. The second segment (44706013-44706010) was downgraded from green and showed encrustations in the first meter from the deployment manhole. Additionally, the segment was identified as potentially having a force main discharge which resulted in increased flow levels during the inspection.

Red Condition Grade Discussion – Of the five (5) pipe segments with a final condition grade of red, four (4) reported an automatic condition of red, and one (1) segment (44705005-44705004) came back with “PE not found,” with an automatic grade was red. Upon further review of the Envelope output graph, it appears the SewerBatt actually identified the target manhole correctly at 20 meters (65 feet). This rating may have been due to the short pipe length and unidentifiable response signature from the manhole.

Another segment (44706010-44706004) received a red grade due to significant attenuation of the response from the target manhole. Based on review of the CCTV inspection, only minor encrustations were found in the first 10 meters of the deployment manhole.

Segment 44706012-44706011 had a similar response, however the encrustations near the deployment manhole were slightly larger and debris was identified near the target manhole.

One of the few pipes with noticeable structural issues, 44706014-44706013, also received a red grade. There was significant horizontal cracking ~14 feet from the deployment manhole. The SewerBatt responded in the area of this defect (at 4.08m – See Figure 3-5). Additionally, deposits were identified beyond this area which may have further affected the response from the target manhole.

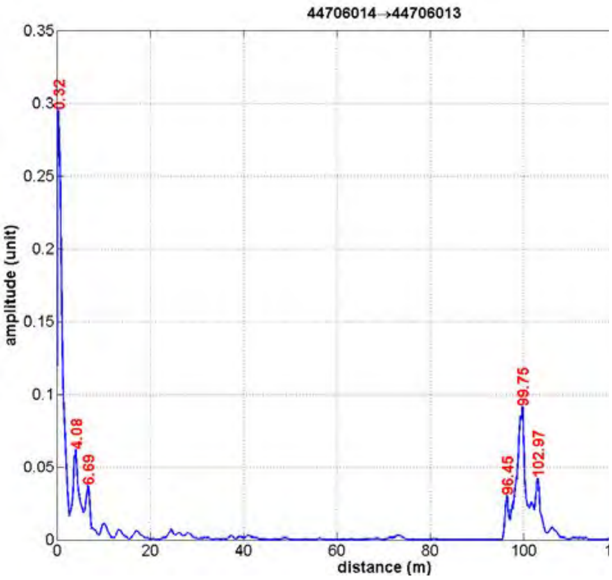

Figure 3-5. SewerBatt/CCTV Response Comparison (Segment ID 44706014-44706013)

The final section with a grade of red, 44712002-44712001, showed minor grease deposits throughout the entire section (Figure 3-6). Additionally, the review of the CCTV inspection showed the noticeably turbulent flow in the pipe.

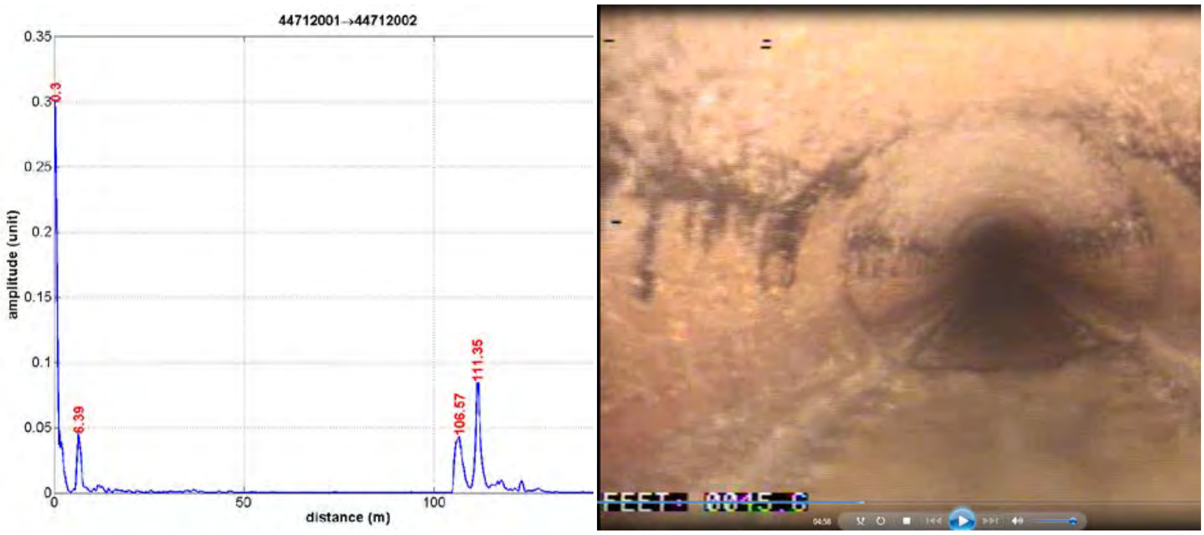

Figure 3-6. SewerBatt/CCTV Response Comparison (Segment ID 44712002-44712001)

3.3 Greenhills Area - Rapid Deployment Evaluation Summary

As mentioned previously in Section 2.4, the Greenhills study area involved SewerBatt measurements at 53 pipe segments, representing approximately 10,000 linear feet of pipe with pipe sizes of 8” and 10” diameters. A primary goal of this study area was to evaluate the time required to perform the acoustic inspections with the SewerBatt.

Overall, 62 assessments were performed between 9.53 AM and 2.00 PM on May 9, 2013. Greenhills is a suburban residential neighborhood with a relatively large number of lateral connections (or taps) in the pipes which resulted in a significant loss of acoustic energy. Therefore, only twenty nine (29) segments generated valid SewerBatt data. Of the (29) segments with valid SewerBatt data, seventeen (17) were given red condition grades after manual override. Seven (7) segments ended up with an amber grade, and five (5) segments were given green grades.

Since the main intent of the deployment in the Greenhills area was to assess how quickly the SewerBatt can be deployed for obtaining quick results, only three (3) sections were supported with CCTV inspections. For each of those sections, SewerBatt returned a condition grade of red. Table 3-3 presents a summary of these results.

Segment ID	CCTV Date	CCTV Findings	SewerBatt Date	SewerBatt RAG Grade (Initial/Revised)	SewerBatt Comments from Envelope Plot Review
31601005-31601001	5/10/2013	Medium Roots	5/9/2013	R/R	Strong response at 109’, numerous lower responses throughout
31602004-31601005	5/10/2013	No Issues - 6 taps	5/9/2013	R/R	Strong responses at 32’ and 52’

31602007-31602008	6/17/2013	Roots from tap – grease on crown of pipe - pipe fragment in flow	5/9/2013	R/R	Strong response at 59’, numerous lower responses throughout

Table 3-3. Summary of SewerBatt and CCTV Results for Greenhills

In two (2) of the three (3) pipe segments supported with CCTV data, SewerBatt responded at locations where CCTV identified roots in the pipe. Figure 3-7 shows the SewerBatt and CCTV response comparison for segment 31602008-31602007 (note roots at tap ~91’ on the CCTV and strong SewerBatt response at 17.52m). It should be noted that the CCTV and SewerBatt assessments for this segment were initiated from opposite manholes.

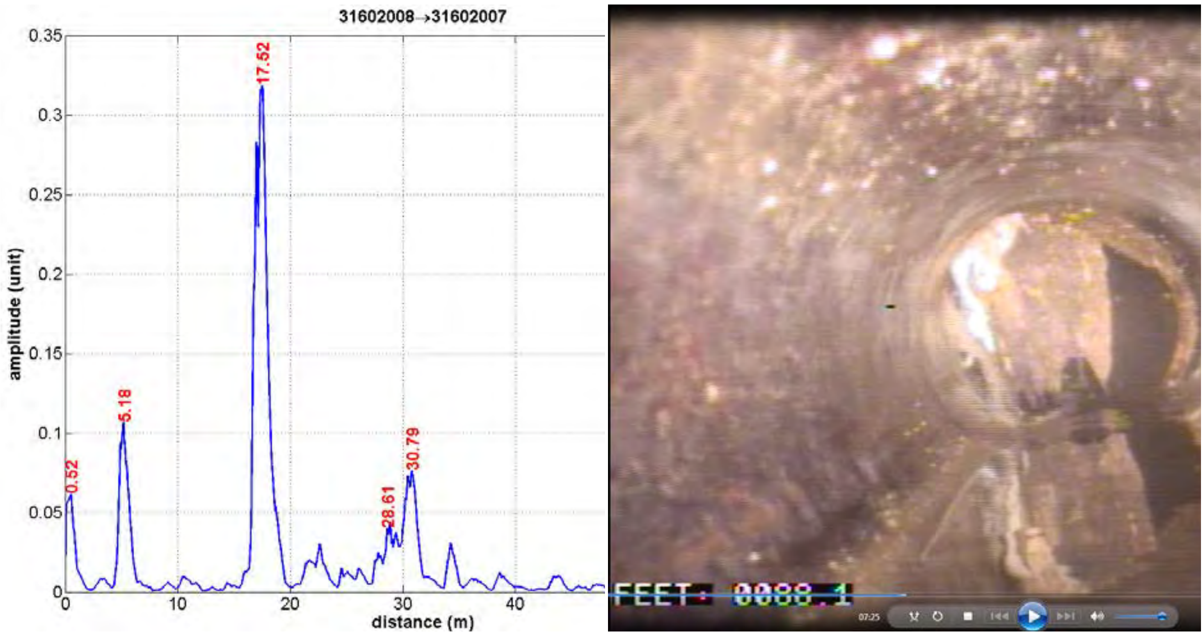

Figure 3-7. SewerBatt/CCTV Response Comparison (Segment ID 31602008-31602007)

3.4 Miscellaneous Pipe Evaluation Summary

As indicated in Section 3.3, in residential neighborhoods, such as Greenhills which contain pipe segments with many lateral connections, the strength of the acoustic signal will likely decay quickly. The signal responses in Greenhills decayed to an extent that, beyond a short distance (approximately 20 to 50m), showed little detail was visible in the recorded results. To potentially address this issue, ASTL proposed that their team return to Cincinnati in August 2013, and bring with them a newer production unit with some alternative excitation signals and sensor orientations to evaluate in several of the pipes in the Greenhills area. The goal of this evaluation was to observe the extent to which the signal penetration could be improved in pipes with many lateral connections.

Two series of comparative tests were carried out. The first series compared the results from the prototype equipment with those from the newer production equipment. The second series of tests compared the results from two different excitation signals (chirp and Gaussian pulse) and different locations of the sensor head within the pipe end cross section (center, left, right, top and bottom). Overall, the test data were insufficient to draw any firm conclusions, but the results appear to indicate that the gauss pulse excitation signal coupled with an increased power at lower frequencies give incrementally stronger responses. The detailed results tabulated by ASTL are presented in Appendix C of this report.

3.5 SewerBatt Operator Feedback

As a part of this evaluation, MSDGC field personnel were asked to provide input on the SewerBatt performance from an operator perspective. The following is a categorized summary of their observations:

Usability – The device is portable and light-weight. The batteries hold their charge for a while (days to weeks depending upon use) and repairs on the speaker/microphone are simple. The sensor head is not waterproof and requires careful insertion and should not be submerged under water. The extension pole provided was 30 feet long and a few of the manholes in the study area were deeper and could not be assessed. The long (30 + feet) wire connecting the sensor head and the electronic module must be managed in the field. At the time of preparation of this report, ASTL was developing a blue-tooth based wireless module that will address the cable management issues.

Data Quality - In off-road conditions with limited or no lateral taps, the results appear to be very precise. However, when testing sewer lines that had multiple lateral taps, the majority of the signal was lost in the sewer line leading to mostly “red” assessments, necessitating further inspection by conventional technologies such as CCTV.

Software – The software on the computer requires some training to maneuver through the menu items and understand the output. Also, without a substantial defect signature library, a detailed field interpretation of the results is difficult; only RAG-type rapid assessments can be made.

4.0 Summary and Conclusions

For the purposes of this report, the SewerBatt RAG output scores have been used to determine: 1) if the pipe is open (no further service required), 2) there is a potential blockage (red), or 3) additional investigation is needed (amber). The actual output numbers (energy outputs, DE ratio) that make up these ranges can be flexible based on the user's experience and the policies established by individual organizations. As reported previously in Section 3.0, for the purposes of this report, the SewerBatt score of green was reliable in detecting open pipes. Also, based on numerous comparisons of the SewerBatt "Envelope" plots to CCTV inspection results, under certain conditions, the SewerBatt was capable of locating defects within a sewer segment. This demonstration also revealed that the SewerBatt device used during this project was unreliable for evaluating sewer segments with many lateral connections, or taps, as the signal loss was high. Also, the "alpha" version of the RAG algorithm, used during this project, needs additional refinement.

Overall, the use of SewerBatt as a pipe-condition inspection tool needs to be evaluated in context with the existing tools available to wastewater utilities. Figure 4-1 presents a graphic summary of where the SewerBatt (acoustic condition assessment) as a sewer pipe inspection tool is likely to fit into a wastewater utility's "tool-box."

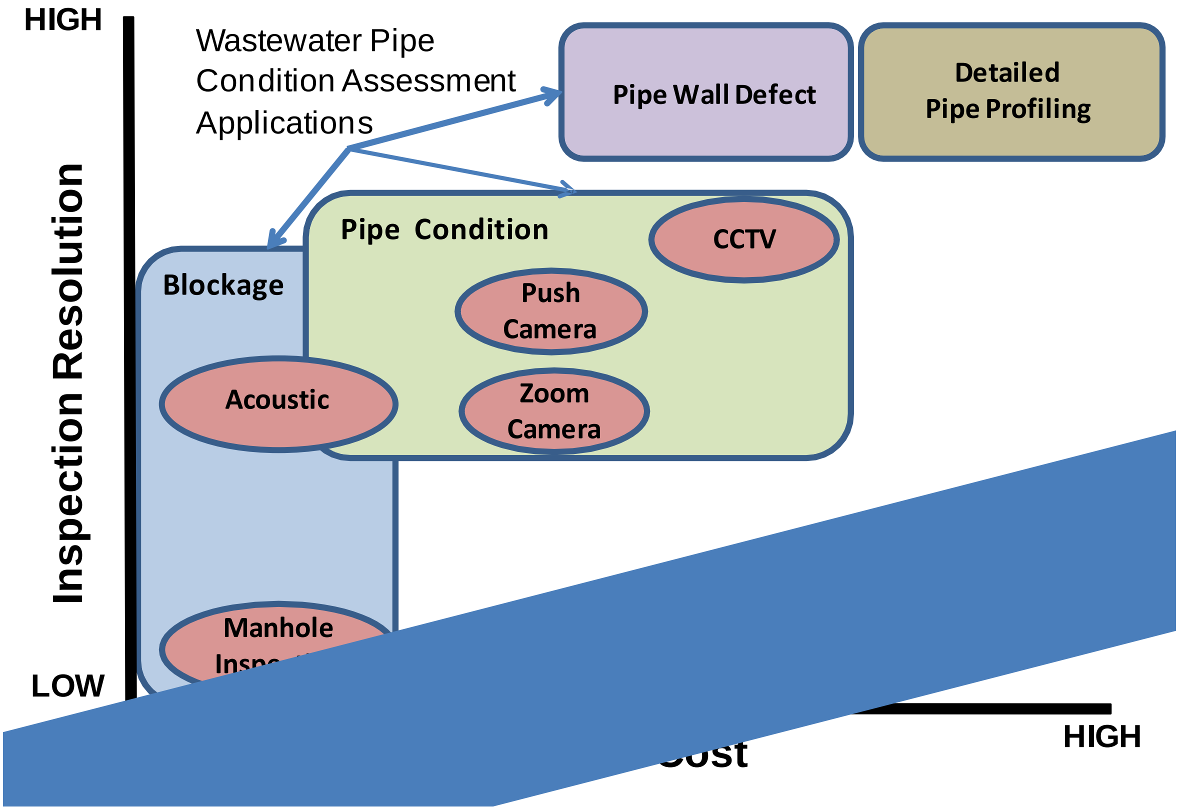

Figure 4-1. Sewer Pipe-Condition Assessment Tools (Adapted from: InfoSense, 2013)

4.1 Inspection Cost per Foot Analysis

The costs for CCTV inspection and cleaning of small diameter pipelines can vary widely from pipe to pipe and from utility to utility. There are many variables that affect the cost of pipe inspection for any given utility. For MSDGC, cost variables for CCTV inspection of small diameter pipes include factors such as personnel costs, travel costs, setup, planning and data management costs. Certain locations, that are not in the public right-of-way, in easements or difficult to access due to off-road locations, often require special arrangements or specially equipped off-road vehicles. Tables 4-1 and 4-2 summarize the average cost of on-road and off-road CCTV inspections, respectively, for MSDGC.

S. No.	Labor/Equipment	Unit Cost/Hour	Annual Quantity	Annual Cost	Assumptions
1	Crew	$38.46	2,000	$76,923	Assume 2 persons and annual burdened salary of $80,000 per person, dedicated ~1/2 time (1,000 hours/year each)
2	CCTV Truck	$25.00	1,000	$25,000	Assuming 1,000 hours of average operation per year
3	Polaris ATV	$80.00	200	$16,000	Assuming 200 hours of operation per year needed for special access at select locations
4	Setup, Planning and Data Management	$100.00	1,000	$100,000	Includes Multiple Personnel, Work Order management, GIS software and Data Management Costs, QA/QC of CCTV data
			Total	$217,923	$ per year (computed from above)
			Average Daily CCTV Production	1000	feet/day (MSDGC estimate)
			Average Annual CCTV Production	130,000	feet/per year (1/2 time 130 workdays - 26 weeks, 5 days/week)
			CCTV Inspection Cost	$1.68	$/foot of on-road pipe inspected

Table 4-1. MSDGC On-Road CCTV Inspection Costs

S. No.	Labor/Equipment	Unit Cost/Hour	Annual Quantity	Annual Cost	Assumptions
1	Crew	$38.46	2,000	$76,923	Assume 2 persons and annual burdened salary of $80,000 per person, dedicated ~1/2 time (1,000 hours/year each)
2	CCTV Off-Road Tractor	$71.50	1,000	$71,500	Assuming 1,000 hours of average operation per year
3	Polaris ATV	$80.00	200	$16,000	Assuming 200 hours of operation per year needed for special access at select locations

S. No.	Labor/Equipment	Unit Cost/Hour	Annual Quantity	Annual Cost	Assumptions
4	Setup, Planning and Data Management	$100.00	1,000	$100,000	Includes Multiple Personnel, Work Order management, GIS software and Data Management Costs, QA/QC of CCTV data
				Total $264,423	$ per year (computed from above)
			Average Daily CCTV Production	1000	feet/day (MSDGC estimate)
			Average Annual CCTV Production	130,000	feet/per year (1/2 time 130 workdays - 26 weeks, 5 days/week)
			CCTV Inspection Cost	$2.03	$/foot of off-road pipe inspected

Table 4-2. MSDGC Off-Road CCTV Inspection Costs

The Water Environment Research Foundation (WERF) and EPA (WERF, 1997, EPA, 1999) have reported an average nationwide CCTV inspection cost of $4,600 per mile or $0.87 per foot. In the above referenced EPA report, ADS Environmental Services (ADS, 1998) reports an average CCTV inspection cost range of $1,000 to $11,450 per mile, which at the high end computes to $2.17 per linear foot. The most recent WERF report (WERF, 2013) reviewed the trends and cost drivers of CCTV inspection as a function of pipeline diameter, project length, and regional location. WERF reported that the majority of the CCTV projects for inspecting pipelines fell under $3.00 per foot regardless of pipe size. Furthermore, the WERF report indicated that the majority of the projects reported a unit cost of less than $2.00 per foot, once the overall inspected pipe length surpassed 5,000 feet. The report concluded that 5,000 linear feet of pipe is the threshold for attaining savings from economies of scale. To provide a cost comparison, Table 4-3 summarizes the expected cost of both on-road and off-road SewerBatt inspections for MSDGC.

S. No.	Labor/Equipment	Unit Cost/Hour	Annual Quantity	Annual Cost	Assumptions
1	Crew	$38.46	2,000	$76,923	Assume 2 persons and annual burdened salary of $80,000 per person, dedicated ~1/2 time (1,000 hours/year each)
2	SewerBatt Purchase Price	$25.00	1,000	$25,000	$25,000 purchase price cost of SewerBatt spread over 1000 hours of use. Not amortized for 3-years expected life
3	Regular Truck	$6.00	1,000	$6,000	A regular truck will be needed to carry personnel to site
3	Polaris ATV	$80.00	200	$16,000	Assuming 200 hours of operation per year needed for special access at select locations

S. No.	Labor/Equipment	Unit Cost/Hour	Annual Quantity	Annual Cost	Assumptions
4	Setup, Planning and Data Management	$100.00	500	$50,000	Assumes these costs will be halved compared to CCTV inspection. Includes Multiple Personnel, Work Order management, GIS software and Data Management Costs, QA/QC of SewerBatt data
				Total $173,923	$ per year (computed from above)
			Average Daily SewerBatt Production	10,000	feet/day (based on Greenhills data)
			Average Annual SewerBatt Production	1,300,000	feet/per year (1/2 time 130 workdays - 26 weeks, 5 days/week)
			SewerBatt Inspection Cost	$0.13	$/foot of on-road and off/road pipe inspected

Table 4-3. SewerBatt On/Off-Road Inspection Costs

Although the inspection output or detail provided by SewerBatt is not equivalent to a CCTV report, the order of magnitude cost-per-foot savings makes a good case for using the SewerBatt as a tool to perform screening type assessments (prior to the deployment of the more expensive condition assessment equipment or cleaning).

4.2 Rapid Deployment Capability

The majority of the pipes selected for CCTV inspection, acoustic inspection and cleaning for this demonstration project were off-road difficult to access, inspect, and assess. The objective of the project was to demonstrate the performance of the acoustic inspection technologies rather than evaluate the cost of performance. It can be reported that one of the key advantages of SewerBatt is the rapid deployment feature using portable equipment that can result in significant cost-savings to the utilities in comparison with traditional inspection methods such as CCTV inspection, especially when “screening-type” assessments, such as those to determine cleaning needs, are the goal of the inspections.

The SewerBatt actual acoustic test durations for this project were all less than one minute each. When compared to CCTV inspection rates of 30 feet/minute, the rapid assessment capabilities of the acoustic-based SewerBatt system is apparent. While this tool does not eliminate the need for using CCTVs in assessing pipes, it can limit the deployment of the more expensive CCTV resources to focus on critical pipe segments.

4.3 Opportunity to Refocus Critical Resources Deployed for Pipe Cleaning

As reported previously in Section 1.1, cleaning and inspecting sewer pipes is essential for utilities to operate and maintain a properly functioning collection system and avoid SSOs. For many utilities, sewer cleaning and inspection programs are generally part of a larger CMOM program. The routine maintenance of a sewer system often includes sewer system cleaning, root removal/treatment, and cleaning/clearing of sewer mainline stoppages. However, understanding where and when to perform cleaning activities is not necessarily a straight-forward task. The three common approaches adopted by utilities are as follows:

Routine Cleaning - Some wastewater utilities clean their sewer system as a matter of course without knowing in advance whether the system or portions of the system require cleaning. Pipes with blockages receive the same attention and resources as those with potentially no cleaning needs. In this approach, the use of staff and equipment is not optimized, thus consuming staff time and resources that could be directed to other more productive maintenance activities.

Directed Cleaning - In an attempt to direct maintenance staff and cleaning equipment to just those pipes in a sewer system that require attention, some agencies attempt to identify cleaning needs by conducting inspection of the sewers prior to cleaning. These pre-cleaning inspections are conducted using various approaches and equipment to varying degrees of success, efficiency and speed.

Reactive Cleaning - For many wastewater utilities, staff time is directed solely towards reactive cleaning where staff and equipment are deployed to address blockages, spills or other emergencies.

4.4 Conclusion

The emergence of acoustic sewer inspection technologies (e.g., SewerBatt) as rapid deployment, low-cost, reliable, pre-cleaning assessment tools is focusing growing attention on the potential for more cost-effective sewer cleaning programs. Through the ease of deployment, reduction of cost, increases in reliability of these inspection approaches, combined with the potential for reducing the "cleaning of clean pipes," significant cost savings are attainable. As utilities apply these new inspection technologies, they can move towards implementing sewer cleaning programs that consist of planned directed and quick response cleaning. Also, these cost savings can be realized while improving collection system performance and achieving the protection of public health and water quality.

The results of this demonstration project reveal the potential for more cost-effective sewer cleaning programs. The site specific pre-cleaning assessment inspection costs resulting from this project and MSDGC's historic practices for CCTV (on-road), CCTV (off-road), and SewerBatt (on- and off-road) are $1.68/ft., $2.03/ft., and $0.13/ft., respectively. Thus, for pre-cleaning assessment, the application of the SewerBatt can reduce MSDGC's costs by $1.55/ft. for on-road sewers and $1.90/ft. for off-road sewers. In addition, by moving to a sewer cleaning program predominated by planned directed cleaning, MSDGC can save $2.00/ft. by reducing its "cleaning of clean pipe." In total, when costs of conventional CCTV inspection and cleaning are combined, for each pipe segment that is deemed "clean" using the SewerBatt, MSDGC can save $3.55/ft. for on-road sewers and $3.90/ft. for off-road sewers.

The results of this demonstration of the SewerBatt show promise for its application as a tool for cost-effective, pre-cleaning assessment, post-cleaning quality assurance and quick condition assessment screening. The application of the SewerBatt in an overall collection system O&M program should enable wastewater utilities to optimize their sewer cleaning efforts and free up valuable resources to more effectively implement critical CMOM and asset management programs. Also, with further development, SewerBatt has the potential to provide a very useful sewer defect identification and location capability.

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Appendix A – SewerBatt Report on Cincinnati Trials

CONDITION ASSESSMENT OF WASTEWATER COLLECTION SYSTEMS

US Environmental Protection Agency

Contract No EP-C-11_006

SewerBatt Trial

Report ref AST001-RT002-02

Acoustic Sensing Technology (UK) Ltd
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6.0 Issue and approvals log

Report ref	Issue date	Author	Checked	Approved
AST001-RT002-01	03/09/2013	R Long	N Hawkins	R Long
AST001-RT002-02	11/12/2013	R Long	N Hawkins	R Long

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7.0 Introduction

The United States Environmental Protection Agency (US EPA) is sponsoring a series of investigations into emerging technologies for the assessment of the condition of wastewater collection systems. One of the these technologies is SewerBatt, a system manufactured by Acoustic Sensing Technology (UK) Ltd. SewerBatt uses acoustic technology to determine the condition of sewers and drain pipes.

SewerBatt uses acoustic technology to detect conditions inside sewers and drainage pipes. An acoustic sensor head comprising a sound source and an array of microphones is positioned in one end of the pipe to be tested. An excitation signal is then propagated along the pipe and the response is recorded and then processed. Features (such as lateral connections and the pipe end) and defects (such as broken pipes and sedimentation) affect the sound either by reflecting a part of it back to the SewerBatt sensor, or by absorbing the sound energy. By comparing the responses recorded with a library of known responses the system will seek to identify specific responses. An automated condition assessment system is provided that reviews the acoustic response, makes allowance for the energy loss from the pipe end and lateral connections, and then grades the pipes in a traffic light RAG form.

The Metropolitan Sewer District (MSD) of Greater Cincinnati was supplied with the SewerBatt equipment in April 2013 and has since then been undertaking a series of sewer surveys using the equipment. The project has been supervised for the US EPA by CB&I Federal Services. The equipment supplied for the use of MSD was a prototype built by the University of Bradford. This was because the production equipment being manufactured by Acoustic Sensing was not available at the time that the survey work had to be carried out. The production equipment is now available and some limited testing has been carried by Acoustic Sensing in conjunction with CB&I, EPA and MSD during August 2013. A separate report has been prepared to summarise the results of the work with the production equipment.

This report summarises the results of a SewerBatt tests on 151 pipes surveyed during April and May 2013.

8.0 Interpretation of SewerBatt output

The interpretation of the SewerBatt output provided in the Appendices has been produced by the SewerBatt report generator. They include a listing of selected items from the metadata recorded in the SewerBatt results file, a listing of the responses recorded, an image of the envelope of the responses and a condition assessment generated using the 'traffic light' functionality within SewerBatt. This classifies pipes as either 'Green' (serviceable and not requiring further survey), 'Amber' (serviceable but showing evidence of deterioration of operational and/or structural condition and should be logged up for resurvey after an interval), and 'Red' (pipe shows evidence that serviceability is or may soon be compromised and should be CCTVd in the near future). Version 1.4.1 of ScanField (the SewerBatt software) was used to generate the interpretations in this report. Some comments written by the author of the report are included where appropriate.

The 'traffic light' functionality within SewerBatt is a feature that has only recently been incorporated into the software, and was released to the EPA as an 'alpha' test version.

The traffic light system works in a series of logical steps. The first one is to analyse how strong the pipe end reflection is. If the location of pipe end is detectable either automatically by comparison with the signature database or by visual inspection the system checks the level of matching of the reflection by comparison with pipe end signatures in the database. If the pipe end cannot be detected by either means then RAG of pipe condition becomes red. Otherwise, the system calculates the strength of the pipe end reflection.

The pipe end location having been confirmed, the signature matching for other responses in the acoustic record is repeated to enhance its accuracy.

Next, the system then searches for lateral connections by seeking matches with the signature database. The system also provides the option for the operator to select the location of lateral connections manually if the information is known beforehand but they have not been identified by the database matching process.

Next the system searches for any blockages and/or defects in the pipe by comparing other acoustic responses with the database and calculates the total energy reflected excluding the lateral connections and pipe end. The value of energy determines the RAG classification of the pipe by mapping it to pipes of known condition for which acoustic data has previously been acquired. It has been observed that pipes in serviceable condition generally have an energy value less than 70. Pipes in poor condition have generally been observed to have an energy level of more than 90. Thus the RAG classification is set by default to be as follows;

Green – energy <70

Amber – energy 70 to 90

Red – energy >90

This mapping can be changed if required as additional data becomes available and/or to suit the requirements of particular national Codes of Practice.

Finally, if the RAG in the previous step becomes green or amber the system calculates the strength of the biggest blockage/defect response and compares it with the strength calculated for the pipe end. If the ratio is less than 0.33 the previous calculated RAG classification is not changed, for a value between 0.33 and 0.66 a previously green RAG is elevated to amber and finally for a value more than 0.66 the RAG is set to red irrespective of its previous classification.

The present traffic light algorithm depends on the correct identification of lateral connections and pipe ends. While the user has some options to control this selection, at base it relies on the library of signatures of features and defects that are being built up whenever contemporaneous CCTV and acoustic data of the same pipe become available. At the time of writing this report the signature library comprised the following;

Table 1 - Signature library at date of this report

Pipe size	Blockage (bk)	Broken pipe (bp)	Deformation (df)	Displaced joint (dj)	Encrustation (ec)	Lateral connection (lc)	Pipe end (pe)

150mm (6")	-	1	3	3	1	16	11
200mm (8")	-	-	4	-	-	5	9
250mm (10")	-	-	-	-	-	1	1
300mm (12")	-	-	-	-	-	9	16
380mm (15")	1	-	-	-	-	-	1

In some cases the conditions within the sewer pipes was such that that very little energy was reflected back from the target manhole. This loss of energy is not related primarily to the length of the pipe – indeed some very long pipes of up to 122m in length have been tested and the target manhole is clearly visible in the response, eg Survey 1.14 11706004_11706003 which is 122m long. In cases where signal has been lost the pipes have been listed for CCTV without further assessment, because the signal attenuation may well be an indication that conditions in the pipe have deteriorated to the point where inspection is required. We now recommend that SewerBatt testing should be carried out from both ends of each pipe. This has several advantages, one of which is to provide more data in cases where signal attenuation is high.

In the zone close to the acoustic sensor head SewerBatt is effectively 'blind'. Therefore defects in this zone will not be detected acoustically. To overcome this limitation we are currently working on the addition of a small camera to the sensor head so that this part of the pie can be inspected visually.

9.0 Presentation of results

The results of the SewerBatt tests are summarised in the Appendices. Appendix 1 provides a summary table of all the tests carried out, together with the traffic light classification (in two parts, the auto-generated condition assessment first followed by the classification after review, to take account of the 'alpha' stage of development of this part of the package) and the recommended action in terms of no requirement for further survey, reinspection by SewerBatt after an appropriate period, or CCTV in the near future. .

Appendices 2 to 4 provide a detailed set of analysis results for each pipe. These comprise a listing of the locations of the artefacts in the acoustic response, the matching against the signature library and the percentage match, an envelope plot showing the maximum amplitude of all of the frequency bands analysed, the output from the traffic light analyser and comments.

10.0 Conclusions

Of the 105 pipes surveyed for which useful data was obtained, the result of the analysis of the SewerBatt data is that 35 pipes are serviceable and require no further survey (green traffic light), 25 pipes are displaying some signs of deterioration and while currently serviceable they should be retested by SewerBatt after an appropriate interval (amber traffic light) and 45 pipes should be programmed for CCTV survey (red traffic light). The percentages are as follows.

	By number	By length
Green	35 (33%)	2007m (31%)
Amber	25 (24%)	1745m (27%)
Red	45 (43%)	2819m (43%)
	105 (100%)	6572 (100%)

Thus in this sample the use of SewerBatt could have reduced the use of CCTV by 58% (the sum of the Green and Amber lengths). This figure maps well to the results of similar trials undertaken elsewhere, where the reduction in CCTV achieved usually lies in the range 33% to 66%.

As well as achieving economies in CCTV survey, SewerBatt can also be used for other purposes, such as confirming that sewer jetting operations have been completed to an acceptable standard, and that pipes in the area around the pipe that had been blocked are not suffering some distress themselves.

11.0 Note on measurement units

SewerBatt was originally developed in the UK, using metric units for the many signal processing functions that are performed during its operation. The option to display results in US customary units (in this case distances in feet) is provided in the interface, but at present the internal calculations function correctly only if metric units are selected. For this reason this report has been written using metric units. The option to run the software in US customary units will be included in a later release. Multiply metres by 3.281 to convert to feet.

12.0 Appendix 1 – Summary of results

Survey reference	Survey date and time	pipe size (mm)	GIS length (m)	SewerBatt pipe end (m)	SewerBatt auto condition grade	Final condition grade	Recommendation	Comment
Survey 1.1 - 11702001_11702002_300mm-1.mat	29-Apr-2013 12:06:50	300	36.5	36.05	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.2 - 11702001_11707005_300mm-2.mat	29-Apr-2013 12:05:19	300	89.9	79.62	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Minor responses in several locations and target manhole attenuation may indicate potential for deterioration.
Survey 1.3 - 11702003_11702002_300mm-1.mat	29-Apr-2013 12:13:00	300	97.2	98.04	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.4 - 11702003_11702012_300mm-1.mat	29-Apr-2013 12:15:15	300	40.2	40.42	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.5 - 11705009_11705010_300mm-1.mat	29-Apr-2013 13:35:15	300	45.0	44.87	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.6 - 11705009_11706007_200mm-1.mat	29-Apr-2013 13:33:10	200	47.0	47.21	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.7 - 11705011_11705010_300mm-1.mat	25-Apr-2013 10:12:29	300	92.6	91.74	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.8 - 11705011_11705012_300mm-1.mat	25-Apr-2013 10:19:12	300	86.8	86.19	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.9 - 1705013_11705012_300mm-1.mat	25-Apr-2013 10:41:37	300	82.6	82.51	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Minor responses in several locations and target manhole attenuation may indicate potential for deterioration.
Survey 1.10 - 11705013_11705014_200mm-1.mat	25-Apr-2013 10:50:23	200	46.3	45.95	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.11 - 11706002_11706003_300mm-1.mat	29-Apr-2013 11:51:55	300	110.0	109.20	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.12 - 11706002_11707005_300mm-1.mat	29-Apr-2013 11:53:52	300	89.9	90.68	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.
Survey 1.13 - 11706003_11707005_300mm-1.mat	03-May-2013 17:11:53	300	90.0	92.43	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	Minor responses in several locations and target manhole

								attenuation may indicate potential for deterioration.
Survey 1.14 - 11706004_11706003_300mm-1.mat	29-Apr-2013 11:42:21	300	122.0	122.69	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.
Survey 1.15 - 11706004_11706005_300mm-1.mat	29-Apr-2013 11:40:59	300	78.0	78.19	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.
Survey 1.16 - 11706006_11706005_300mm-1.mat	29-Apr-2013 11:32:51	300	45.4	55.57	Green	Green	Serviceable - no further inspection recommended at this time.	GIS pipe length is believed to have been entered incorrectly. There is clear evidence of pipe end at 55.57 in the SewerBatt data.
Survey 1.17 - 11706006_11706007_150mm-2.mat	29-Apr-2013 11:29:10	150	45.4	45.04	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.18 - 11711001_11706006_300mm-1.mat	29-Apr-2013 11:15:37	300	64.6	64.88	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.19 - 11711001_11712001_300mm-1.mat	29-Apr-2013 11:14:01	300	71.3	71.80	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Minor responses in several locations and target manhole attenuation may indicate potential for deterioration.
Survey 1.20 - 11712002_11712001_300mm-1.mat	29-Apr-2013 10:53:28	300	46.0	47.55	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.21 - 11712002_11712003_300mm-2.mat	29-Apr-2013 10:50:15	300	71.0	71.40	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.22 - 11712004_11712003_300mm-1.mat	25-Apr-2013 11:25:36	300	65.5	65.25	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.23 - 11712004_11712005_300mm-1.mat	25-Apr-2013 11:28:16	300	41.5	40.71	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.24 - 11712005_11712006_300mm-1.mat	25-Apr-2013 11:44:21	300	61.5	61.19	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.25 - 11713001_11712006_300mm-1.mat	25-Apr-2013 12:04:33	300	32.4	31.89	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.26 - 11713001_11713002_300mm-1.mat	25-Apr-2013 12:06:23	300	86.5	86.27	Green	Green	Serviceable - no further inspection recommended at this time.	

Survey 1.27 - 11713003_11713002_300mm-1.mat	25-Apr-2013 12:19:50	300	115.5	115.71	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy.
Survey 1.28 - 11713003_11713004_300mm-1.mat	25-Apr-2013 12:23:22	300	66.9	66.91	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy.
Survey 1.29 - 11713003_11713018_200mm-1.mat	25-Apr-2013 12:27:04	200	22.2	22.58	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.30 - 11713006_11712006_300mm-1.mat	29-Apr-2013 12:44:27	300	23.0	23.31	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 1.31 - 11713006_11713005_300mm-2.mat	29-Apr-2013 12:55:48	300	96.6	96.66	Red	Red	CCTV recommended.	
Survey 1.32 - 11713006_11713007_300mm-1.mat	29-Apr-2013 12:48:09	300	76.2	76.27	Red	Red	CCTV recommended.	
Survey 1.33 - 11713014_11713018_300mm-1.mat	29-Apr-2013 13:10:20	300	52.6	53.02	Red	Red	CCTV recommended.	
Survey 1.34 - 15016001_11713004_300mm-1.mat	25-Apr-2013 12:54:55	300	83.4	83.78	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy.
Survey 1.35 - 15016001_15016002_300mm-1.mat	25-Apr-2013 13:02:57	300	68.2	69.96	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Minor responses in several locations and target manhole attenuation may indicate potential for deterioration.
Survey 2.1 - 44705004_44705005_300mm-1.mat	29-May-2013 12:24:51	300	53.0	Not found	-	Red	CCTV recommended.	
Survey 2.2 - 44705004_447060017_300mm-1.mat	29-May-2013 12:13:44	300	53.0	48.36	Green	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 2.3 - 44706004_44706010_300mm-1.mat	29-May-2013 10:24:39	300	58.2	56.43	Red	Red	CCTV recommended.	
Survey 2.4 - 44706004_44707026_300mm-1.mat	29-May-2013 10:17:15	300	54.0	55.61	Green	Amber	Log for reSewerBatt survey after an appropriate interval	

Survey 2.5 - 44706008_44706009_300mm-1.mat	04-Jun-2013 16:46:30	300	82.9	90.29	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 2.6 - 44706009_44706010_300mm-1.mat	04-Jun-2013 16:57:53	300	31.7	31.11	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.7 - 44706010_44706009_200mm-3.mat	29-May-2013 10:57:03	200	31.6	Not found	-	Red	CCTV recommended.	
Survey 2.8 - 44706010_44706011_200mm-2.mat	29-May-2013 10:47:30	200	-	No data	No data	No data	-	No usable data was recorded for this pipe
Survey 2.9 - 44706010_44706013_300mm-1.mat	29-May-2013 11:06:51	300	104.2	104.94	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy.
Survey 2.10 - 44706011_44706010_300mm-1.mat	04-Jun-2013 16:53:23	300	3.65	No data	No data	No data	-	No usable data was recorded for this pipe
Survey 2.11 - 44706011_44706012_300mm-1.mat	04-Jun-2013 16:50:33	300	87.4	87.27	Red	Red	CCTV recommended.	
Survey 2.12 - 44706014_44706013_300mm-1.mat	29-May-2013 11:25:03	300	95.7	96.45	Red	Red	CCTV recommended.	
Survey 2.13 - 44706014_44706015_300mm-1.mat	29-May-2013 11:32:39	300	63.0	61.19	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.14 - 44712001_44705005_300mm-1.mat	29-May-2013 12:39:38	300	115.8	117.41	Green	Amber	Log for reSewerBatt survey after an appropriate interval	Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy.
Survey 2.15 - 44712001_44712002_300mm-1.mat	29-May-2013 12:45:33	300	105.3	106.57	Red	Red	CCTV recommended.	
Survey 2.16 - 44712007_44712002_300mm-1.mat	29-May-2013 13:11:11	300	54.3	55.04	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.17 - 44712007_44712008_300mm-1.mat	29-May-2013 13:14:17	300	52.7	54.17	Amber	Green	Serviceable - no further inspection recommended at this time.	Regraded to account for selection of manhole response.
Survey 2.18 - 48209013_44712008_300mm-1.mat	03-Jun-2013 09:49:59	300	109.7	106.67	Green	Green	Serviceable - no further inspection recommended at this time.	

Survey 2.19 - 48209013_48209014_300mm-1.mat	03-Jun-2013 09:51:46	300	93.8	93.80	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.20 - 48209015_48209014_300mm-1.mat	03-Jun-2013 10:09:59	300	76.0	75.35	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.21 - 48209015_48209016_300mm-1.mat	03-Jun-2013 10:11:44	300	69.0	68.75	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.22- 48209016_48209017_300mm-1.mat	03-Jun-2013 10:30:33	300	69.0	74.79	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 2.23 - 49209018_48209017_300mm-1.mat	04-Jun-2013 14:15:45	300	65.6	66.56	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.1 - 31601001_31601002_200mm-1.mat	09-May-2013 10:06:31	200	49.0	47.11	Red	Red	CCTV recommended.	
Survey 3.2 - 31601001_31601005_200mm-1.mat	09-May-2013 10:04:38	200	68.5	67.40	Red	Red	CCTV recommended.	
Survey 3.3 - 31601001_31601006_200mm-3.mat	09-May-2013 10:22:34	200	62.0	62.40	Red	Red	CCTV recommended.	
Survey 3.4 - 31601003_31601002_200mm-1.mat	09-May-2013 10:30:14	200	81.0	Not found	-	Red	CCTV recommended.	
Survey 3.5 - 31601003_31601004_200mm-1.mat	09-May-2013 10:32:04	200	64.0	Not found	-	Red	CCTV recommended.	
Survey 3.6 - 31602001_31602003_200mm-1.mat	09-May-2013 12:06:13	200	42.0	39.05	Red	Red	CCTV recommended.	
Survey 3.7 - 31602001_31602016_200mm-1.mat	09-May-2013 12:07:36	200	29.0	27.89	Amber	Red	CCTV recommended.	Override to Red due to defective nature of two laterals and many artefacts.
Survey 3.8 - 31602004_31601005_200mm-1.mat	09-May-2013 09:55:22	200	62.0	61.46	Red	Red	CCTV recommended.	
Survey 3.9 - 31602004_31602005_200mm-2.mat	09-May-2013 09:59:31	200	45.0	Not found	-	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.10 - 31602006_31602003_200mm-1.mat	09-May-2013 11:58:22	200	44.0	Not found	-	Red	CCTV recommended.	

Survey 3.11 - 31602006_31602007_200mm-1.mat	09-May-2013 11:56:22	200	29.0	27.72	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 3.12 - 31602008_31602007_200mm-1.mat	09-May-2013 11:51:22	200	45.0	43.40	Red	Red	CCTV recommended.	
Survey 3.13 - 31602008_31602009_200mm-3.mat	09-May-2013 11:50:05	200	91.5	Not found	-	Red	CCTV recommended.	
Survey 3.14 - 31602008_31602014_200mm-1.mat	09-May-2013 11:46:26	200	47.0	46.68	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 3.15 - 31602015_31602009_200mm-1.mat	09-May-2013 12:25:42	200	79.5	Not found	-	Red	CCTV recommended.	
Survey 3.16 - 31602015_31714009_200mm-1.mat	09-May-2013 12:27:48	200	92.0	Not found	-	Red	CCTV recommended.	
Survey 3.17 - 31714003_31714002_200mm-1.mat	09-May-2013 13:17:31	200	15.0	12.51	Green	Red	CCTV recommended.	CCTV recommended due to reported lateral in poor condition and significant attenuation of response from target manhole.
Survey 3.18 - 31714003_31714004_200mm-1.mat	09-May-2013 13:14:17	200	69.5	Not found	-	Red	CCTV recommended.	
Survey 3.19 - 31714003_31714010_200mm-1.mat	09-May-2013 13:15:42	200	26.0	Not found	-	Red	CCTV recommended.	
Survey 3.20 - 31714005_31714004_200mm-1.mat	09-May-2013 13:25:26	200	-	No data	No data	No data	-	No usable data was recorded for this pipe
Survey 3.21 - 31714006_31714005_200mm-1.mat	09-May-2013 13:30:04	200	39.0	38.19	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.22 - 31714006_31714007_200mm-1.mat	09-May-2013 13:31:32	200	-	No data	No data	No data	-	No usable data was recorded for this pipe
Survey 3.23 - =31714009_31714008_200mm-1.mat	09-May-2013 12:32:24	200	73.0	Not found	-	Red	CCTV recommended.	
Survey 3.24 - 31714009_31714018_200mm-1.mat	09-May-2013 12:33:53	200	91.0	Not found	-	Red	CCTV recommended.	

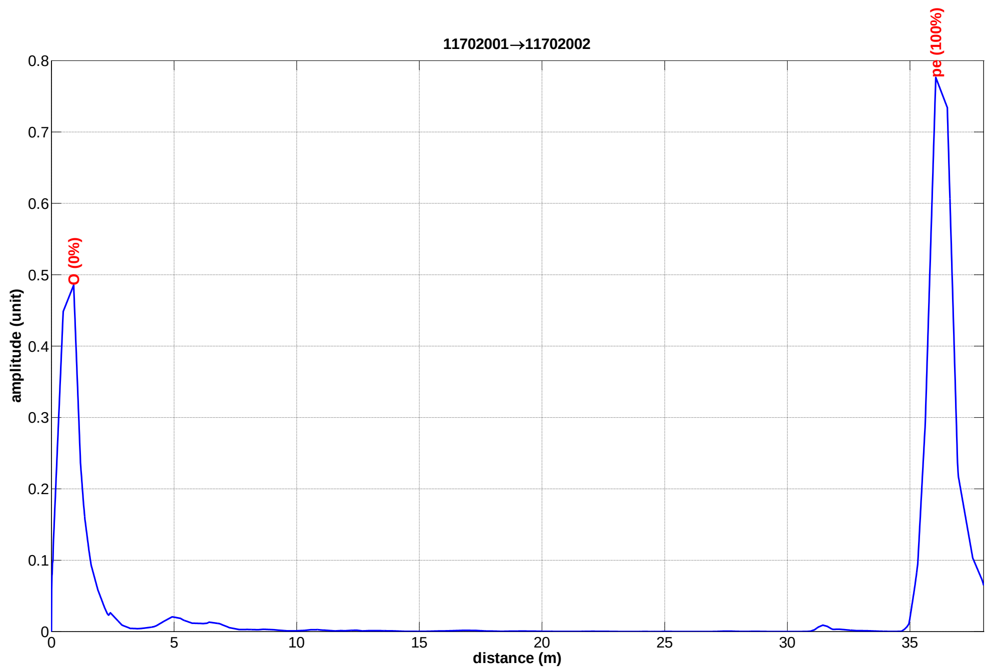
Survey 3.25 - 31714011_31714004_200mm-1.mat	09-May-2013 13:09:33	200	92.0	Not found	-	Red	CCTV recommended.	
Survey 3.26 - 31714011_31714012_200mm-1.mat	09-May-2013 13:08:13	200	53.0	53.32	Red	Red	CCTV recommended.	
Survey 3.27 - 31714011_31714017_200mm-1.mat	09-May-2013 13:06:39	200	59.0	59.14	Red	Red	CCTV recommended.	
Survey 3.28 - 31714014_31714013_200mm-1.mat	09-May-2013 13:00:52	200	22.0	21.63	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 3.29 - 31714014_31714015_200mm-1.mat	09-May-2013 12:57:52	200	40.0	39.56	Red	Red	CCTV recommended.	
Survey 3.30 - 31714014_31714019_200mm-1.mat	09-May-2013 12:59:15	200	40.0	37.96	Red	Red	CCTV recommended.	
Survey 3.31 - 31714016_31714015_200mm-1.mat	09-May-2013 12:51:11	200	32.0	28.98	Red	Red	CCTV recommended.	
Survey 3.32 - 31714016_31714017_200mm-1.mat	09-May-2013 12:48:55	200	29.5	26.16	Red	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.33 - 31714016_31714020_200mm-1.mat	09-May-2013 12:50:51	200	31.0	30.70	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 3.34 - 31714021_31714018_200mm-1.mat	09-May-2013 12:38:13	200	35.0	32.48	Red	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.35 - 31714021_31714022_200mm-1.mat	09-May-2013 12:40:03	200	26.0	25.97	Red	Red	CCTV recommended.	
Survey 3.36 - 31714022_31714023_200mm-1.mat	09-May-2013 12:43:53	200	36.0	35.53	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.37 - 31715005_31715006_200mm-1.mat	09-May-2013 11:24:02	200	14.5	13.84	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.38 - 31715005_31716014_200mm-1.mat	09-May-2013 11:25:29	200	61.0	60.13	Red	Red	CCTV recommended.	
Survey 3.39 - 31715011_31602016_200mm-1.mat	09-May-2013 11:17:07	200	92.0	Not found	-	Red	CCTV recommended.	

Survey 3.40 - 31715011_31715006_200mm-1.mat	09-May-2013 11:19:07	200	92.0	Not found	-	Red	CCTV recommended.	
Survey 3.41 - 31715013_31715010_200mm-1.mat	09-May-2013 11:30:11	200	52.0	52.30	Red	Red	CCTV recommended.	
Survey 3.42 - 31715013_31715016_200mm-1.mat	09-May-2013 11:31:37	200	63.0	63.23	Amber	Amber	Log for reSewerBatt survey after an appropriate interval	
Survey 3.43 - 31715016_31715020_200mm-1.mat	09-May-2013 11:35:31	200	50.5	51.24	Green	Amber	Log for reSewerBatt survey after an appropriate interval	manual override to Amber due nature of reported defects
Survey 3.44 - 31715016_31715022_200mm-1.mat	09-May-2013 11:36:59	200	83.0	Not found	-	Red	CCTV recommended.	
Survey 3.45 - 31715023_31602014_200mm-1.mat	09-May-2013 11:42:07	200	62.0	Not found	-	Red	CCTV recommended.	
Survey 3.46 - 31715023_31715022_200mm-1.mat	09-May-2013 11:40:45	200	51.5	Not found	-	Red	CCTV recommended.	
Survey 3.47 - 31715024_31602015_200mm-1.mat	09-May-2013 12:19:32	200	52.5	52.04	Green	Green	Serviceable - no further inspection recommended at this time.	
Survey 3.48 - 31715024_31715021_200mm-1.mat	09-May-2013 12:17:34	200	75.5	Not found	-	Red	CCTV recommended.	
Survey 3.49 - 31716012_31716011_200mm-1.mat	09-May-2013 11:00:58	200	46.0	Not found	-	Red	CCTV recommended.	
Survey 3.50 - 31716012_31716013_150mm-1.mat	09-May-2013 10:56:08	150	53.5	54.10	Red	Red	CCTV recommended.	
Survey 3.51 - 31716015_31716013_200mm-1.mat	09-May-2013 10:40:58	200	68.0	Not found	-	Red	CCTV recommended.	

13.0 Appendix 2 – Interpretation of SewerBatt output – Galia & South

14.0 Survey 1.1 - 11702001_11702002_300mm-1.mat

SITE : south rd
TEST DATE & TIME : 29-Apr-2013 12:06:50
WATER LEVEL : 21mm
DIAMETER : 300mm
START MH : 11702001
END MH : 11702002
REPORT :
1 : O (0%) at 0.91m
2 : pe (100%) at 36.05m



CONDITION REPORT
36.05 : pe
ENERGY : 29
PE : 0.78
DE ratio : 0
AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 36.5m. The pipe is serviceable and no further inspection is recommended at this time.

15.0 Survey 1.2 - 11702001_11707005_300mm-2.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:05:19

WATER LEVEL : 21mm

DIAMETER : 300mm

START MH : 11702001

END MH : 11707005

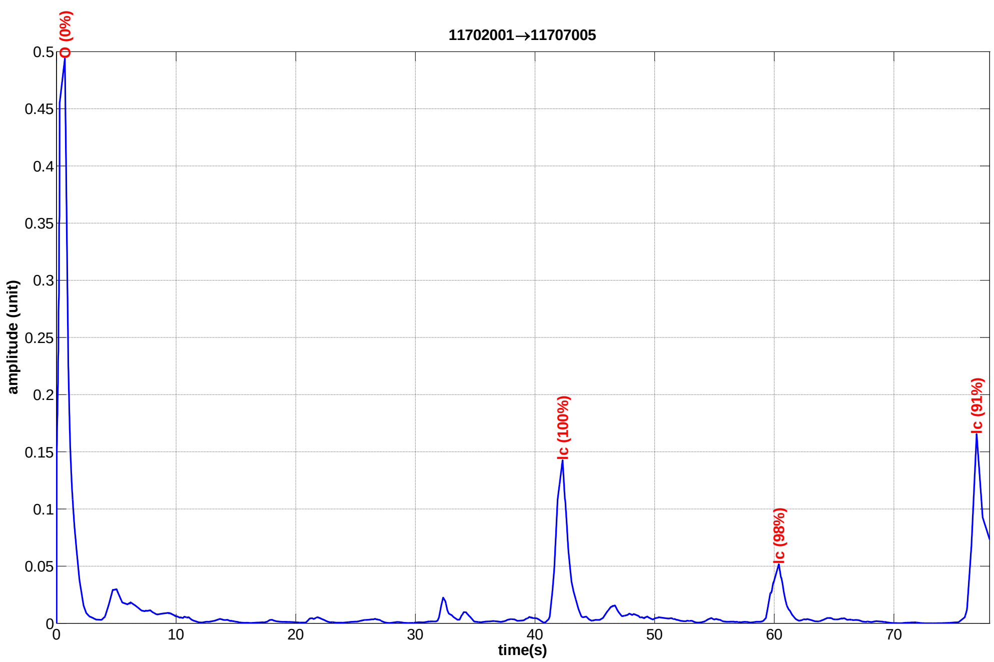
REPORT :

1 : O (0%) at 0.71m

2 : lc (100%) at 42.31m

3 : lc (98%) at 60.38m

4 : lc (91%) at 76.92m



CONDITION REPORT

42.31 : lc (Good)

60.38 : lc (Good)

76.92 : pe

ENERGY : 59

PE : 0.17

DE ratio : 0
AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENTS – GIS pipe length = 89.9m. Pipe is currently serviceable but minor responses along the length of the pipe indicate potential for deterioration. Log for resurvey.

16.0 Survey 1.3 - 11702003_11702002_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:13:00

WATER LEVEL : 21mm

DIAMETER : 300mm

START MH : 11702003

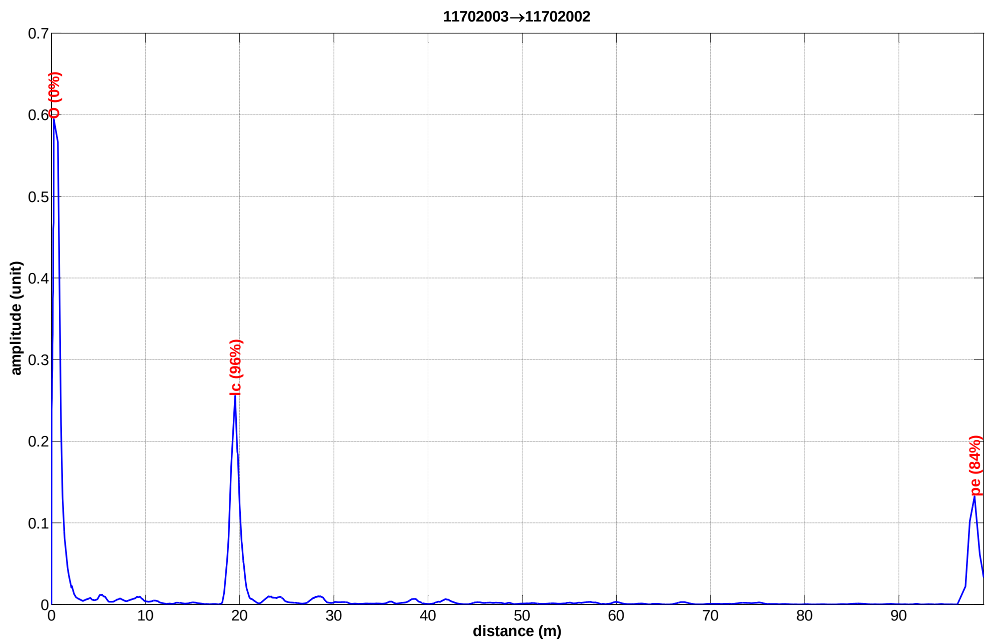
END MH : 11702002

REPORT :

1 : O (0%) at 0.26m

2 : lc (96%) at 19.52m

3 : pe (84%) at 98.04m



CONDITION REPORT :

19.52 : lc (Good)

98.04 : pe

ENERGY : 29

PE : 0.13

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 76.5m. Pipe is serviceable. No further survey is required at this time.

17.0 Survey 1.4 - 11702003_11702012_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:15:15

WATER LEVEL : 21mm

DIAMETER : 300mm

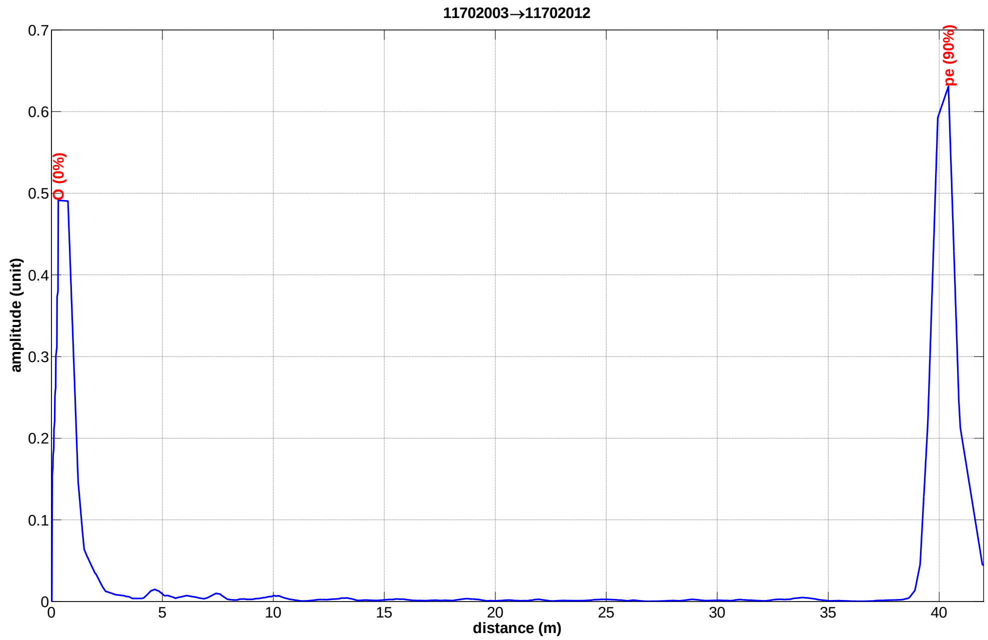
START MH : 11702003

END MH : 11702012

REPORT :

1 : O (0%) at 0.31m

2 : pe (90%) at 40.42m



CONDITION REPORT :

40.42 : pe

ENERGY : 34

PE : 0.63

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 40.2m. Pipe is serviceable. No further survey is required at this time.

18.0 Survey 1.5 - 11705009_11705010_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 13:35:15

WATER LEVEL : 22mm

DIAMETER : 300mm

START MH : 11705009

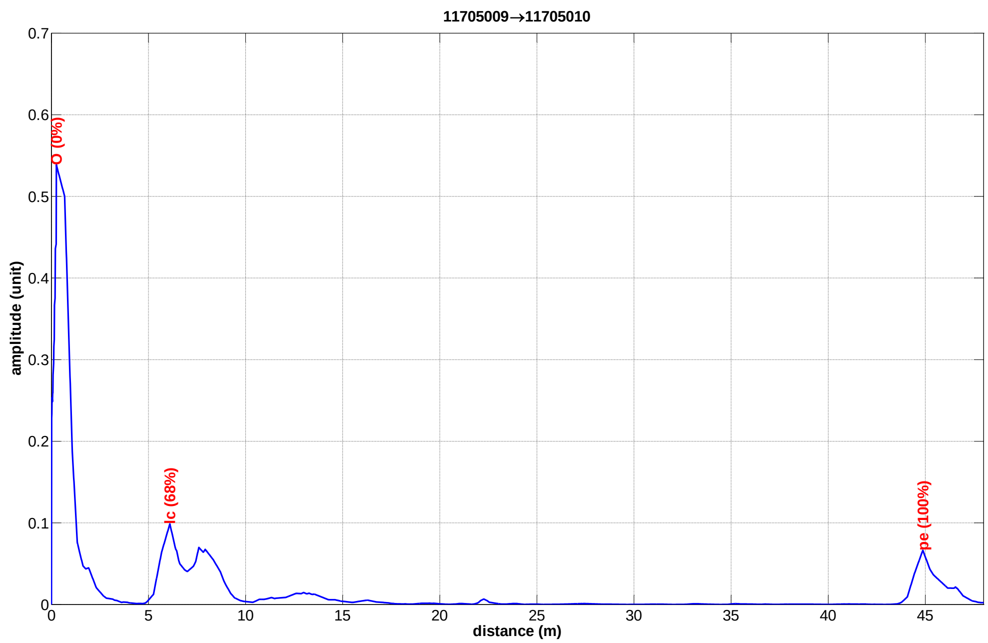
END MH : 11705010

REPORT :

1 : O (0%) at 0.26m

2 : lc (68%) at 6.1m

3 : pe (100%) at 44.87m



CONDITION REPORT :

6.1 : lc (intruding, defective)

44.87 : pe

ENERGY : 48

PE : 0.07

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 45.0m. Pipe is serviceable. No further survey is required at this time.

19.0 Survey 1.6 - 11705009_11706007_200mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 13:33:10

WATER LEVEL : 22mm

DIAMETER : 200mm

START MH : 11705009

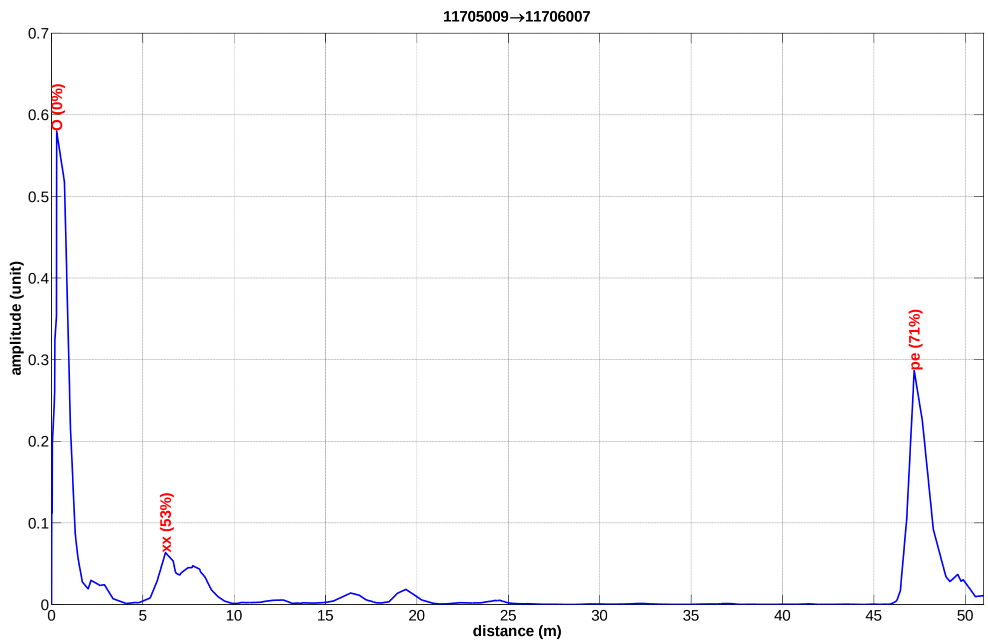
END MH : 11706007

REPORT :

1 : O (0%) at 0.29m

2 : xx (53%) at 6.24m

3 : pe (71%) at 47.21m



CONDITION REPORT :

6.24 : xx

47.21 : pe

ENERGY : 23

PE : 0.29

DE ratio : 0.22

AUTO CONDITION GRADE – Green

COMMENTS – GIS Pipe length = 47.0m. Pipe is serviceable. No further survey is required at this time.

20.0 Survey 1.7 - 11705011_11705010_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 10:12:29

WATER LEVEL : 20mm

DIAMETER : 300mm

START MH : 11705011

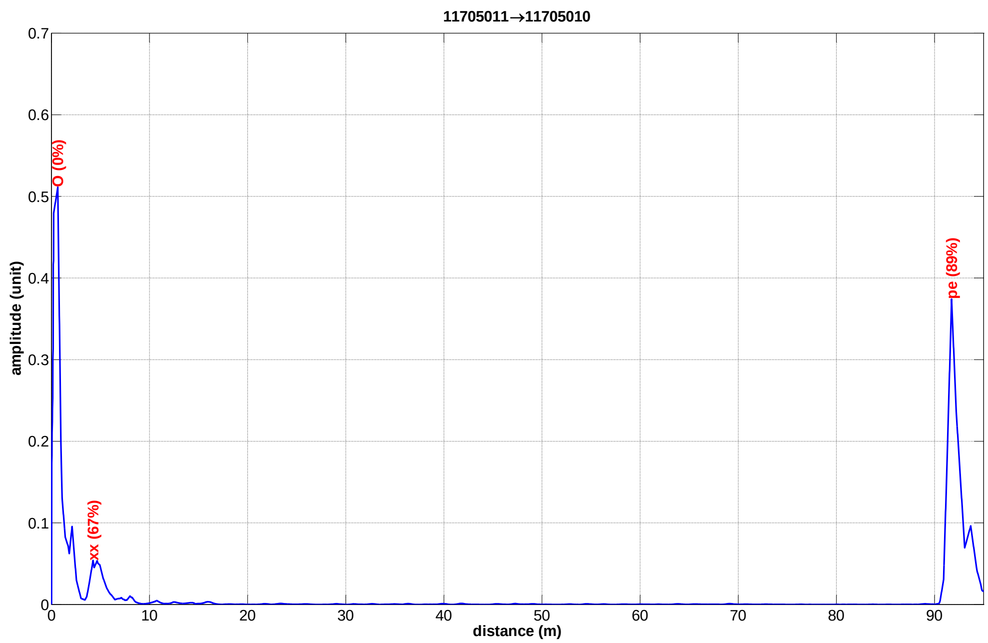
END MH : 11705010

REPORT :

1 : O (0%) at 0.65m

2 : xx (67%) at 4.25m

3 : pe (89%) at 91.74m



CONDITION REPORT :

4.25 : xx

91.74 : pe

ENERGY : 20

PE : 0.37

DE ratio : 0.14

AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 92.6m. Pipe is serviceable. No further survey is required at this time.

21.0 Survey 1.8 - 11705011_11705012_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 10:19:12

WATER LEVEL : 20mm

DIAMETER : 300mm

START MH : 11705011

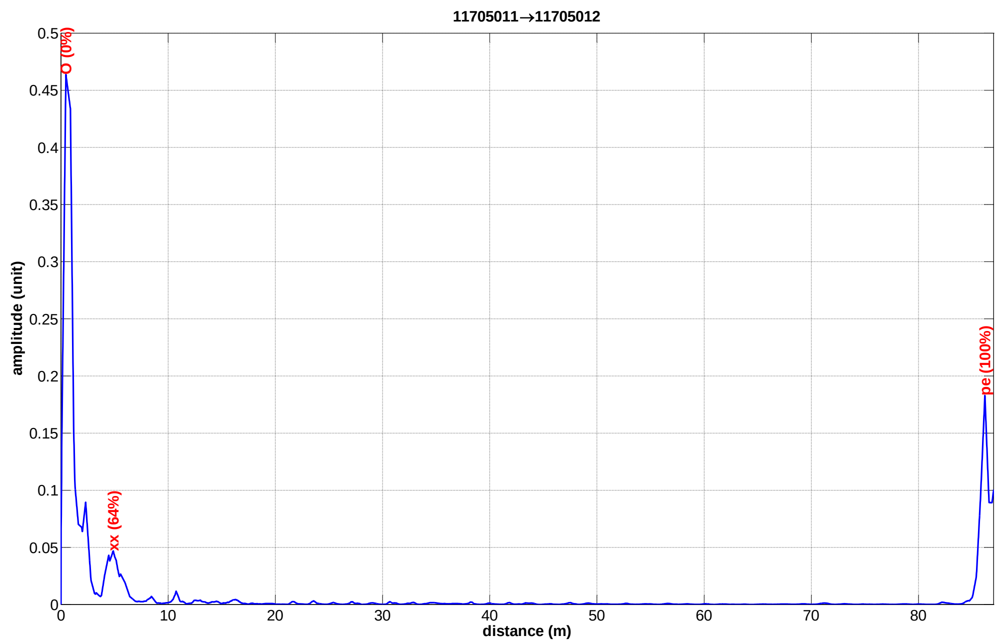
END MH : 11705012

REPORT :

1 : O (0%) at 0.46m

2 : xx (64%) at 4.88m

3 : pe (100%) at 86.19m



CONDITION REPORT :

4.88 : xx

86.19 : pe (good)

ENERGY : 26

PE : 0.18

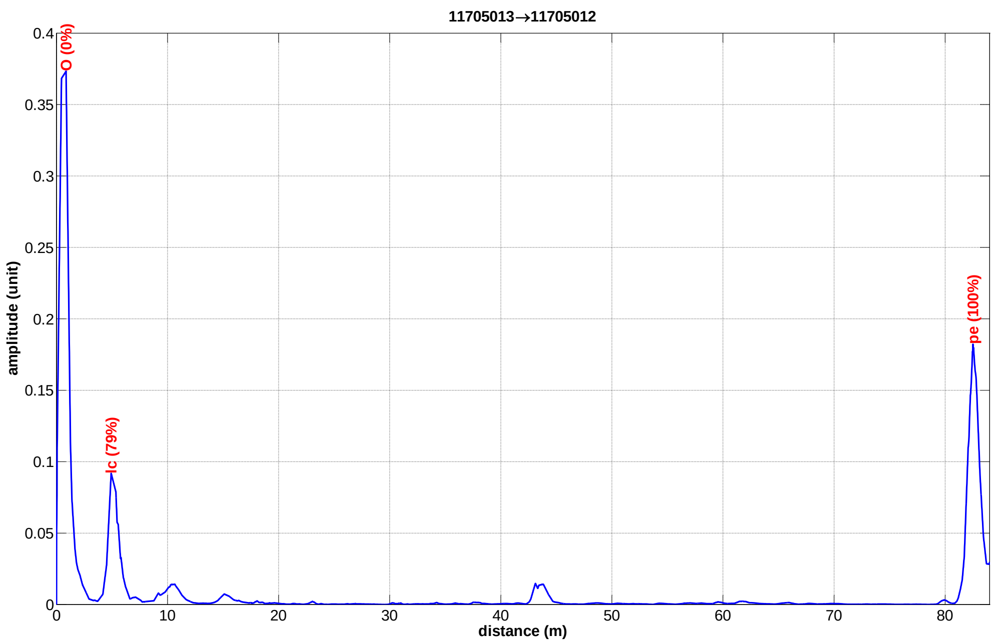
DE ratio : 0.26

AUTO CONDITION GRADE – Green

COMMENTS – GIS pipe length = 86.8m. Pipe is serviceable. No further survey is required at this time.

22.0 Survey 1.9 - 1705013_11705012_300mm-1.mat

SITE : SOUTH RD
TEST DATE & TIME : 25-Apr-2013 10:41:37
WATER LEVEL : 20mm
DIAMETER : 300mm
START MH : 11705013
END MH : 11705012
REPORT :
1 : O (0%) at 0.87m
2 : lc (79%) at 4.93m
3 : pe (100%) at 82.51m



CONDITION REPORT :
4.93 : lc (intruding, defective)
82.51 : pe (good)
ENERGY : 23
PE : 0.18
DE ratio : 0
AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS pipe length = 82.6m. Small responses recorded, eg at 44m indicate potential for deterioration. Log for resurvey after an appropriate interval.

23.0 Survey 1.10 - 11705013_11705014_200mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 10:50:23

WATER LEVEL : 20mm

DIAMETER : 200mm

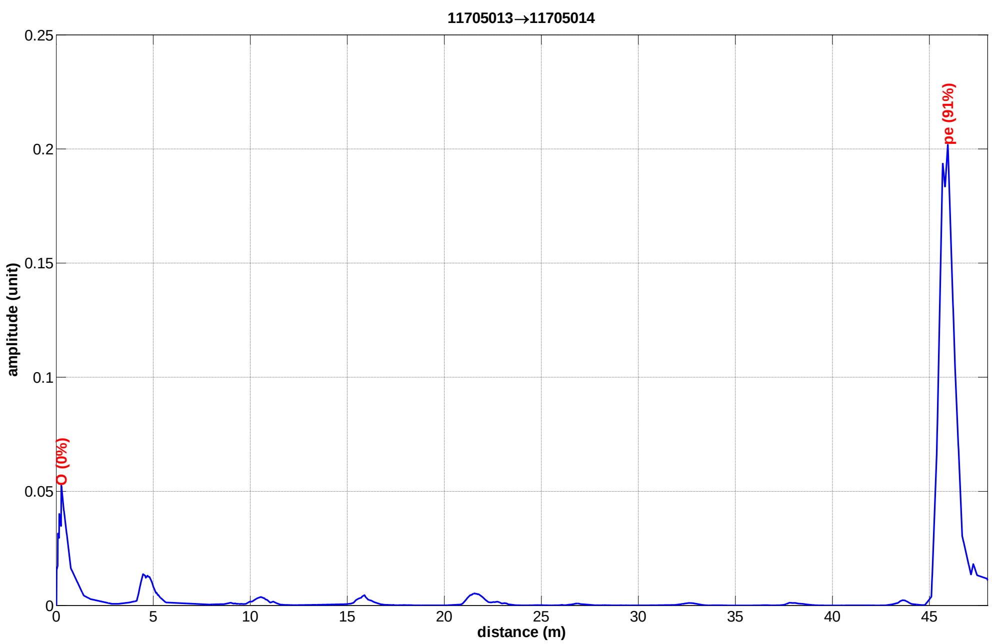
START MH : 11705013

END MH : 11705014

REPORT :

1 : O (0%) at 0.26m

2 : pe (91%) at 45.95m



CONDITION REPORT :

45.95 : pe

ENERGY : 9

PE : 0.2

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT

24.0 Survey 1.11 - 11706002_11706003_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:51:55

WATER LEVEL : 21mm

DIAMETER : 300mm

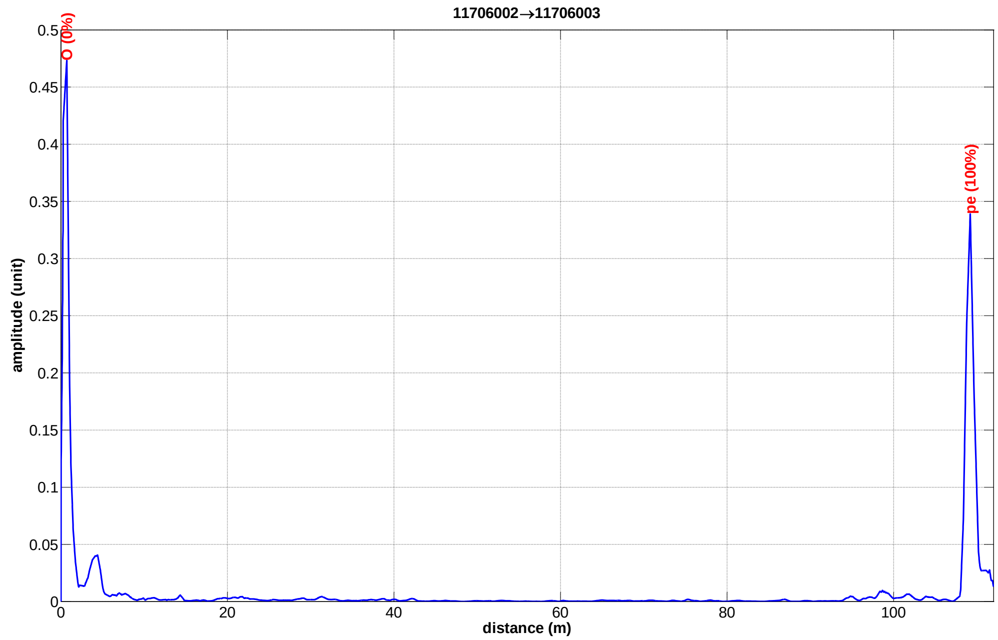
START MH : 11706002

END MH : 11706003

REPORT :

1 : O (0%) at 0.71m

2 : pe (100%) at 109.2m



CONDITION REPORT :

109.2 : pe

ENERGY : 34

PE : 0.34

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENTS – GIS length 110m. Pipe is serviceable. No further survey is required at this time.

25.0 Survey 1.12 - 11706002_11707005_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:53:52

WATER LEVEL : 21mm

DIAMETER : 300mm

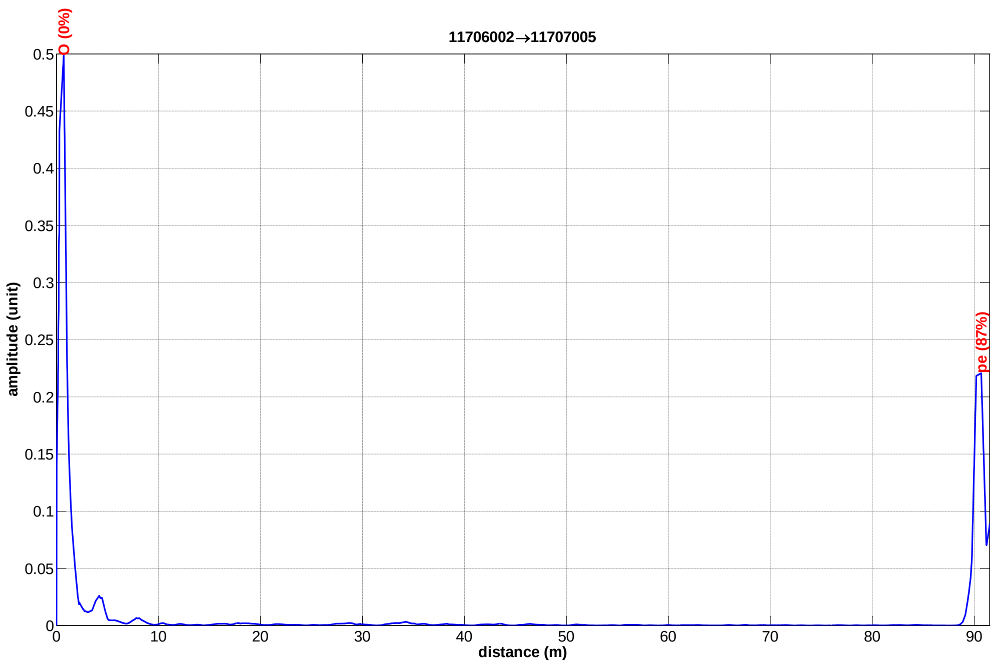
START MH : 11706002

END MH : 11707005

REPORT :

1 : O (0%) at 0.72m

2 : pe (87%) at 90.68m



CONDITION REPORT :

90.68 : pe

ENERGY : 16

PE : 0.22

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS length = 89.9m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration. Log for resurvey after an appropriate interval.

26.0 Survey 1.13 - 11706003_11707005_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 03-May-2013 17:11:53

WATER LEVEL : 0mm

DIAMETER : 300mm

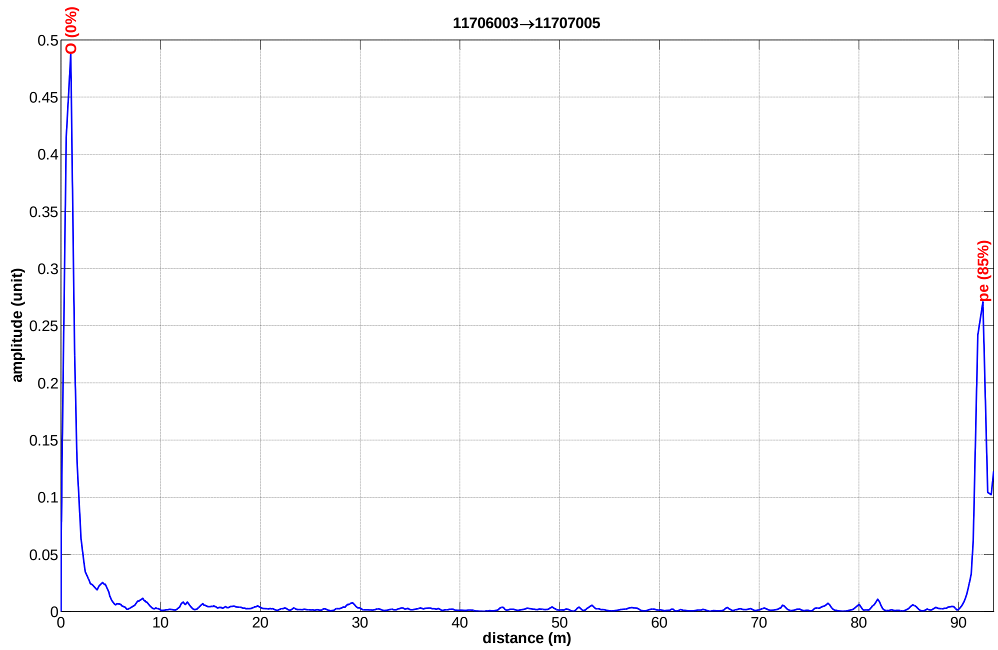
START MH : 11706003

END MH : 11707005

REPORT :

1 : O (0%) at 0.99m

2 : pe (85%) at 92.43m



CONDITION REPORT :

92.43 : pe

ENERGY : 74

PE : 0.27

DE ratio : 0

AUTO CONDITION GRADE – Amber

COMMENT – GIS length = 90.0m. Amber grading in this case appears to be the result of many small responses along the length of the pipe. The energy score of 74 is close to the lower amber threshold of 70, indicating that the loss of serviceability is minor.

27.0 Survey 1.14 - 11706004_11706003_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:42:21

WATER LEVEL : 21mm

DIAMETER : 300mm

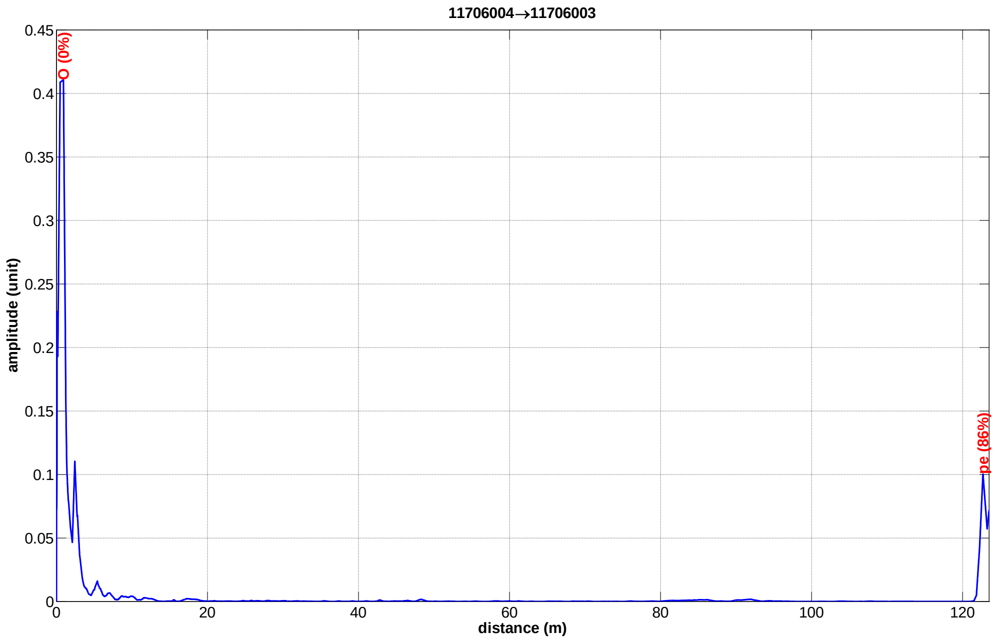
START MH : 11706004

END MH : 11706003

REPORT :

1 : O (0%) at 0.93m

2 : pe (86%) at 122.69m



CONDITION REPORT :

122.69 : pe

ENERGY : 13

PE : 0.1

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT GIS length = 122m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.

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28.0 Survey 1.15 - 11706004_11706005_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:40:59

WATER LEVEL : 21mm

DIAMETER : 300mm

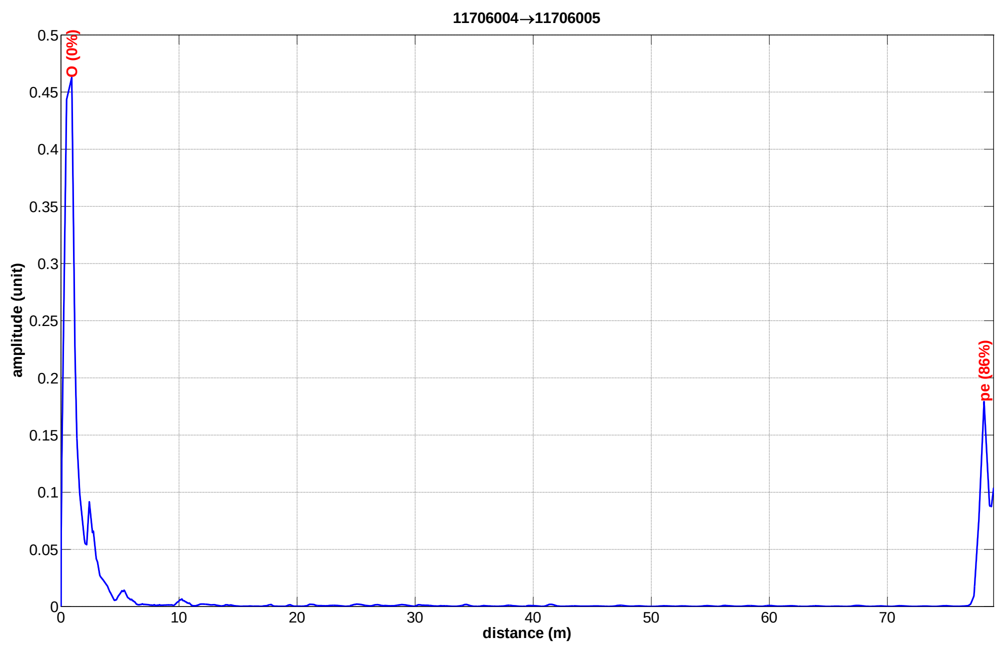
START MH : 11706004

END MH : 11706005

REPORT :

1 : O (0%) at 0.92m

2 : pe (86%) at 78.19m



CONDITION REPORT :

78.19 : pe

ENERGY : 23

PE : 0.18

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS Length = 78m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration. Log for resurvey after an appropriate interval.

29.0 Survey 1.16 - 11706006_11706005_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:32:51

WATER LEVEL : 21mm

DIAMETER : 300mm

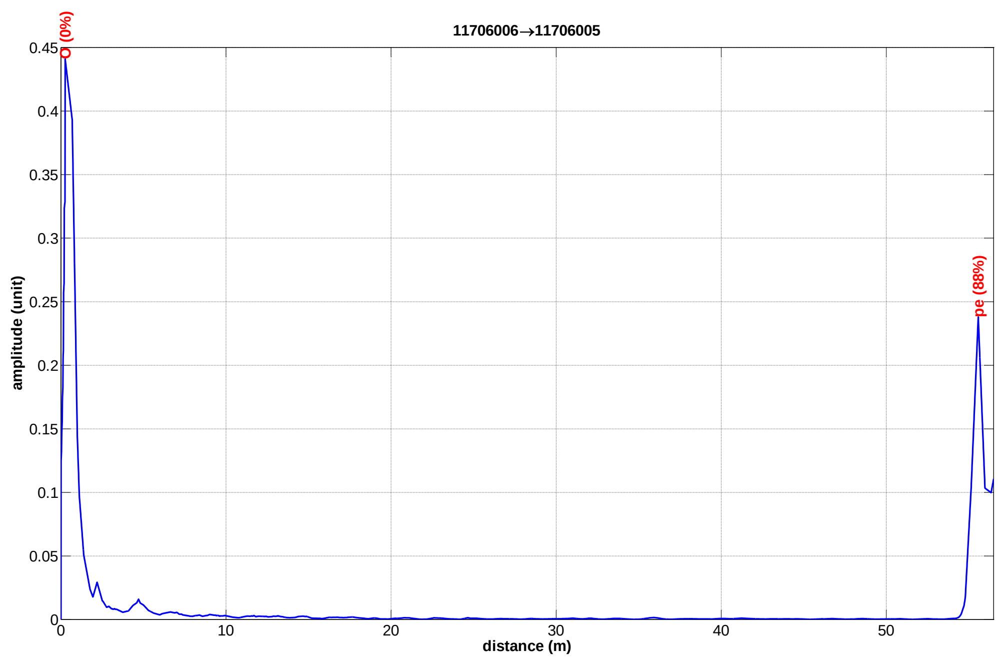
START MH : 11706006

END MH : 11706005

REPORT :

1 : O (0%) at 0.26m

2 : pe (88%) at 55.57m



CONDITION REPORT :

55.57 : pe

ENERGY : 19

PE : 0.24

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length recorded in metadata as 45.4m is incorrect. Pipe is serviceable. No further survey is required at this time.

30.0 Survey 1.17 - 11706006_11706007_150mm-2.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:29:10

WATER LEVEL : 21mm

DIAMETER : 300mm

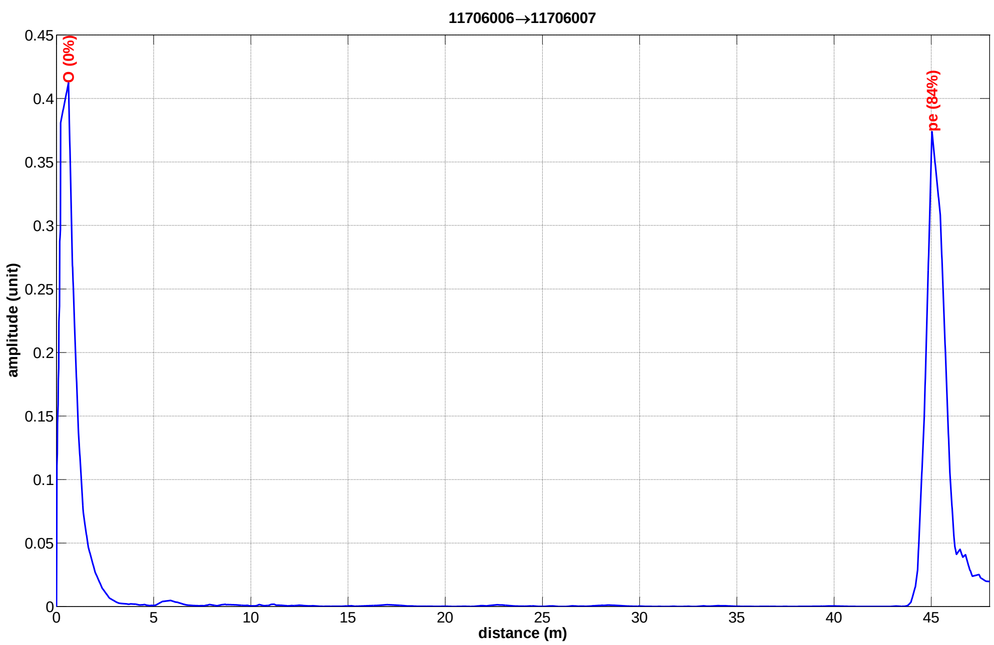
START MH : 11706006

END MH : 11706007

REPORT :

1 : O (0%) at 0.62m

2 : pe (84%) at 45.04m



CONDITION REPORT :

45.04 : pe (good)

ENERGY : 8

PE : 0.37

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS length = 45.4m. Three tests were taken in this pipe. Two of these recorded a large loss of signal. The test used for the analysis showed a serviceable pipe; this could not have been recorded if it were not the case, hence the reason why this test has been selected.

31.0 Survey 1.18 - 11711001_11706006_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 11:15:37

WATER LEVEL : 20mm

DIAMETER : 300mm

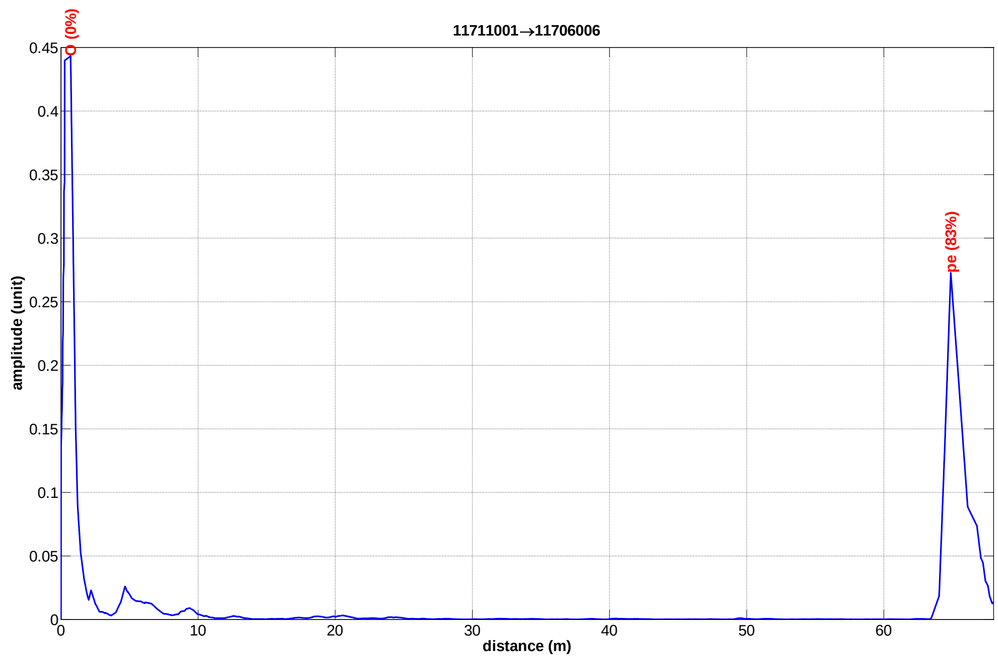
START MH : 11711001

END MH : 11706006

REPORT :

1 : O (0%) at 0.71m

2 : pe (83%) at 64.88m



CONDITION REPORT :

64.88 : pe

ENERGY : 18

PE : 0.27

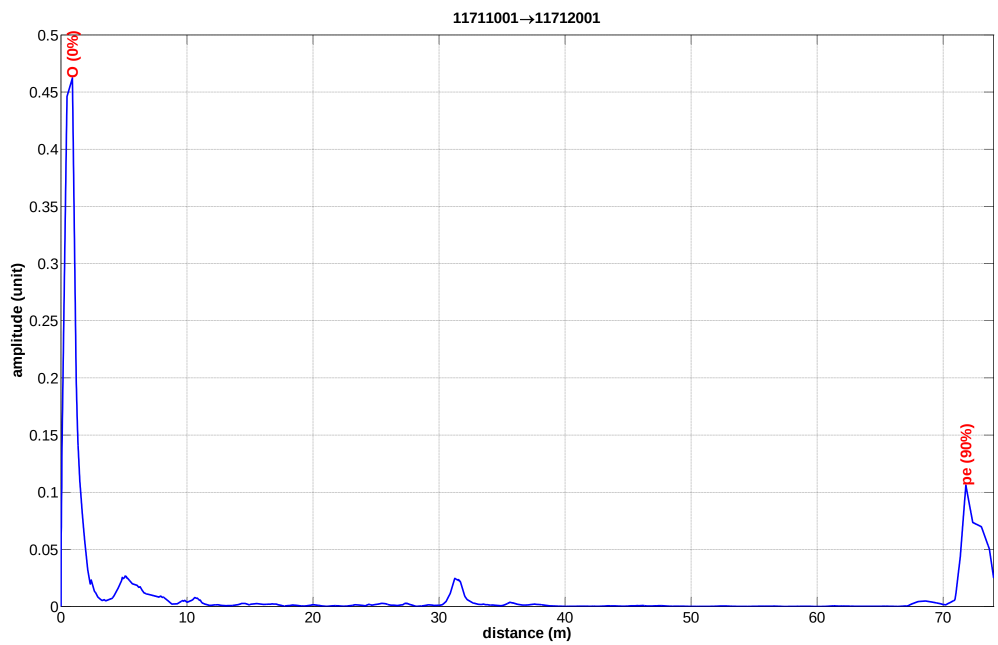
DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT GIS Length 64.6m. Energy is slightly reduced by the small response between 4m and 7m and some very minor responses between 7m and 25m.

32.0 Survey 1.19 - 11711001_11712001_300mm-1.mat

SITE : south rd
TEST DATE & TIME : 29-Apr-2013 11:14:01
WATER LEVEL : 20mm
DIAMETER : 300mm
START MH : 11711001
END MH : 11712001
REPORT :
1 : O (0%) at 0.91m
2 : pe (90%) at 71.8m



CONDITION REPORT :
71.8 : pe
ENERGY : 35
PE : 0.11
DE ratio : 0
AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS length 71.3m. Energy is reduced by the small responses at 5m, 32m and 68m, and some minor responses up to 40m. Taken with the attenuation of the response from the target manhole there is potential for deterioration in this pipe. Log for resurvey after an appropriate period.

33.0 Survey 1.20 - 11712002_11712001_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 10:53:28

WATER LEVEL : 20mm

DIAMETER : 300mm

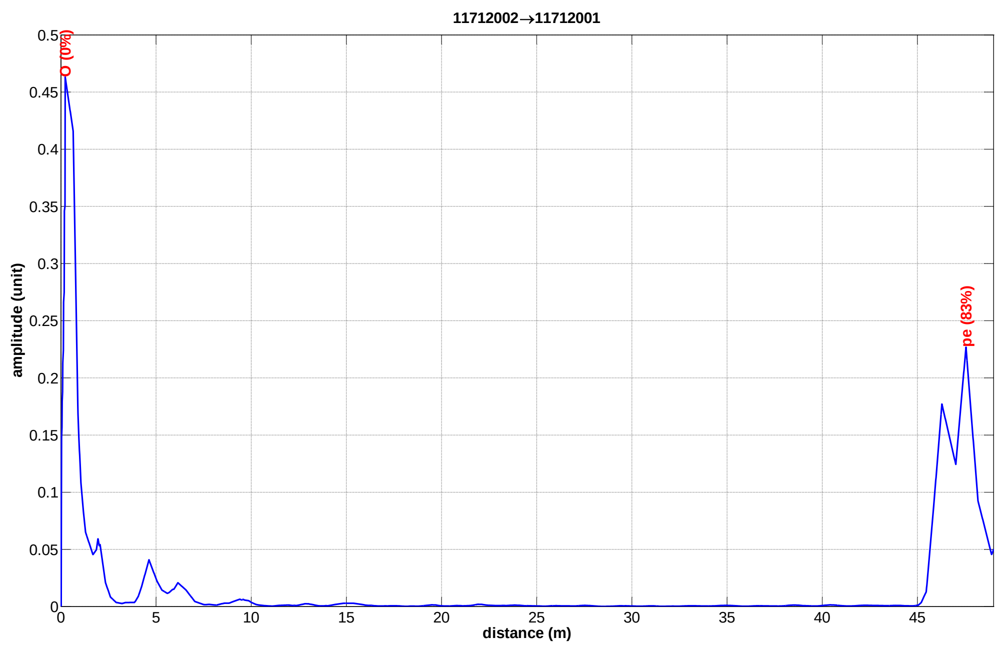
START MH : 11712002

END MH : 11712001

REPORT :

1 : O (0%) at 0.22m

2 : pe (83%) at 47.55m



CONDITION REPORT :

47.55 : pe

ENERGY : 41

PE : 0.23

DE ratio : 0

CONDITION _ Green

COMMENT – GIS length = 46.0m. Energy is reduced by the responses between 3m and 10m and some minor intermittent responses along the length of the pipe.

34.0 Survey 1.21 - 11712002_11712003_300mm-2.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 10:50:15

WATER LEVEL : 20mm

DIAMETER : 300mm

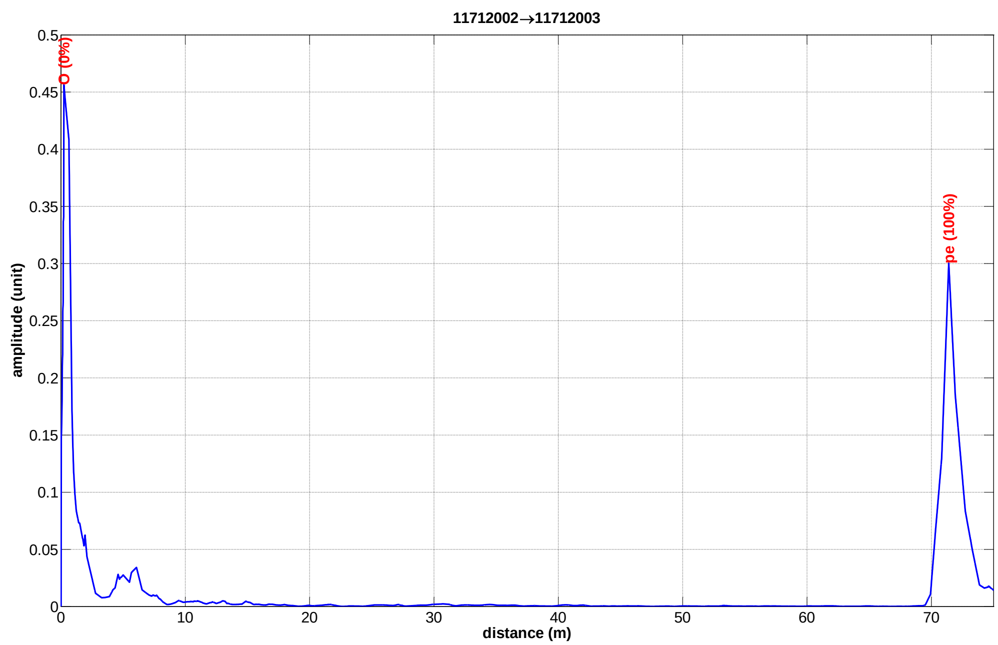
START MH : 11712002

END MH : 11712003

REPORT :

1 : O (0%) at 0.24m

2 : pe (100%) at 71.4m



CONDITION REPORT :

71.4 : pe

ENERGY : 27

PE : 0.3

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS length = 71.0m. Energy is reduced by the response between 4m and 10m and some minor intermittent responses between 10m and 35m.

35.0 Survey 1.22 - 11712004_11712003_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 11:25:36

WATER LEVEL : 76.2mm

DIAMETER : 300mm

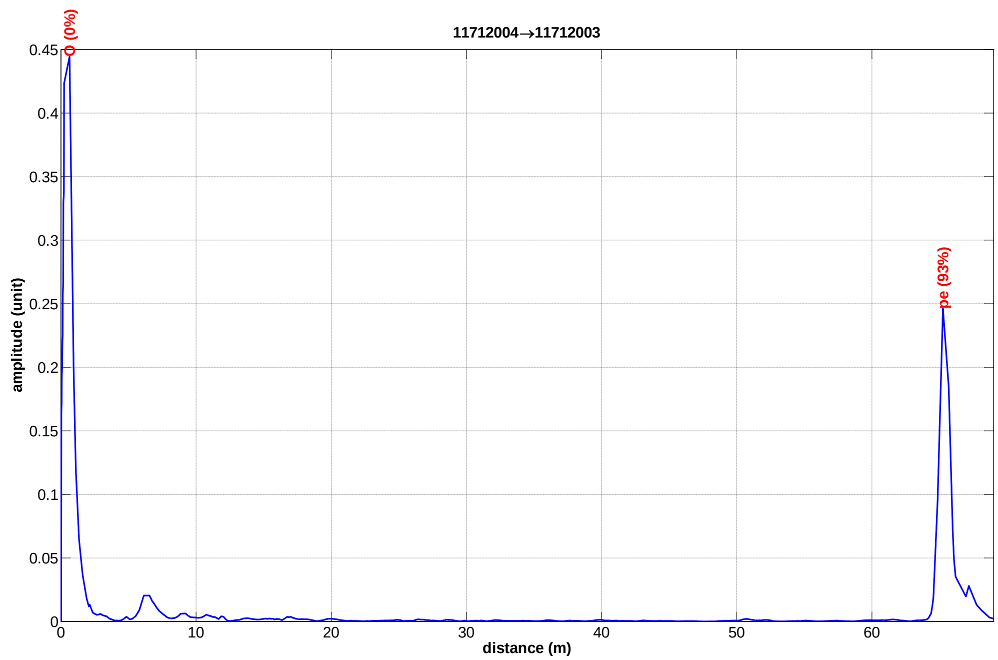
START MH : 11712004

END MH : 11712003

REPORT :

1 : O (0%) at 0.64m

2 : pe (93%) at 65.25m



CONDITION REPORT :

65.25 : pe

ENERGY : 18

PE : 0.25

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS length = 65.5. Pipe is serviceable. No further survey is required at this time.

36.0 Survey 1.23 - 11712004_11712005_300mm-1.mat

37.0

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 11:28:16

WATER LEVEL : 76.2mm

DIAMETER : 300mm

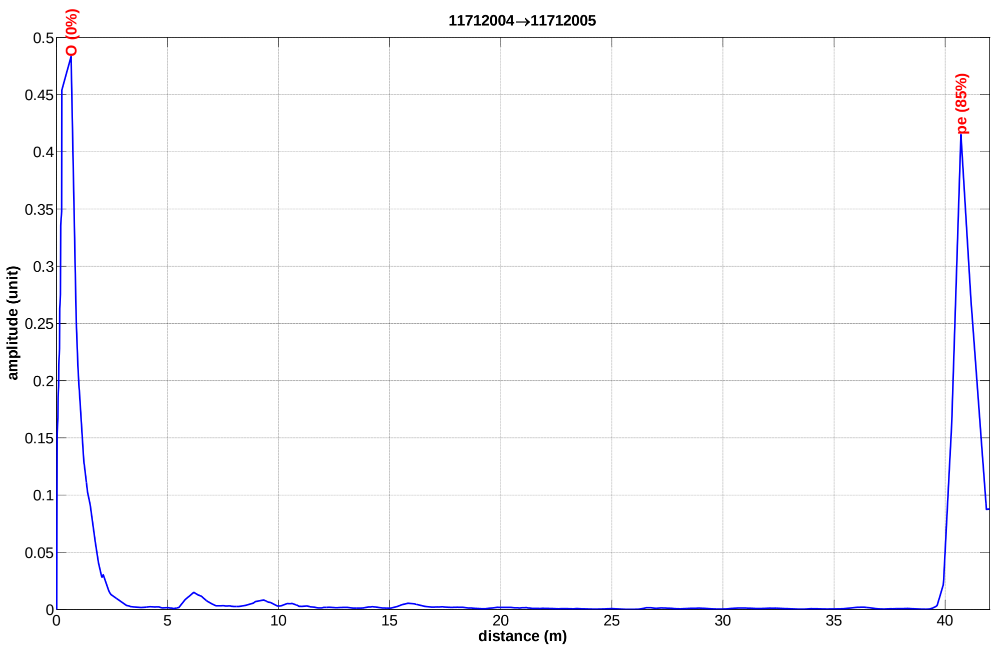
START MH : 11712004

END MH : 11712005

REPORT :

1 : O (0%) at 0.66m

2 : pe (85%) at 40.71m



CONDITION REPORT :

40.71 : pe

ENERGY : 29

PE : 0.42

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS length = 41.5m. Pipe is serviceable. No further survey is required at this time.

38.0 Survey 1.24 - 11712005_11712006_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 11:44:21

WATER LEVEL : 80mm

DIAMETER : 300mm

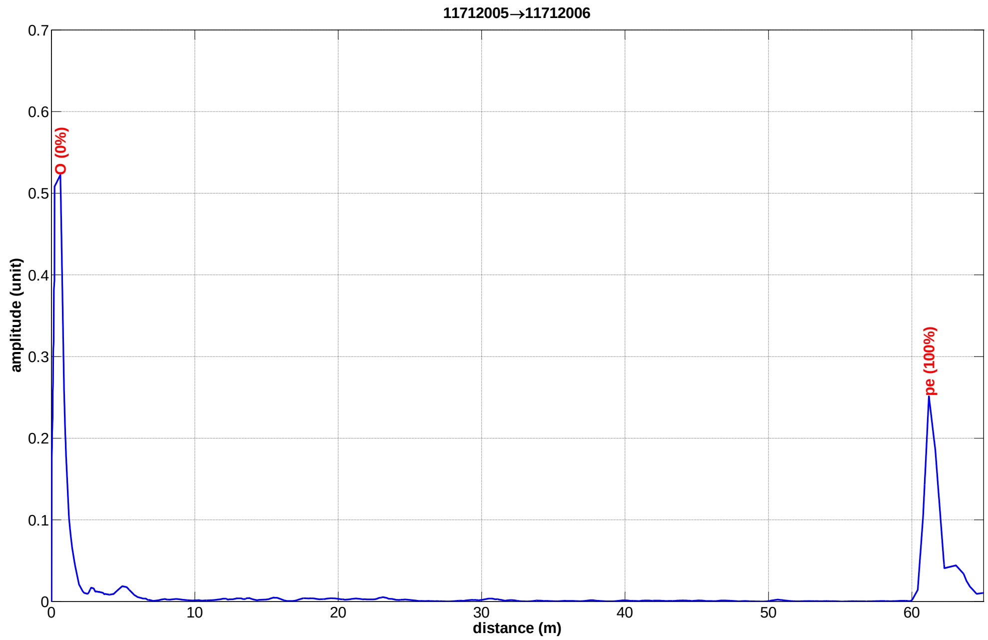
START MH : 11712005

END MH : 11712006

REPORT :

1 : O (0%) at 0.63m

2 : pe (100%) at 61.19m



CONDITION REPORT :

61.19 : pe (Good)

ENERGY : 36

PE : 0.25

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS Length = 61.5m. Pipe is serviceable. No further survey is required at this time.

39.0 Survey 1.25 - 11713001_11712006_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:04:33

WATER LEVEL : 20mm

DIAMETER : 300mm

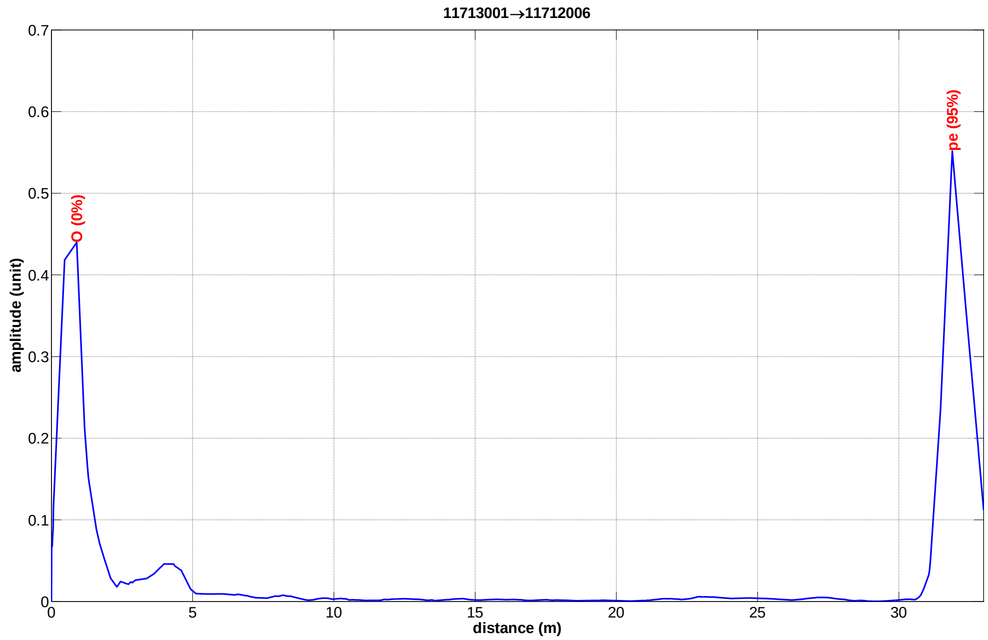
START MH : 11713001

END MH : 11712006

REPORT :

1 : O (0%) at 0.9m

2 : pe (95%) at 31.89m



CONDITION REPORT :

31.89 : pe (Good)

ENERGY : 62

PE : 0.55

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 32.4m. Pipe is serviceable. No further survey is required at this time.

40.0 Survey 1.26 - 11713001_11713002_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:06:23

WATER LEVEL : 76mm

DIAMETER : 300mm

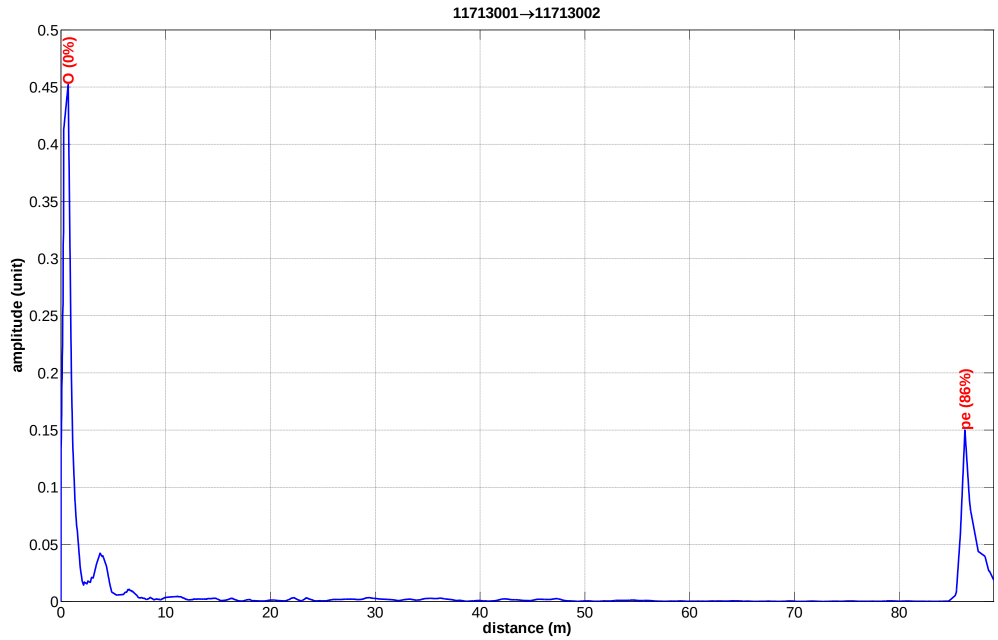
START MH : 11713001

END MH : 11713002

REPORT :

1 : O (0%) at 0.69m

2 : pe (86%) at 86.27m



CONDITION REPORT :

86.27 : pe (good)

ENERGY : 23

PE : 0.15

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS Length = 86.5m. Pipe is serviceable. No further survey is required at this time.

41.0 Survey 1.27 - 11713003_11713002_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:19:50

WATER LEVEL : 70mm

DIAMETER : 300mm

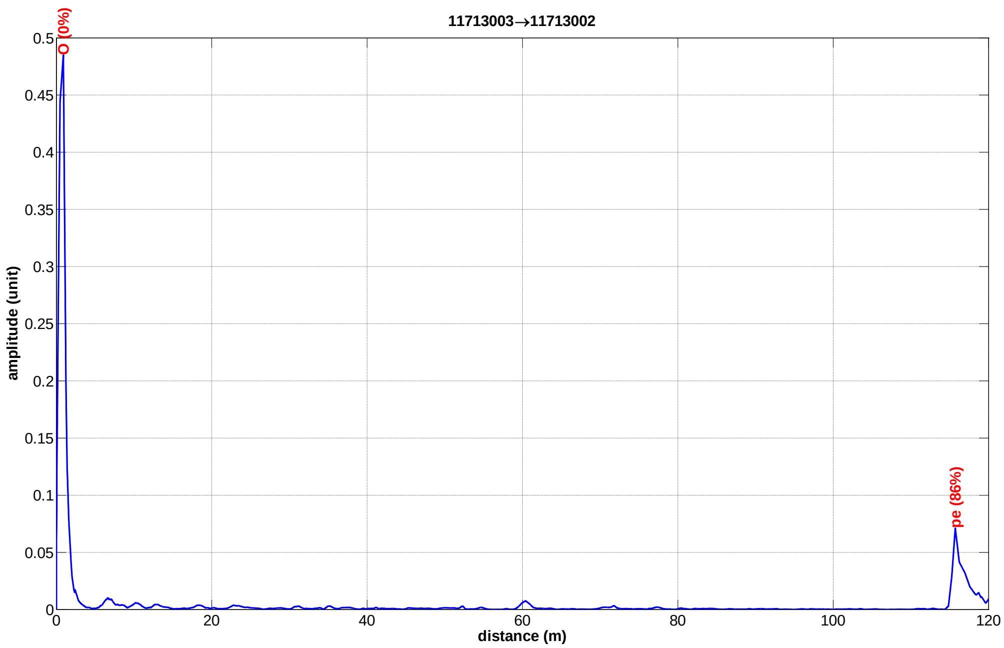
START MH : 11713003

END MH : 11713002

REPORT :

1 : O (0%) at 0.9m

2 : pe (86%) at 115.71m



CONDITION REPORT :

115.71 : pe

ENERGY : 17

PE : 0.07

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS pipe length = 115.5m. Significant attenuation of response from target manhole in the absence of responses along the pipe indicates defects that are absorbing the acoustic energy. Log for reinspection after an appropriate interval.

42.0 Survey 1.28 - 11713003_11713004_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:23:22

WATER LEVEL : 70mm

DIAMETER : 300mm

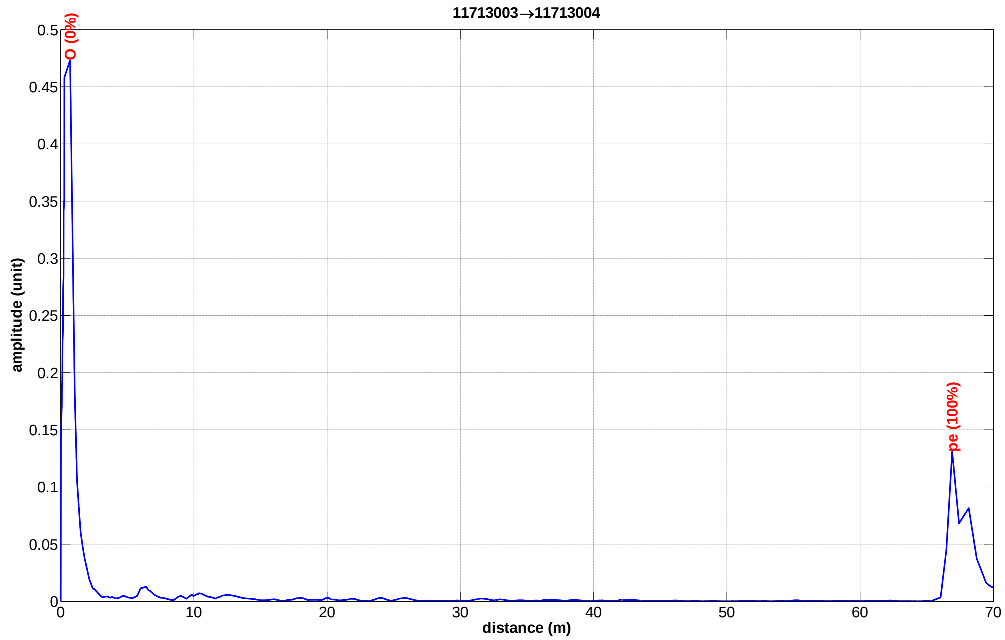
START MH : 11713003

END MH : 11713004

REPORT :

1 : O (0%) at 0.71m

2 : pe (100%) at 66.91m



CONDITION REPORT :

66.91 : pe

ENERGY : 18

PE : 0.13

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS Length = 66.9m. Pipe is currently serviceable but attenuation of target manhole response indicates potential for deterioration. Log for resurvey after an appropriate interval.

43.0 Survey 1.29 - 11713003_11713018_200mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:27:04

WATER LEVEL : 50mm

DIAMETER : 200mm

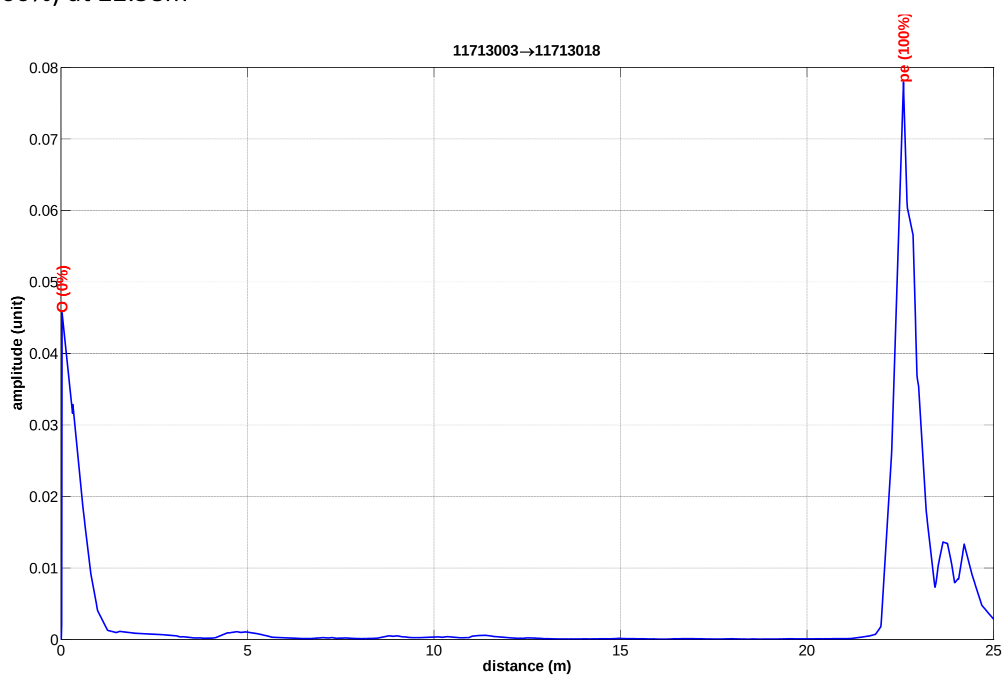
START MH : 11713003

END MH : 11713018

REPORT :

1 : O (0%) at 0.03m

2 : pe (100%) at 22.58m



CONDITION REPORT :

22.58 : pe (Good)

ENERGY : 0

PE : 0.08

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT - GIS Length = 22.2m. Pipe is serviceable. No further survey is required at this time.

44.0 Survey 1.30 - 11713006_11712006_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:44:27

WATER LEVEL : 21mm

DIAMETER : 300mm

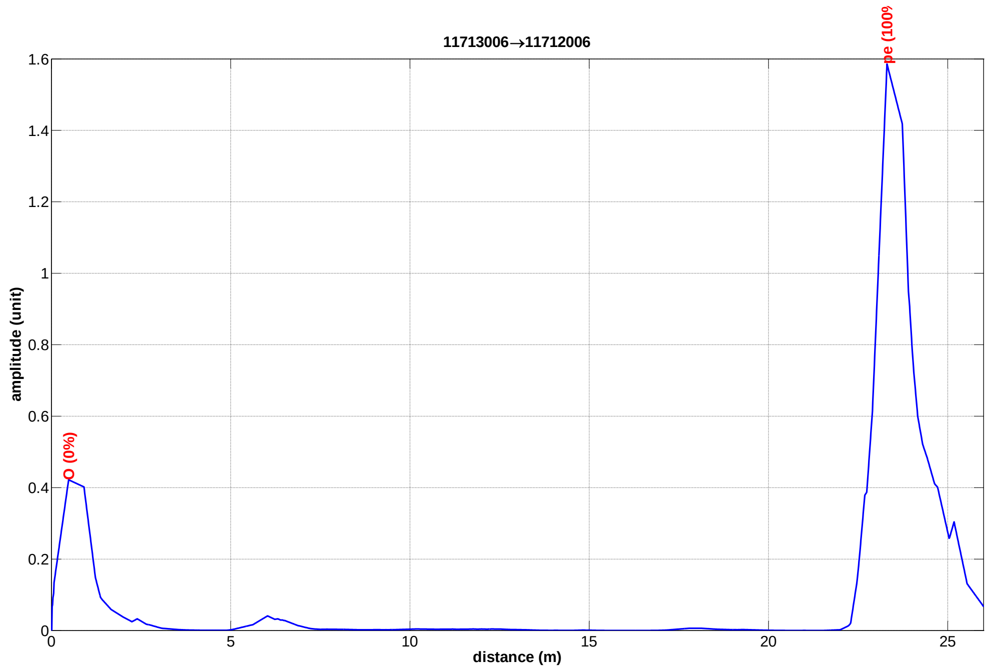
START MH : 11713006

END MH : 11712006

REPORT :

1 : O (0%) at 0.48m

2 : pe (100%) at 23.31m



CONDITION REPORT :

23.31 : pe (Good)

ENERGY : 54

PE : 1.59

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS length = 23.0m. Pipe is serviceable. No further survey is required at this time.

45.0 Survey 1.31 - 11713006_11713005_300mm-2.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:55:48

WATER LEVEL : 22mm

DIAMETER : 300mm

START MH : 11713006

END MH : 11713005

REPORT :

1 : O (0%) at 0.69m

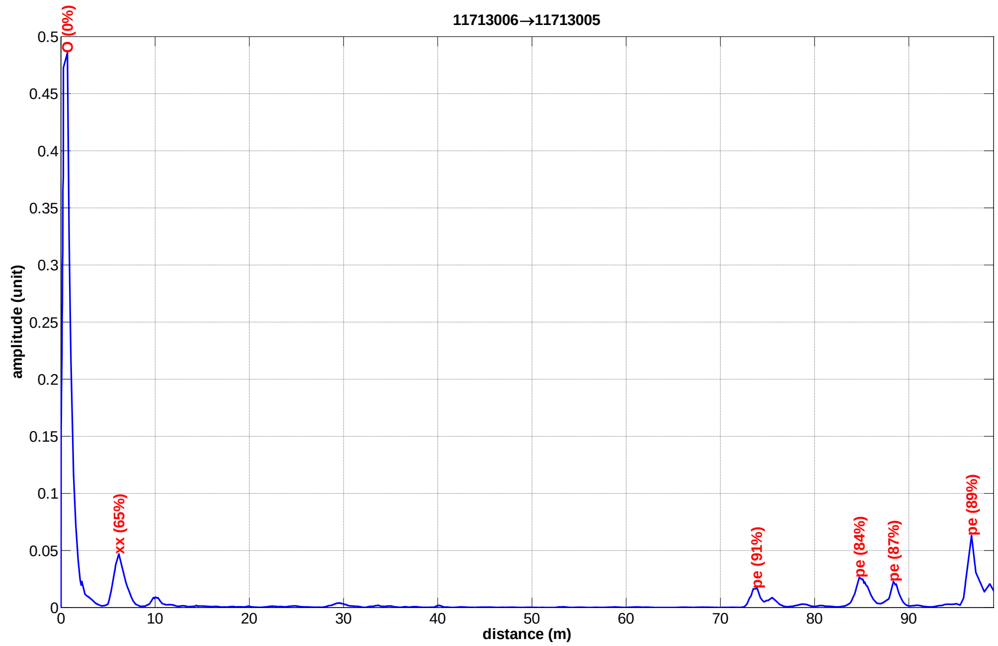
2 : xx (65%) at 6.15m

3 : pe (91%) at 73.84m

4 : pe (84%) at 84.74m

5 : pe (87%) at 88.37m

6 : pe (89%) at 96.66m



CONDITION REPORT :

6.15 : xx

73.84 : lc (Good)

84.74 : lc (Good)

88.37 : lc (Good)

96.66 : pe (good)

ENERGY : 25

PE : 0.06

DE ratio : 0.74

AUTO CONDITION GRADE – Red

COMMENT – GIS Length = 96.6m. Responses at 73.84m, 84.74m and 88.37m were initially identified as pipe ends, but subsequently reclassified by the system as lateral connections once the true pipe end at 96.66m had been confirmed through the interface. There is an unidentified response at 6.15m. The reason for the red classification in this case is the low level of response from the target manhole. CCTV is recommended in this case.

46.0 Survey 1.32 - 11713006_11713007_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 12:48:09

WATER LEVEL : 21mm

DIAMETER : 300mm

START MH : 11713006

END MH : 11713007

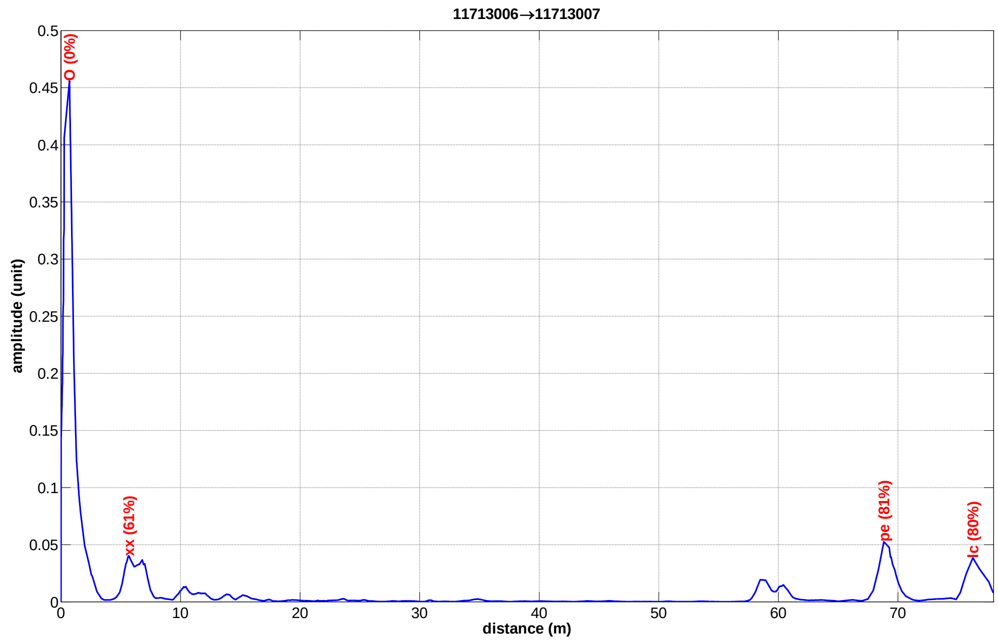
REPORT :

1 : O (0%) at 0.72m

2 : xx (61%) at 5.67m

3 : pe (81%) at 68.82m

4 : lc (80%) at 76.27m



CONDITION REPORT :

5.67 : xx

68.82 : lc (defective)

76.27 : pe

ENERGY : 41

PE : 0.04

DE ratio : 1.04

AUTO CONDITION GRADE - Red

COMMENT – GIS Length = 76.2m. The response at 68.82m was initially identified as pipe end, but subsequently reclassified by the system as a lateral connection once the true pipe end at 76.27m had been confirmed through the interface, after which the system reclassified the response at 68.82 as a defective connection. There is an unidentified response at 5.67m. CCTV is recommended in this case.

47.0 Survey 1.33 - 11713014_11713018_300mm-1.mat

SITE : south rd

TEST DATE & TIME : 29-Apr-2013 13:10:20

WATER LEVEL : 22mm

DIAMETER : 300mm

START MH : 11713014

END MH : 11713018

REPORT :

1 : O (0%) at 0.48m

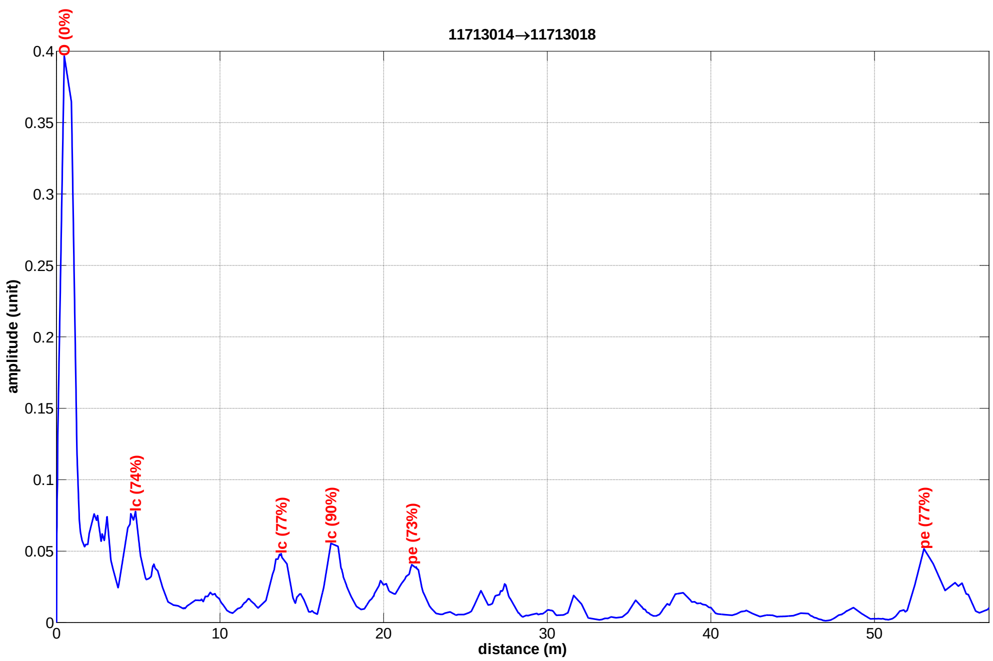
2 : lc (74%) at 4.83m

3 : lc (77%) at 13.74m

4 : lc (90%) at 16.78m

5 : pe (73%) at 21.72m

6 : pe (77%) at 53.02m



CONDITION REPORT :

4.83 : xx

13.74 : xx

16.78 : lc (Good)

21.72 : xx

53.02 : pe

ENERGY : 239

PE : 0.05

DE ratio : 1.51

AUTO CONDITION GRADE – Red

COMMENT – GIS length = 52.6m. There are many responses along the length of the pipe and the energy loss is very high. CCTV is recommended.

48.0 Survey 1.34 - 15016001_11713004_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 12:54:55

WATER LEVEL : 20mm

DIAMETER : 300mm

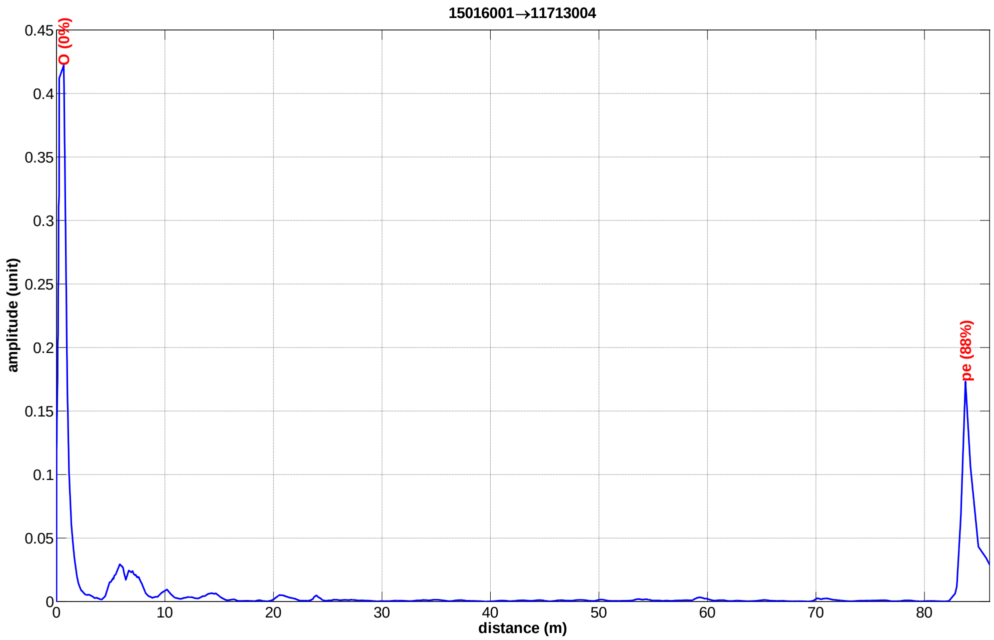
START MH : 15016001

END MH : 11713004

REPORT :

1 : O (0%) at 0.68m

2 : pe (88%) at 83.78m



CONDITION REPORT :

83.78 : pe

ENERGY : 25

PE : 0.17

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS Length = 83.4m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration. Log for resurvey after an appropriate interval.

49.0 Survey 1.35 - 15016001_15016002_300mm-1.mat

SITE : SOUTH RD

TEST DATE & TIME : 25-Apr-2013 13:02:57

WATER LEVEL : 20mm

DIAMETER : 300mm

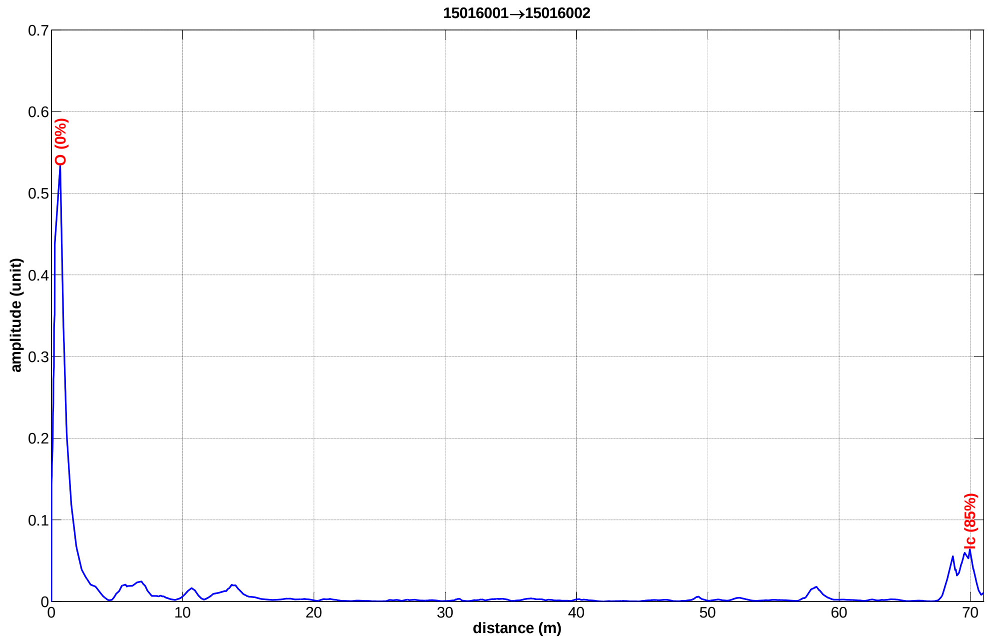
START MH : 15016001

END MH : 15016002

REPORT :

1 : O (0%) at 0.67m

2 : lc (85%) at 69.96m



CONDITION REPORT :

69.96 : pe

ENERGY : 55

PE : 0.06

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS pipe length = 68.2m. Pipe end was initially identified as a lateral connection. This was subsequently reclassified as a pipe end based on the GIS data. There are minor responses along the length of the pipe and the response from the target manhole is significantly attenuated. The energy level is approaching the amber threshold of 70, indicating that there are some serviceability issues with this pipe but CCTV is not recommended at the present time. Log for resurvey after an appropriate interval.

50.0 Appendix 3 – Interpretation of SewerBatt output – Hunt Road

51.0 Survey 2.1 - 44705004_44705005_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 12:24:51

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44705004

END MH : 44705005

TEST FILE : 44705004_44705005_300mm-1.mat

REPORT :

1 : xx at 0.33m

2 : xx at 19.45m

3 : xx at 27.29m

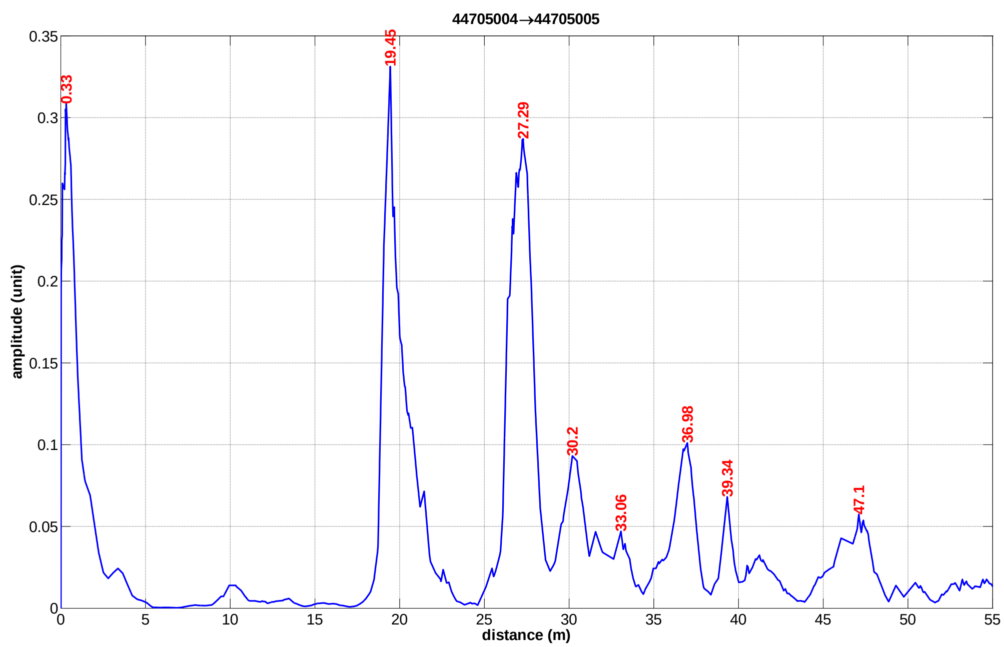
4 : xx at 30.2m

5 : xx at 33.06m

6 : xx at 36.98m

7 : xx at 39.34m

8 : xx at 47.1m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS length = 53m. Condition assessment performed manually this case. CCTV is recommended on account of the many strong responses recorded and the heavily attenuated response from the target manhole.

52.0 Survey 2.2 - 44705004_447060017_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 12:13:44

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44705004

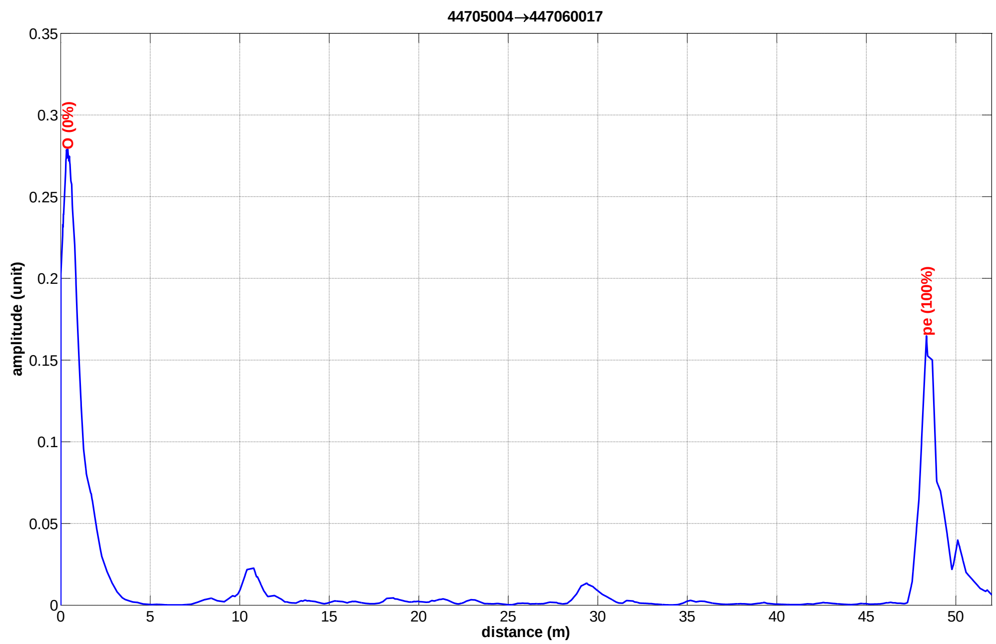
END MH : 447060017

TEST FILE : 44705004_447060017_300mm-1.mat

REPORT :

1 : O (0%) at 0.4m

2 : pe (100%) at 48.36m



CONDITION REPORT :

48.36 : pe (Good)

ENERGY : 40

PE : 0.16

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS length = 53.0m. The system reported a faulty microphone for this test. In the absence of a repeat test the available data from the other microphones has been used. The strong response at 48.36m may be a lateral or a defect. The pipe is serviceable but should be logged for reinspection after an appropriate interval on account of the significantly attenuated response from the target manhole and small responses at 11m and 19m that indicate a potential for deterioration.

53.0 Survey 2.3 - 44706004_44706010_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 10:24:39

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44706004

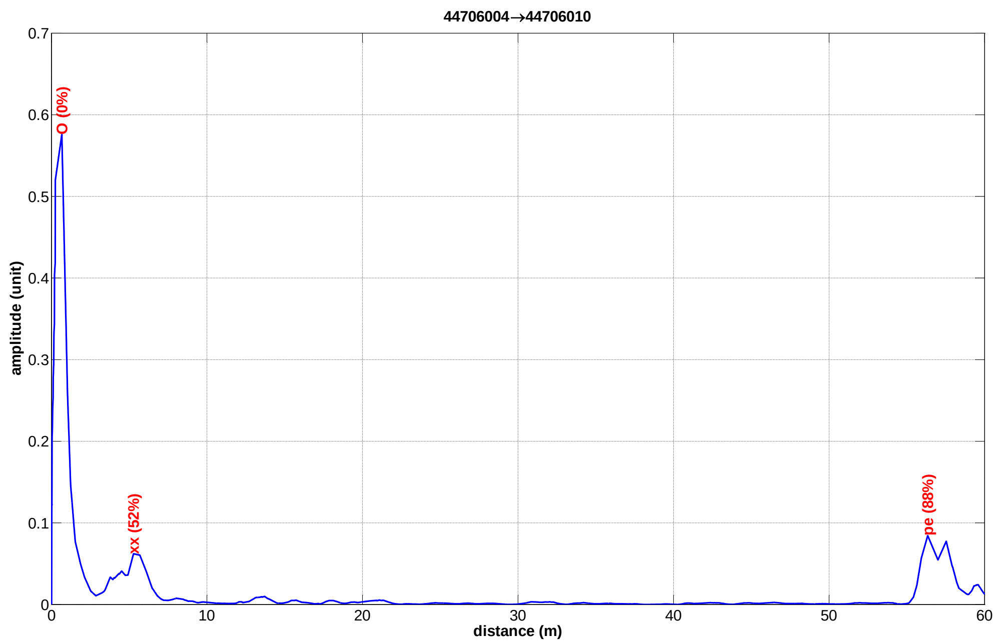
END MH : 44706010

REPORT :

1 : O (0%) at 0.67m

2 : xx (52%) at 5.28m

3 : pe (88%) at 56.34m



CONDITION REPORT :

5.28 : xx

56.34 : pe (Good)

ENERGY : 51

PE : 0.08

DE ratio : 0.74

AUTO CONDITION GRADE – Red

COMMENT – GIS length = 58.2m. The energy loss is within the 'Green' zone but a 'Red' classification has been applied by the system due to the significant attenuation of the response from the target manhole. This may be due to issues such as sediment or roots and CCTV is recommended.

54.0 Survey 2.4 - 44706004_44707026_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 10:17:15

WATER LEVEL : 1mm

DIAMETER : 300mm

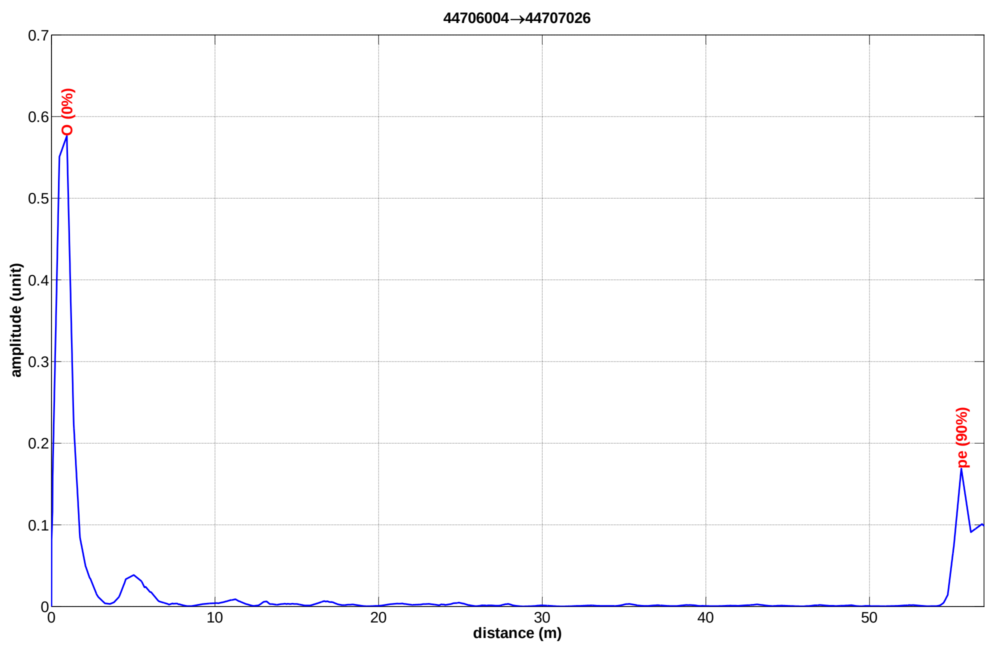
START MH : 44706004

END MH : 44707026

REPORT :

1 : O (0%) at 0.94m

2 : pe (90%) at 55.61m



CONDITION REPORT :

55.61 : pe (Good)

ENERGY : 38

PE : 0.17

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS Pipe length = 54.0m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.

55.0 Survey 2.5 - 44706008_44706009_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 04-Jun-2013 16:46:30

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44706008

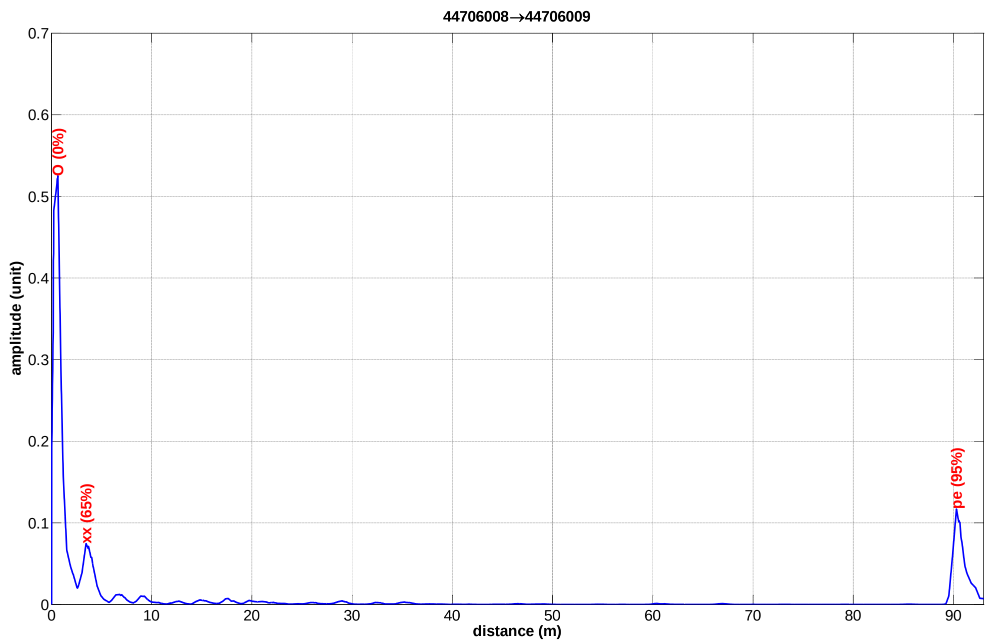
END MH : 44706009

REPORT :

1 : O (0%) at 0.65m

2 : xx (65%) at 3.46m

3 : pe (95%) at 90.29m



CONDITION REPORT :

3.46 : xx

90.29 : pe

ENERGY : 22

PE : 0.12

DE ratio : 0.64

AUTO CONDITION GRADE – Amber

COMMENT – GIS Pipe length = 82.9m. SewerBatt output shows pipe length as 90.29m. It is recommended that the pipe should be logged up for reinspection after an appropriate period.

56.0 Survey 2.6 - 44706009_44706010_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 04-Jun-2013 16:57:53

WATER LEVEL : 1mm

DIAMETER : 300mm

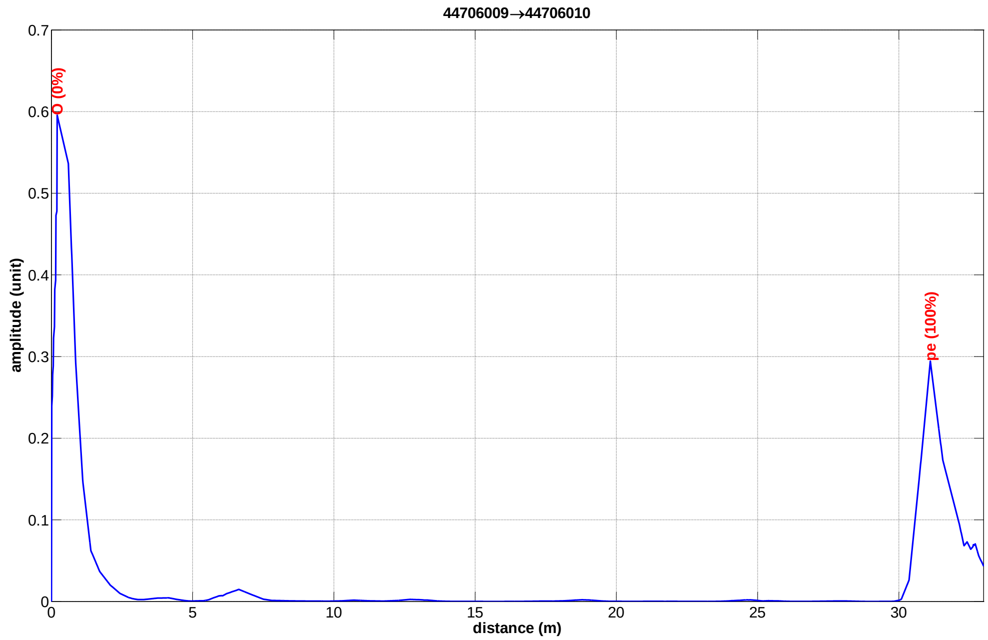
START MH : 44706009

END MH : 44706010

REPORT :

1 : O (0%) at 0.2m

2 : pe (100%) at 31.11m



REPORT :

1.11 : pe (Good)

ENERGY : 23

PE : 0.29

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 31.69m. Pipe is serviceable. No further survey is required at this time.

57.0 Survey 2.7 - 44706010_44706009_200mm-3.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 10:57:03

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 44706010

END MH : 44706009

REPORT :

1 : xx at 0.02m

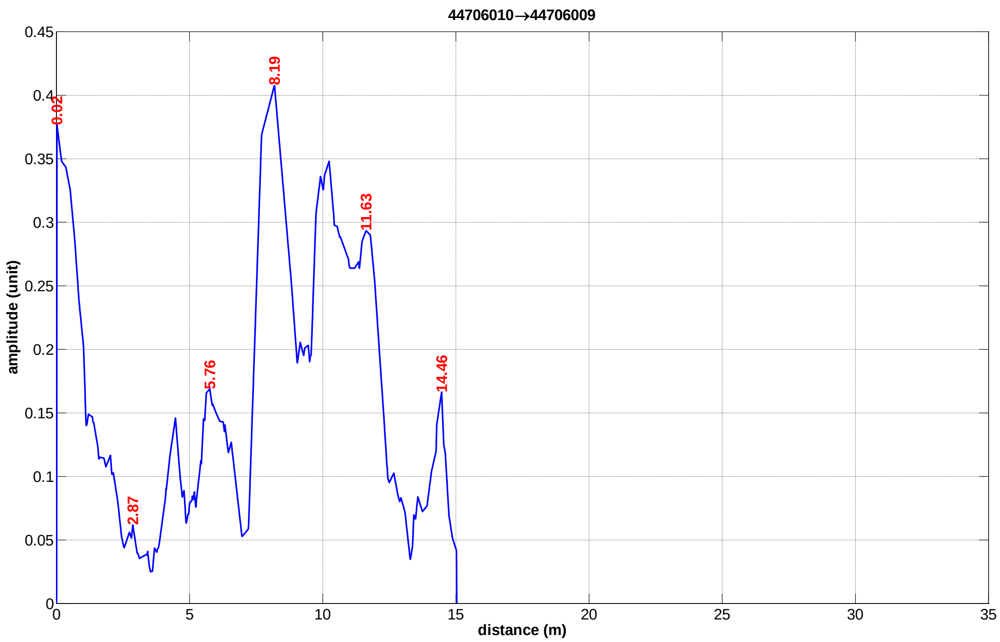
2 : xx at 2.87m

3 : xx at 5.76m

4 : xx at 8.19m

5 : xx at 11.63m

6 : xx at 14.46m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 31.6m. The SewerBatt output data provided includes three tests of this pipe. All of them provide results similar to the above, where the record is truncated some distance short of the target manhole. Given the many responses recorded in the data that is available then CCTV is recommended.

58.0 Survey 2.8 - 44706010_44706011_200mm-2.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 10:47:30

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 44706010

END MH : 44706011

REPORT :

No usable data was recorded at this site.

59.0 Survey 2.9 - 44706010_44706013_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 11:06:51

WATER LEVEL : 1mm

DIAMETER : 300mm

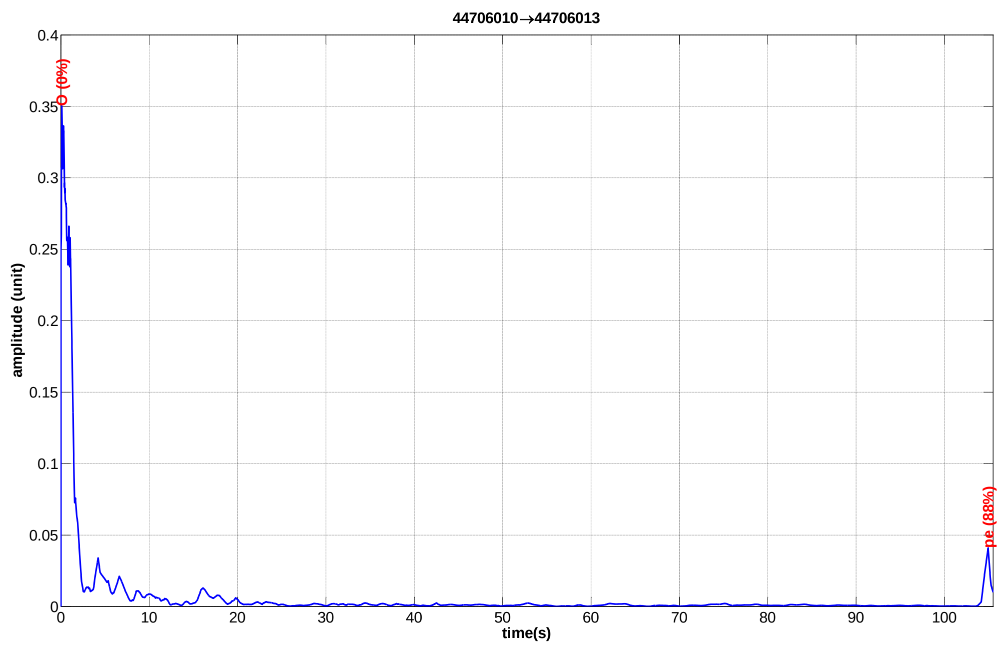
START MH : 44706010

END MH : 44706013

REPORT :

1 : O (0%) at 0.1m

2 : pe (88%) at 104.94m



CONDITION REPORT :
104.94 : pe (Good)
ENERGY : 36
PE : 0.04
DE ratio : 0
AUTO CONDITION GRADE – Green (manual override to Amber)

COMMENT – GIS Pipe length = 104.2m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.

60.0 Survey 2.10 - 44706011_44706010_300mm-1.mat

SITE : blue ash
TEST DATE & TIME : 04-Jun-2013 16:53:23
WATER LEVEL : 1mm
DIAMETER : 300mm
START MH : 44706011
END MH : 44706010
REPORT :
No usable data was recorded at this site.

COMMENT – GIS pipe length = 3.65m

61.0 Survey 2.11 - 44706011_44706012_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 04-Jun-2013 16:50:33

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44706011

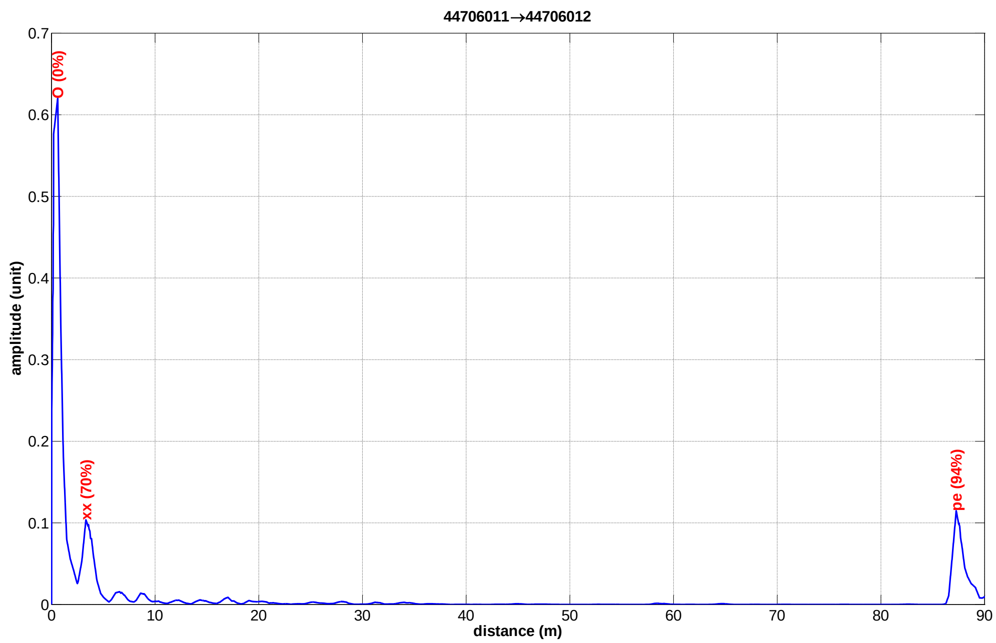
END MH : 44706012

REPORT :

1 : O (0%) at 0.61m

2 : xx (70%) at 3.32m

3 : pe (94%) at 87.27m



REPORT :

3.32 : xx

87.27 : pe (Good)

ENERGY : 29

PE : 0.11

DE ratio : 0.9

AUTO CONDITION GRADE – Red

COMMENT – GIS Pipe length = 87.4m. The energy loss is within the ‘Green’ zone but a ‘Red’ classification has been applied by the system due to the significant attenuation of the response from the target manhole. This may be due to issues such as sediment or roots and CCTV is recommended.

62.0 Survey 2.12 - 44706014_44706013_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 11:25:03

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44706014

END MH : 44706013

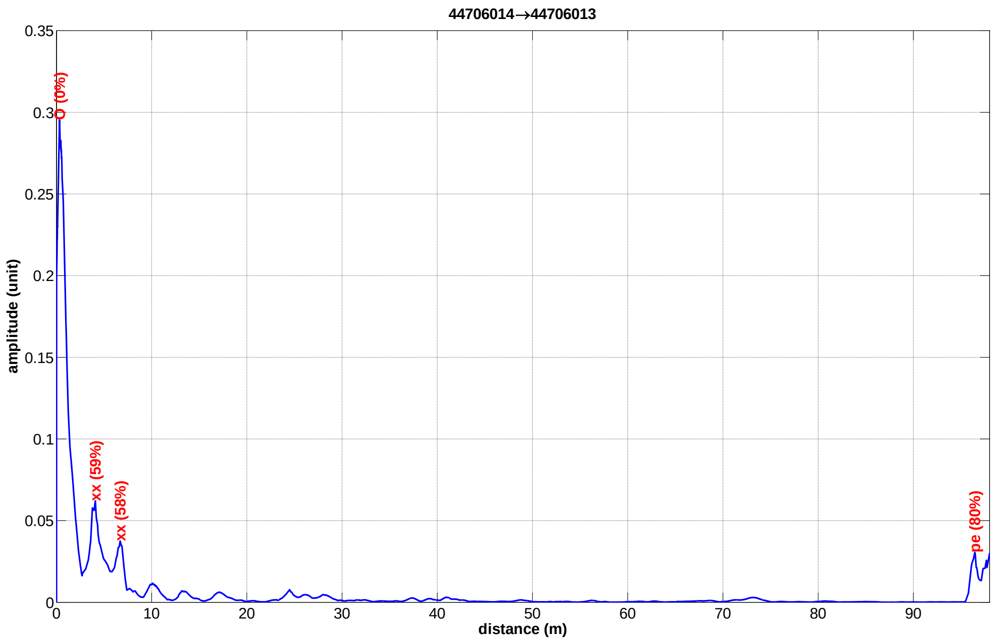
REPORT :

1 : O (0%) at 0.32m

2 : xx (59%) at 4.08m

3 : xx (58%) at 6.69m

4 : pe (80%) at 96.45m



REPORT :

4.08 : xx

6.69 : xx

96.45 : pe (Good)

ENERGY : 38

PE : 0.03

DE ratio : 2.04

AUTO CONDITION GRADE – Red

Comment – GIS pipe length = 95.7m. The reflected energy is within the ‘Green’ zone but a ‘Red’ classification has been applied by the system due to the significant attenuation of the response from the target manhole. This may be due to issues such as sediment or roots and CCTV is recommended.

63.0 Survey 2.13 - 44706014_44706015_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 11:32:39

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 44706014

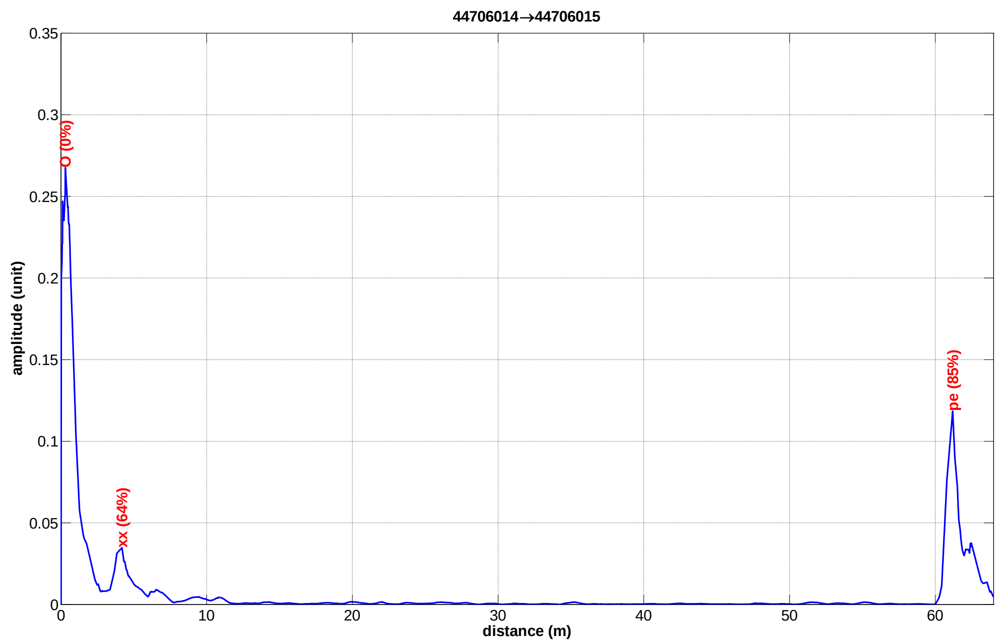
END MH : 44706015

REPORT :

1 : O (0%) at 0.3m

2 : xx (64%) at 4.19m

3 : pe (85%) at 61.19m



REPORT :

4.19 : xx

61.19 : pe (Good)

ENERGY : 22

PE : 0.12

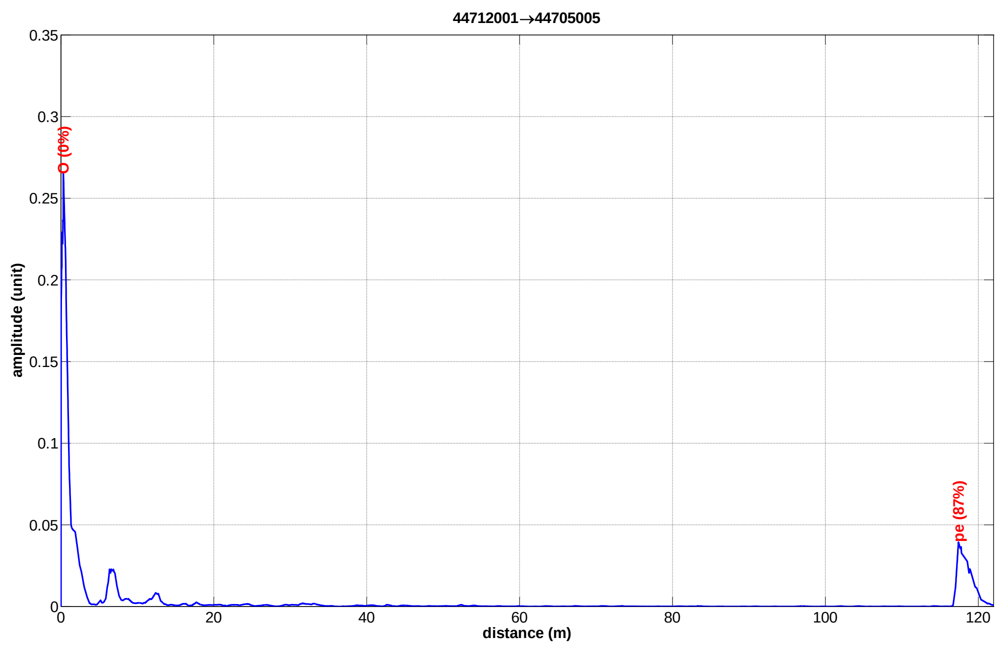
DE ratio : 0.29

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 63.0m. Pipe is serviceable. No further survey is required at this time.

64.0 Survey 2.14 - 44712001_44705005_300mm-1.mat

SITE : blue ash
TEST DATE & TIME : 29-May-2013 12:39:38
WATER LEVEL : 1mm
DIAMETER : 300mm
START MH : 44712001
END MH : 44705005
REPORT :
1 : O (0%) at 0.32m
2 : pe (87%) at 117.41m

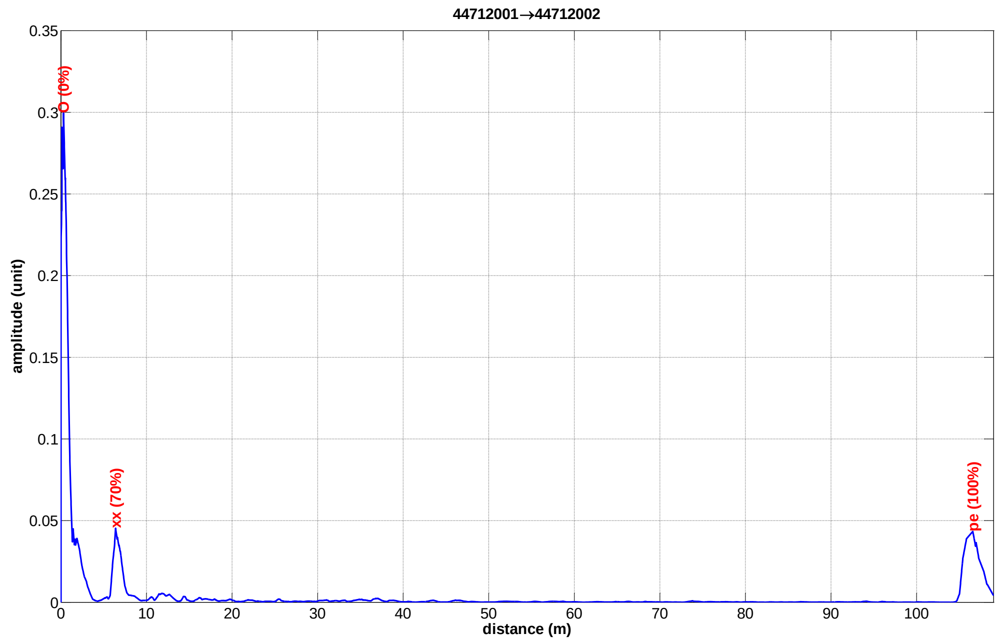


REPORT :
117.41 : pe (Good)
ENERGY : 14
PE : 0.04
DE ratio : 0
AUTO CONDITION GRADE – Green. (manual override to Amber)

COMMENT – GIS Pipe length = 115.8m. Pipe is currently serviceable but significant attenuation of response from remote manhole indicates potential for deterioration.

65.0 Survey 2.15 - 44712001_44712002_300mm-1.mat

SITE : blue ash
TEST DATE & TIME : 29-May-2013 12:45:33
REPORT DATE & TIME : 28-Aug-2013 14:12:31
WATER LEVEL : 1mm
DIAMETER : 300mm
START MH : 44712001
END MH : 44712002
REPORT :
1 : O (0%) at 0.3m
2 : xx (70%) at 6.39m
3 : pe (100%) at 106.57m



CONDITION REPORT :
6.39 : xx
106.57 : pe (Good)
ENERGY : 18
PE : 0.04
DE ratio : 1.04
AUTO CONDITION GRADE – Red

Comment – GIS Pipe length = 105.3m The reflected energy is within the 'Green' zone but a 'Red' classification has been applied by the system due to the significant attenuation of the response from the target manhole. This may be due to issues such as sediment or roots and CCTV is recommended.

66.0 Survey 2.16 - 44712007_44712002_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 13:11:11

WATER LEVEL : 1mm

DIAMETER : 300mm

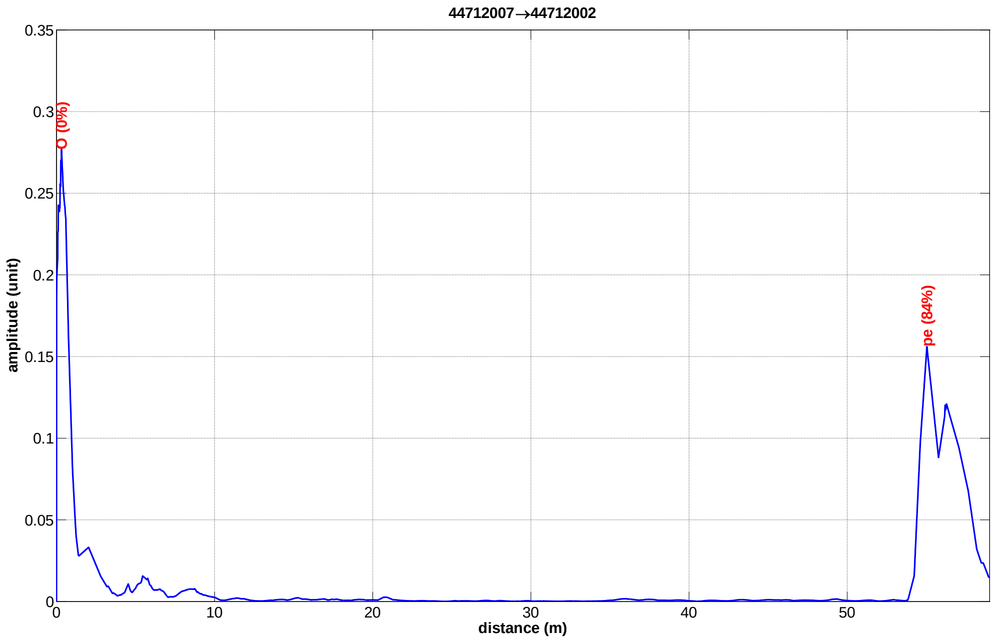
START MH : 44712007

END MH : 44712002

REPORT :

1 : O (0%) at 0.32m

2 : pe (84%) at 55.04m



CONDITION REPORT :

55.04 : pe (Good)

ENERGY : 33

PE : 0.16

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 54.25m. Pipe is serviceable. No further survey is required at this time.

67.0 Survey 2.17 - 44712007_44712008_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 29-May-2013 13:14:17

WATER LEVEL : 1mm

DIAMETER : 300mm

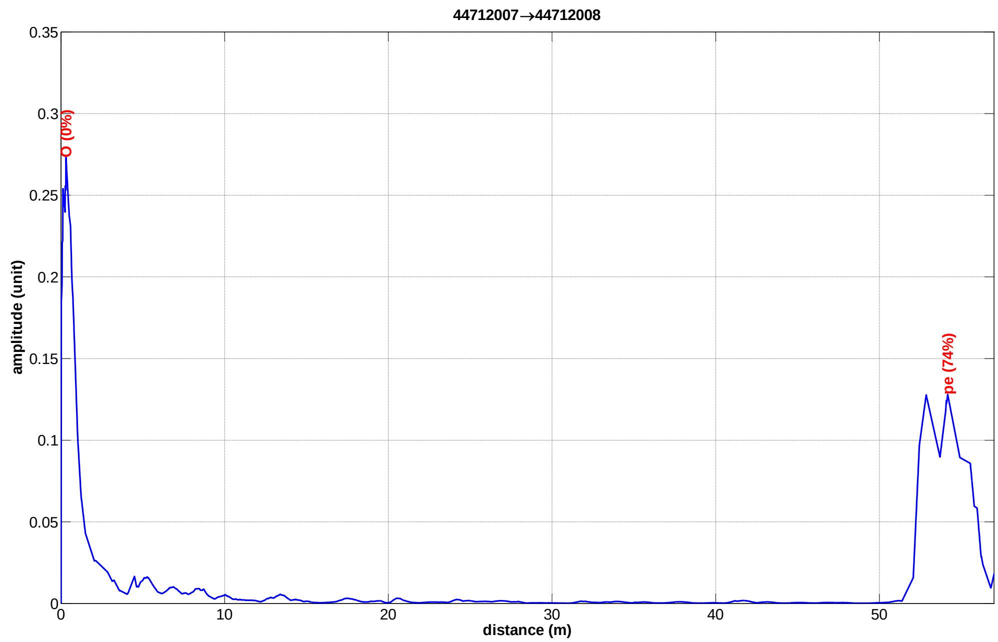
START MH : 44712007

END MH : 44712008

REPORT :

1 : O (0%) at 0.31m

2 : pe (74%) at 54.17m



CONDITION REPORT :

54.17 : pe (Good)

ENERGY : 81

PE : 0.13

DE ratio : 0

AUTO CONDITION GRADE – Amber (manual over-ride to Green – see below)

COMMENT – GIS pipe length = 52.7m. It is likely that the response from the target manhole is at 53m rather than the 54.17m derived by SewerBatt. This is due to the double-peaked response. This being the case, the condition would have been calculated as 'Green' and hence the pipe is considered to be serviceable, with no further action required.

68.0 Survey 2.18 - 48209013_44712008_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 03-Jun-2013 09:49:59

WATER LEVEL : 1mm

DIAMETER : 300mm

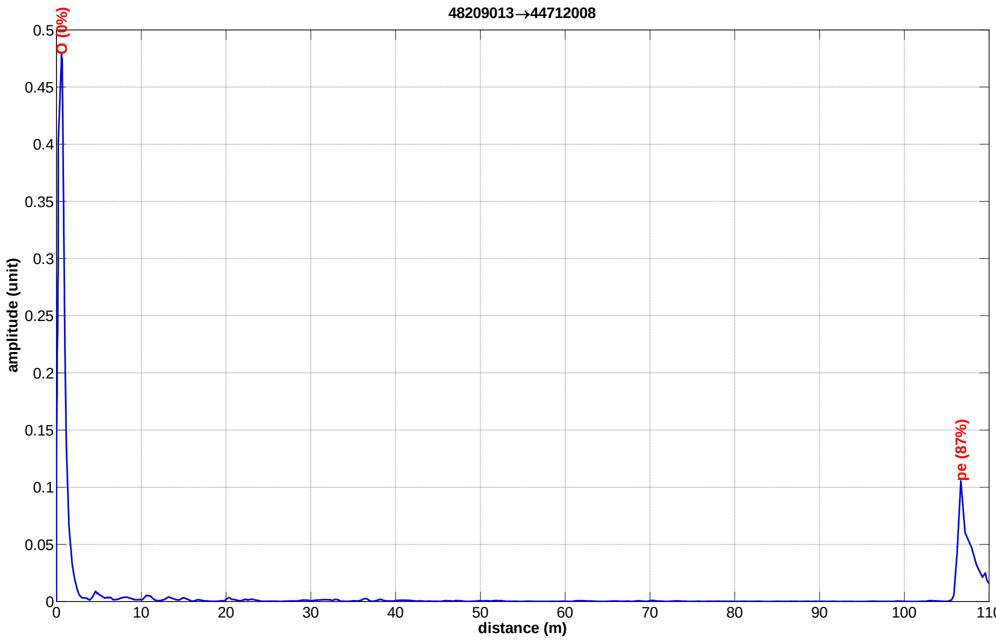
START MH : 48209013

END MH : 44712008

REPORT :

1 : O (0%) at 0.62m

2 : pe (87%) at 106.67m



CONDITION REPORT :

106.67 : pe

ENERGY : 10

PE : 0.11

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 109.7m. Pipe is serviceable. No further survey is required at this time.

69.0 Survey 2.19 - 48209013_48209014_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 03-Jun-2013 09:51:46

WATER LEVEL : 1mm

DIAMETER : 300mm

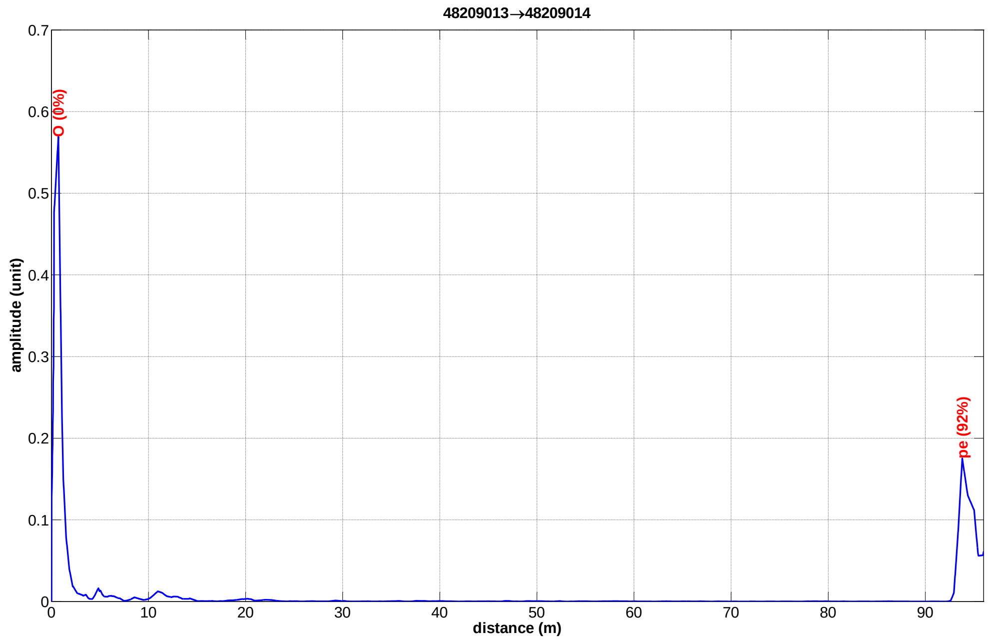
START MH : 48209013

END MH : 48209014

REPORT :

1 : O (0%) at 0.72m

2 : pe (92%) at 93.8m



CONDITION REPORT :

93.8 : pe

ENERGY : 12

PE : 0.18

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 93.8m. Pipe is serviceable. No further survey is required at this time.

70.0 Survey 2.20 - 48209015_48209014_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 03-Jun-2013 10:09:59

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 48209015

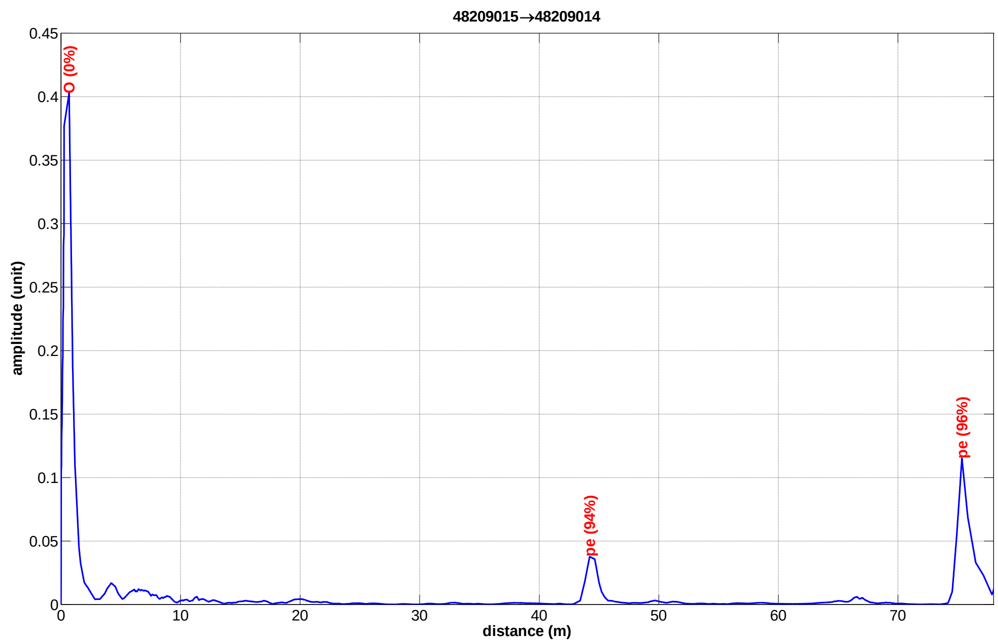
END MH : 48209014

REPORT :

1 : O (0%) at 0.69m

2 : pe (94%) at 44.22m

3 : pe (96%) at 75.35m



CONDITION REPORT :

44.22 : lc (Good)

75.35 : pe (Good)

ENERGY : 24

PE : 0.12

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 76.0m. Pipe is serviceable.

71.0 Survey 2.21 - 48209015_48209016_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 03-Jun-2013 10:11:44

WATER LEVEL : 1mm

DIAMETER : 300mm

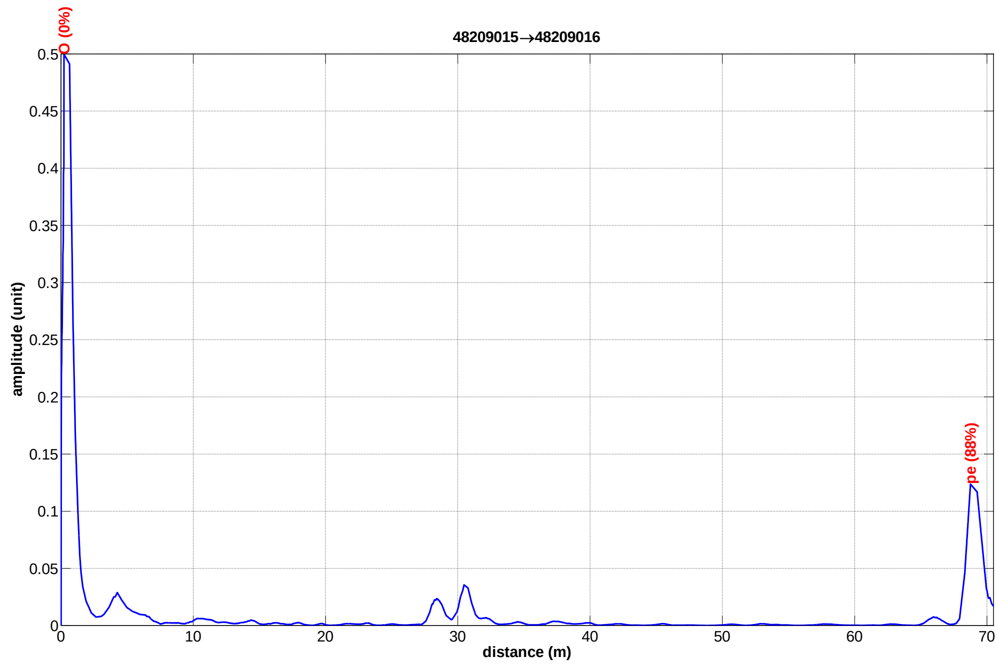
START MH : 48209015

END MH : 48209016

REPORT :

1 : O (0%) at 0.24m

2 : pe (88%) at 68.75m



CONDITION REPORT :

68.75 : pe

ENERGY : 60

PE : 0.12

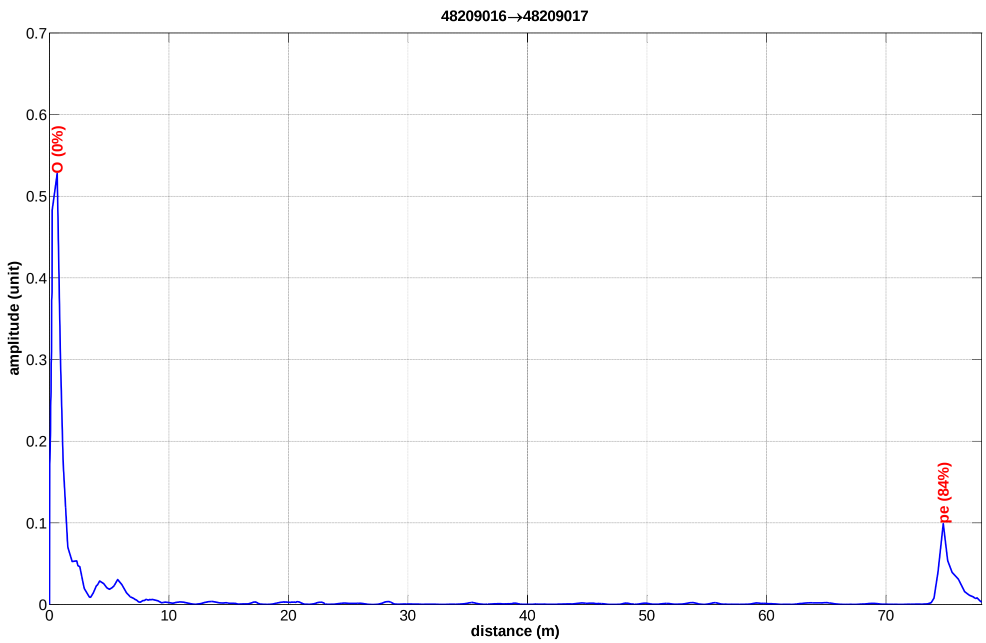
DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 69m. Pipe is serviceable, but responses around 30m may indicate a developing problem and the energy level is approaching the Amber threshold.

72.0 Survey 2.22- 48209016_48209017_300mm-1.mat

SITE : blue ash
TEST DATE & TIME : 03-Jun-2013 10:30:33
WATER LEVEL : 1mm
DIAMETER : 300mm
START MH : 48209016
END MH : 48209017
REPORT :
1 : O (0%) at 0.65m
2 : pe (84%) at 74.79m



CONDITION REPORT :
74.79 : pe
ENERGY : 33
PE : 0.1
DE ratio : 0
AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 69m but SewerBatt result indicates that the true length is around 75m. This may a data entry error on site, since 69m is also the GIS length of the previous pipe surveyed. The pipe is serviceable.

73.0 Survey 2.23 - 49209018_48209017_300mm-1.mat

SITE : blue ash

TEST DATE & TIME : 04-Jun-2013 14:15:45

WATER LEVEL : 1mm

DIAMETER : 300mm

START MH : 49209018

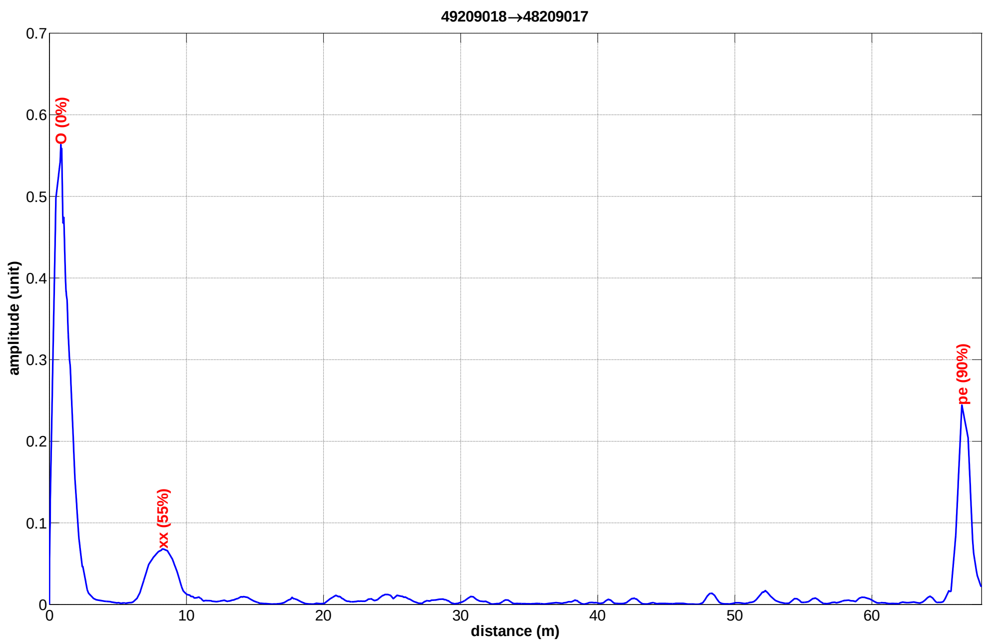
END MH : 48209017

REPORT :

1 : O (0%) at 0.84m

2 : xx (55%) at 8.25m

3 : pe (90%) at 66.56m



CONDITION REPORT :

8.25 : xx

66.56 : pe

ENERGY : 90

PE : 0.24

DE ratio : 0.28

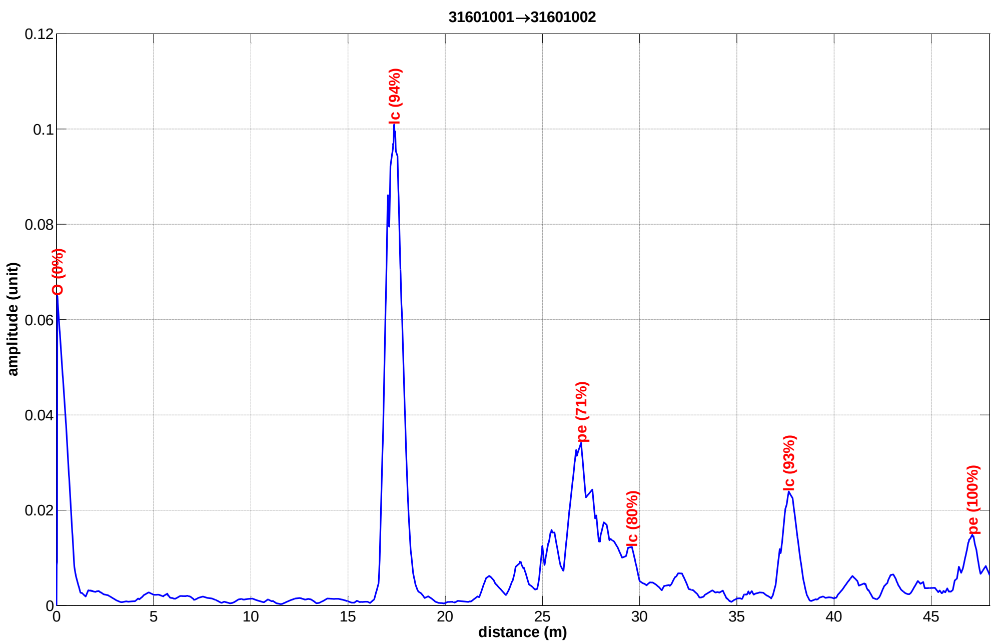
AUTO CONDITION GRADE – Amber

COMMENT – GIS pipe length = 65.6m. The pipe is on the Amber/Red threshold but is serviceable at the present time. Log for resurvey at an appropriate interval.

74.0 Appendix 4 – Interpretation of SewerBatt output – Greenhills

75.0 Survey 3.1 - 31601001_31601002_200mm-1.mat

SITE : green hills
TEST DATE & TIME : 09-May-2013 10:06:31
WATER LEVEL : 0mm
DIAMETER : 200mm
START MH : 31601001
END MH : 31601002
REPORT :
1 : O (0%) at 0.04m
2 : lc (94%) at 17.37m
3 : pe (71%) at 26.99m
4 : lc (80%) at 29.6m
5 : lc (93%) at 37.67m
6 : pe (100%) at 47.11m



CONDITION REPORT :
17.37 : lc
26.99 : xx
29.6 : lc (closed)
37.67 : lc (closed)
47.11 : pe (Good)
ENERGY : 56
PE : 0.01
DE ratio : 2.3

AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 49m. Energy level is in the ‘Green’ zone but the system has allocated ‘Red’ due to amplitude of response at 17.37m and relative weakness of response from the target manhole.

76.0 Survey 3.2 - 31601001_31601005_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:04:38

WATER LEVEL : 0mm

DIAMETER : 200mm

START MH : 31601001

END MH : 31601005

REPORT :

1 : O (0%) at 0.06m

2 : xx (59%) at 12.02m

3 : lc (74%) at 27.55m

4 : lc (91%) at 33.18m

5 : df (68%) at 37.42m

6 : pe (81%) at 41.88m

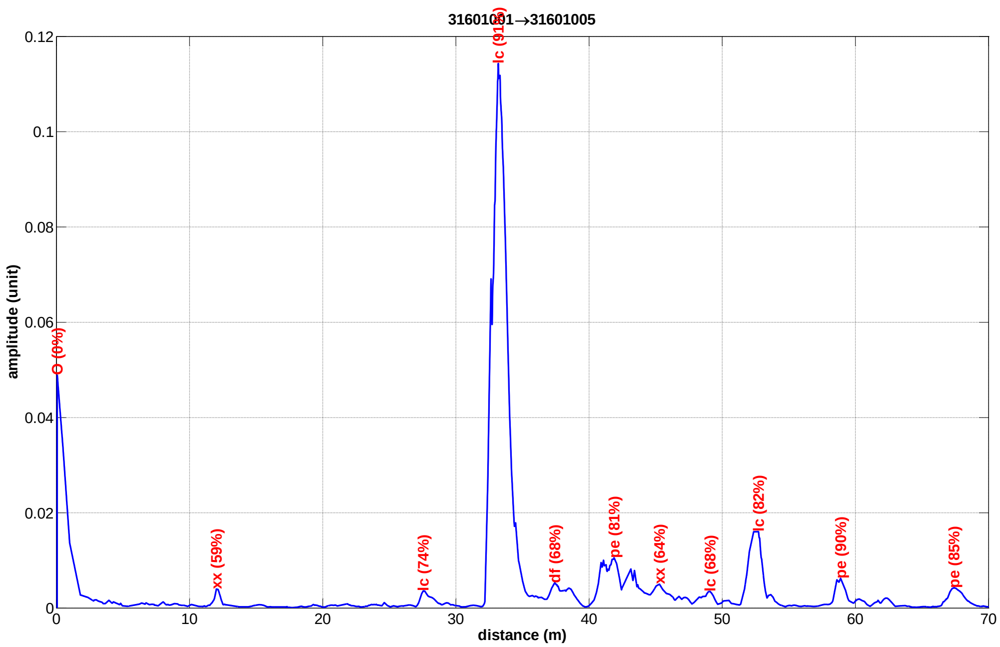
7 : xx (64%) at 45.29m

8 : lc (68%) at 49.09m

9 : lc (82%) at 52.72m

10 : pe (90%) at 58.89m

11 : pe (85%) at 67.4m



CONDITION REPORT :

12.02 : xx

27.55 : xx

37.42 : xx

45.29 : xx
49.09 : xx
67.4 : pe
ENERGY : 84
PE : 0
DE ratio : 26.8
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 68.5m. The energy level is in the ‘Amber’ zone but the system has allocated ‘Red’ due to the strength of the response at 33m and the attenuation of the response from the target manhole.

77.0 Survey 3.3 - 31601001_31601006_200mm-3.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:22:34

WATER LEVEL : 0mm

DIAMETER : 200mm

START MH : 31601001

END MH : 31601006

REPORT :

1 : O (0%) at 0.37m

2 : xx (59%) at 6.51m

3 : xx (58%) at 13.2m

4 : lc (91%) at 22.59m

5 : lc (89%) at 29.21m

6 : pe (83%) at 31.92m

7 : lc (84%) at 34.74m

8 : lc (74%) at 37.18m

9 : xx (62%) at 39.62m

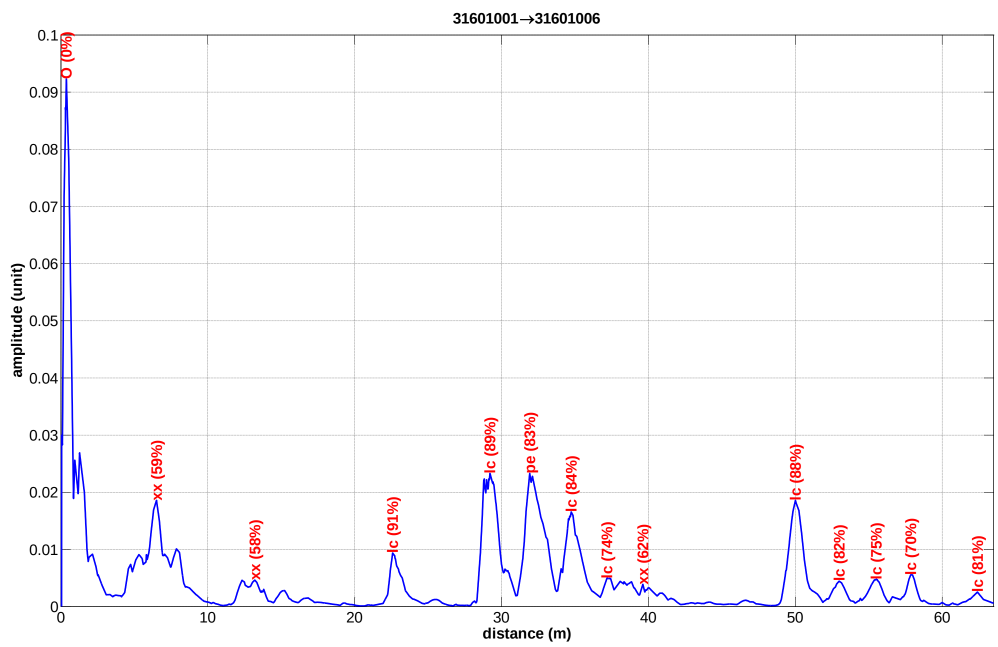
10 : lc (88%) at 50.01m

11 : lc (82%) at 52.98m

12 : lc (75%) at 55.52m

13 : lc (70%) at 57.86m

14 : lc (81%) at 62.4m



CONDITION REPORT :

6.51 : xx
13.2 : xx
22.59 : lc
29.21 : lc
31.92 : lc
34.74 : lc
37.18 : xx
39.62 : xx
50.01 : lc (closed)
52.98 : lc (closed)
55.52 : lc (closed)
57.86 : lc (missing pieces, crack, displacement)
62.4 : pe
ENERGY : 17
PE : 0
DE ratio : 7.3
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 62m. Assuming laterals are correctly identified, the energy level is well into the 'Green' zone, but the system has allocated 'Red' due to the attenuation of the response from the target manhole.

78.0 Survey 3.4 - 31601003_31601002_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:30:14

WATER LEVEL : 0mm

DIAMETER : 200mm

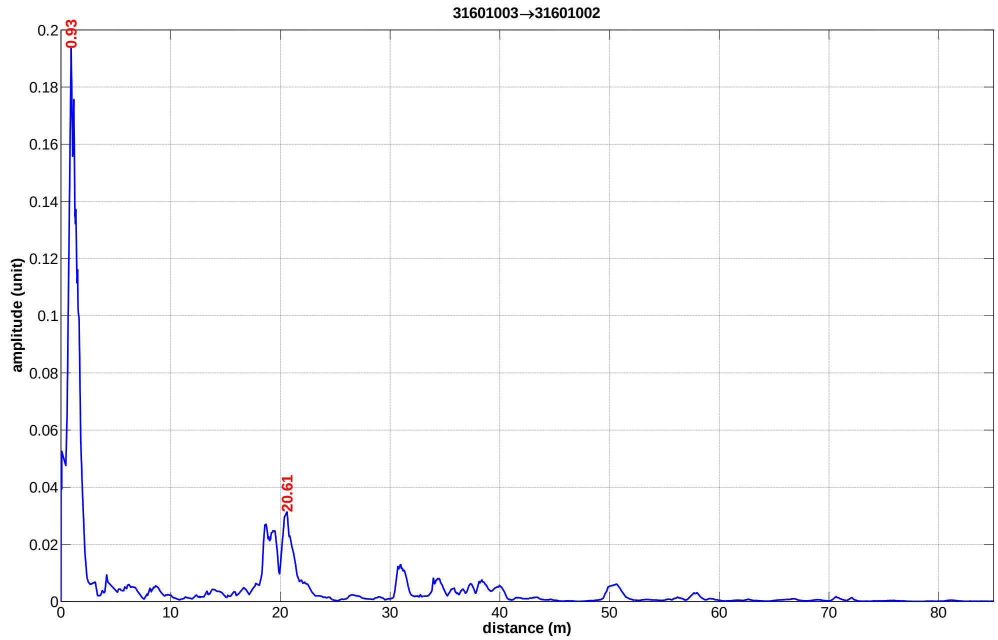
START MH : 31601003

END MH : 31601002

REPORT :

1 : xx at 0.93m

2 : xx at 20.61m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 81m. CCTV is recommended.

79.0 Survey 3.5 - 31601003_31601004_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:32:04

WATER LEVEL : 0mm

DIAMETER : 200mm

START MH : 31601003

END MH : 31601004

REPORT :

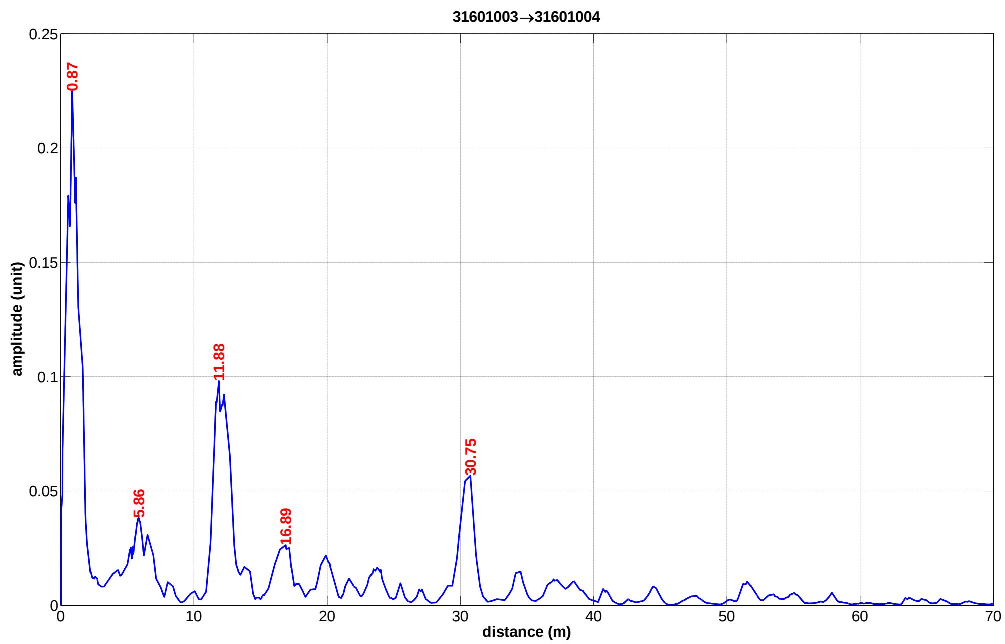
1 : xx at 0.87m

2 : xx at 5.86m

3 : xx at 11.88m

4 : xx at 16.89m

5 : xx at 30.75m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 64m. CCTV is recommended.

80.0 Survey 3.6 - 31602001_31602003_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:06:13

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31602001

END MH : 31602003

REPORT :

1 : lc (89%) at 1.21m

2 : pe (73%) at 12.91m

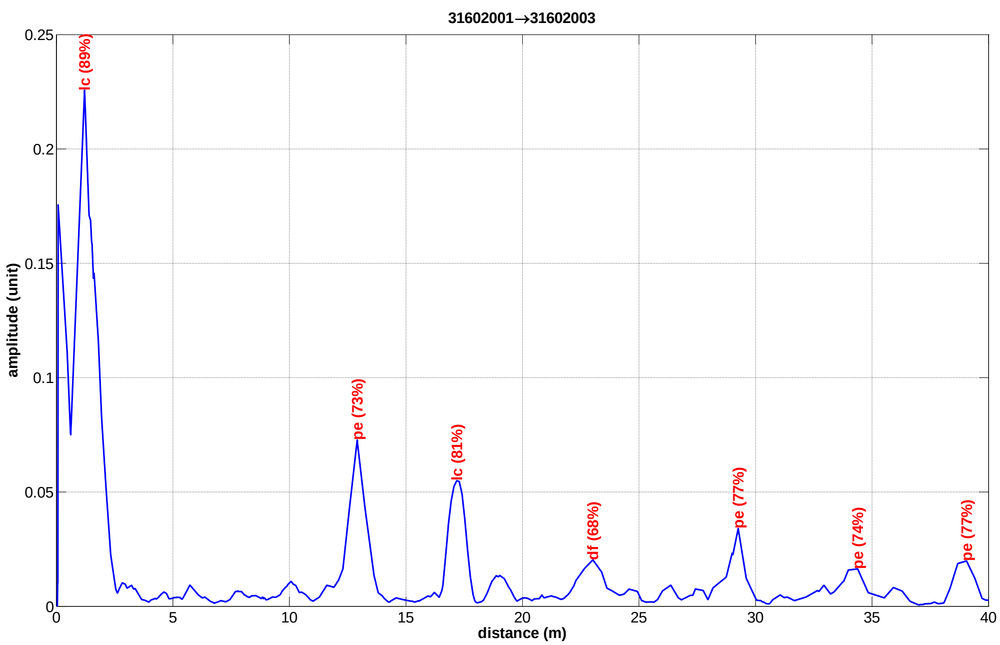
3 : lc (81%) at 17.18m

4 : df (68%) at 23.02m

5 : pe (77%) at 29.26m

6 : pe (74%) at 34.38m

7 : pe (77%) at 39.05m



CONDITION REPORT :

12.91 : xx

17.18 : lc (crack, infiltration)

23.02 : xx

29.26 : xx

34.38 : xx

39.05 : pe

ENERGY : 80

PE : 0.02
DE ratio : 3.67
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 42m. Energy level is in the 'Amber ' zone but the system has allocated 'Red' due to the strength of the response at 33m and the attenuation of the response from the target manhole.

81.0 Survey 3.7 - 31602001_31602016_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:07:36

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31602001

END MH : 31602016

REPORT :

1 : O (0%) at 0.08m

2 : pe (89%) at 6.11m

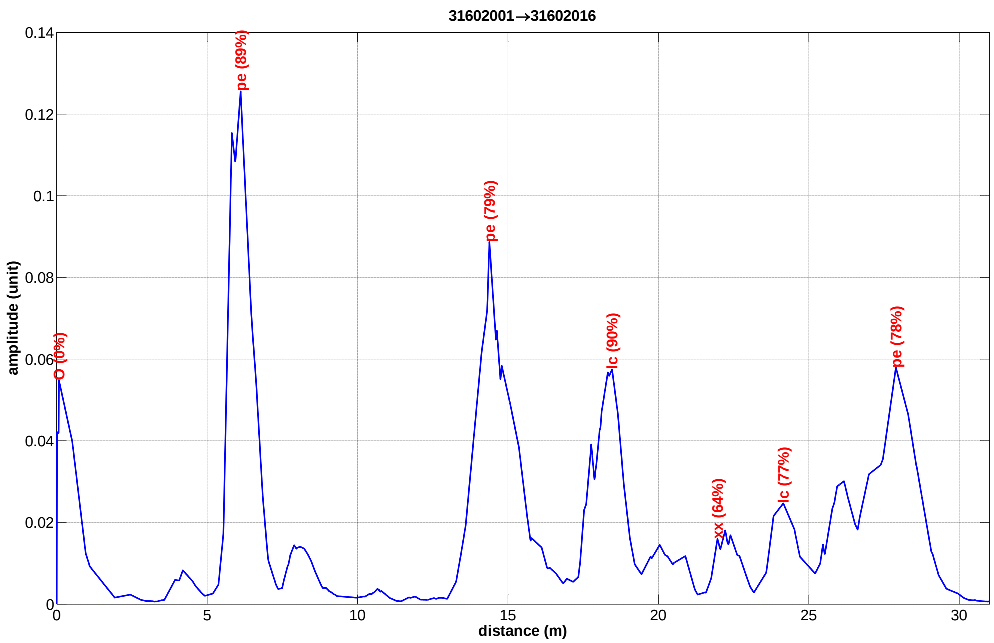
3 : pe (79%) at 14.38m

4 : lc (90%) at 18.46m

5 : xx (64%) at 21.96m

6 : lc (77%) at 24.15m

7 : pe (78%) at 27.89m



CONDITION REPORT :

6.11 : lc (crack, infiltration)

14.38 : lc (crack, infiltration)

18.46 : lc

21.96 : xx

24.15 : xx

27.89 : pe

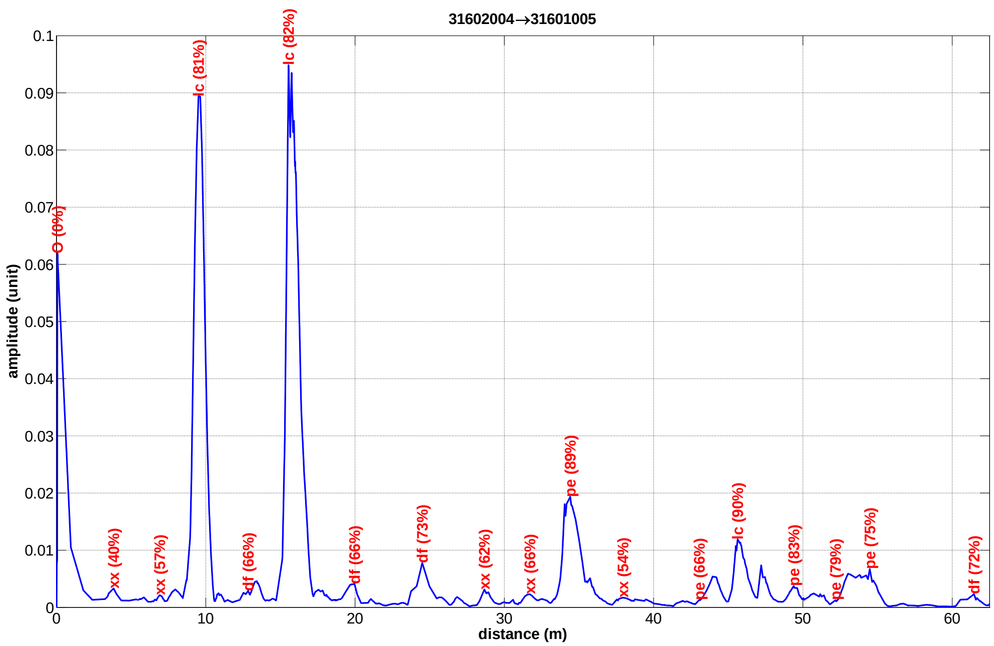
ENERGY : 78

PE : 0.06
DE ratio : 0.43
AUTO CONDITION GRADE – Amber (manual override to red)

COMMENT – GIS pipe length = 29m. Override to Red due to defective nature of two laterals and many artefacts.

82.0 Survey 3.8 - 31602004_31601005_200mm-1.mat

SITE : green hills
TEST DATE & TIME : 09-May-2013 09:55:22
WATER LEVEL : 0mm
DIAMETER : 200mm
START MH : 31602004
END MH : 31601005
REPORT :
1 : O (0%) at 0.06m
2 : xx (40%) at 3.83m
3 : xx (57%) at 6.91m
4 : lc (81%) at 9.52m
5 : df (66%) at 12.84m
6 : lc (82%) at 15.54m
7 : df (66%) at 19.96m
8 : df (73%) at 24.5m
9 : xx (62%) at 28.66m
10 : xx (66%) at 31.7m
11 : pe (89%) at 34.41m
12 : xx (54%) at 37.94m
13 : pe (66%) at 43.06m
14 : lc (90%) at 45.63m
15 : pe (83%) at 49.38m
16 : pe (79%) at 52.18m
17 : pe (75%) at 54.48m
18 : df (72%) at 61.46m



CONDITION REPORT :

3.83 : xx

6.91 : xx

9.52 : lc (missing pieces, crack, displacement)

12.84 : xx

15.54 : lc (closed)

19.96 : xx

24.5 : xx

28.66 : xx

31.7 : xx

34.41 : lc (closed)

37.94 : xx

43.06 : xx

45.63 : lc (closed)

49.38 : xx

52.18 : xx

54.48 : xx

61.46 : pe

ENERGY : 17

PE : 0

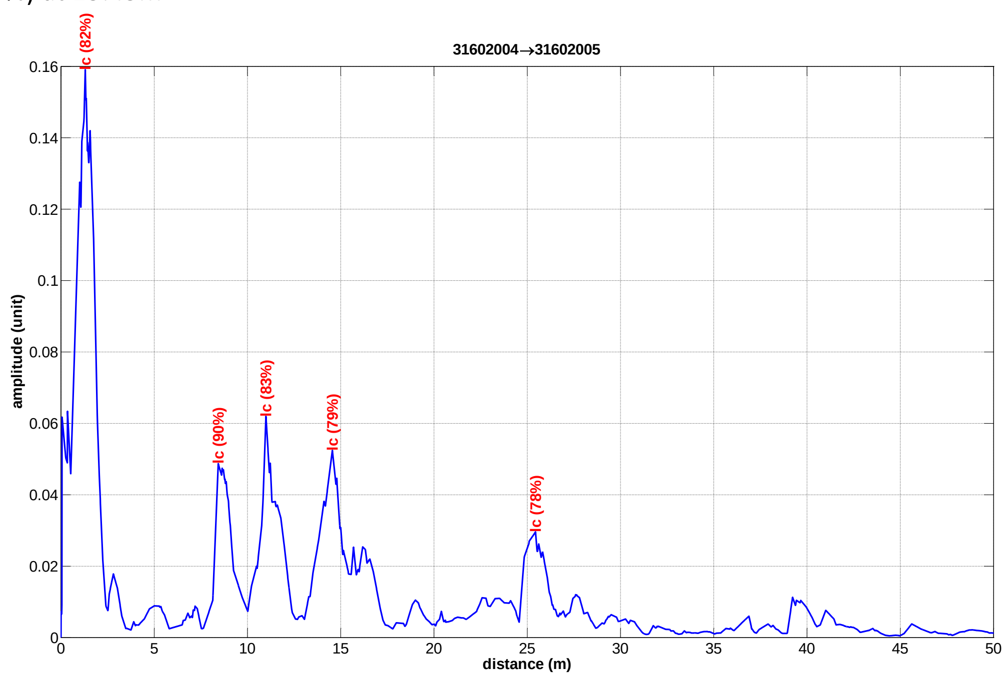
DE ratio : 3.35

AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 62m. Energy is well into the ‘Green’ Zone but the system has allocated ‘Red’ due to the attenuation of the response from the target manhole.

83.0 Survey 3.9 - 31602004_31602005_200mm-2.mat

SITE : green hills
TEST DATE & TIME : 09-May-2013 09:59:31
WATER LEVEL : 0mm
DIAMETER : 200mm
START MH : 31602004
END MH : 31602005
REPORT :
1 : lc (82%) at 1.31m
2 : lc (90%) at 8.43m
3 : lc (83%) at 10.99m
4 : lc (79%) at 14.55m
5 : lc (78%) at 25.45m



AUTO CONDITION GRADE – Amber by manual assessment.

COMMENT – GIS pipe length = 45m. The pipe between the laterals appears to be in reasonable condition. Log for resurvey after an appropriate interval..

84.0 Survey 3.10 - 31602006_31602003_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:58:22

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31602006

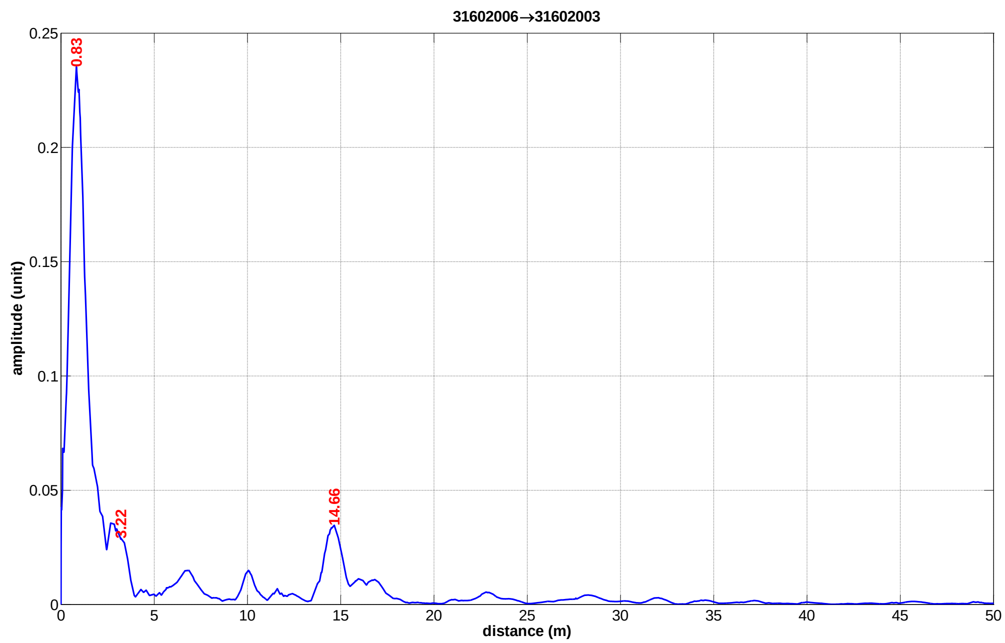
END MH : 31602003

REPORT :

1 : xx at 0.83m

2 : xx at 3.22m

3 : xx at 14.66m

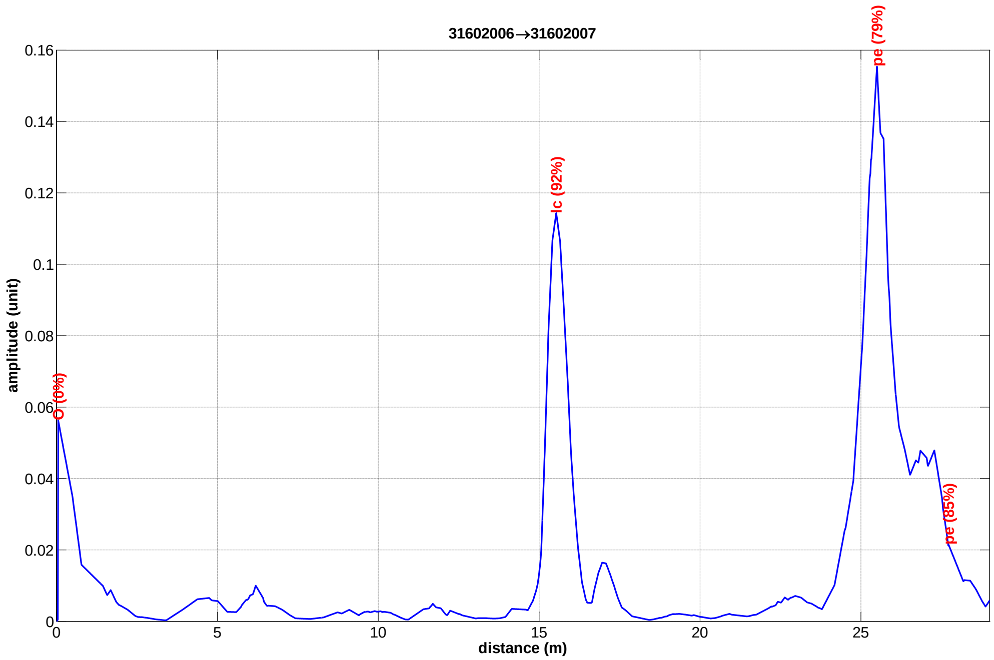


AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 44m. CCTV is recommended.

85.0 Survey 3.11 - 31602006_31602007_200mm-1.mat

SITE : green hills
TEST DATE & TIME : 09-May-2013 11:56:22
WATER LEVEL : 2mm
DIAMETER : 200mm
START MH : 31602006
END MH : 31602007
REPORT :
1 : O (0%) at 0.05m
2 : lc (92%) at 15.53m
3 : pe (79%) at 25.5m
4 : pe (85%) at 27.73m



CONDITION REPORT :
15.53 : lc
25.5 : pe
ENERGY : 34
PE : 0.16
DE ratio : 0
AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 29m. Pipe is serviceable.

86.0 Survey 3.12 - 31602008_31602007_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:51:22

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31602008

END MH : 31602007

REPORT :

1 : O (0%) at 0.52m

2 : lc (76%) at 5.18m

3 : lc (81%) at 10.59m

4 : pe (95%) at 17.52m

5 : pe (76%) at 22.62m

6 : pe (71%) at 26.09m

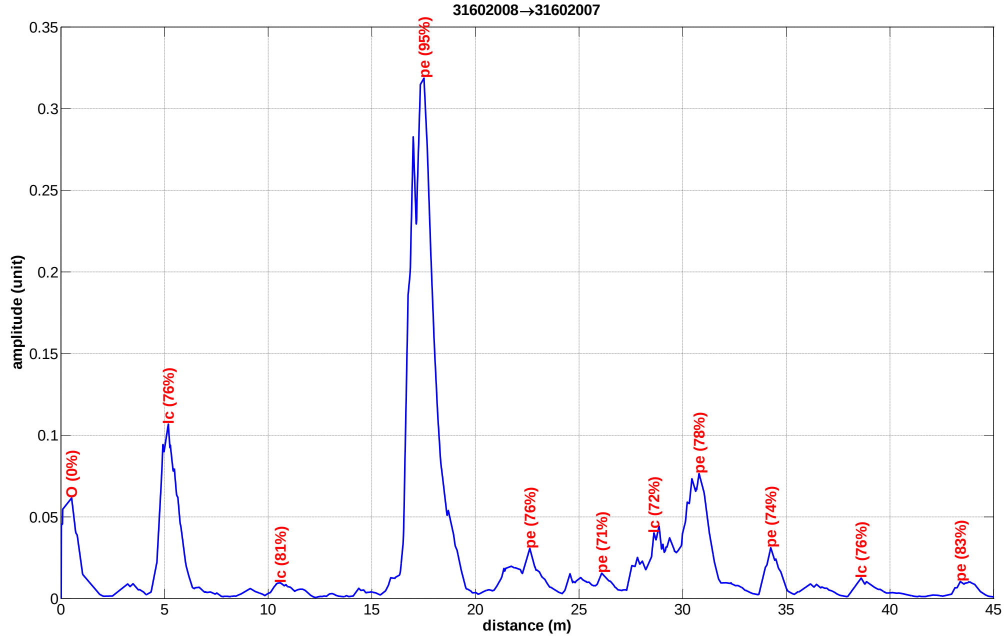
7 : lc (72%) at 28.61m

8 : pe (78%) at 30.79m

9 : pe (74%) at 34.25m

10 : lc (76%) at 38.61m

11 : pe (83%) at 43.4m



CONDITION REPORT :

5.18 : lc (crack, infiltration)

10.59 : xx

17.52 : df (8%, soil visible)

22.62 : xx
26.09 : xx
28.61 : xx
30.79 : xx
34.25 : xx
38.61 : lc
43.4 : pe
ENERGY : 411
PE : 0.01
DE ratio : 30.49
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 45m. CCTV recommended.

87.0 Survey 3.13 - 31602008_31602009_200mm-3.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:50:05

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31602008

END MH : 31602009

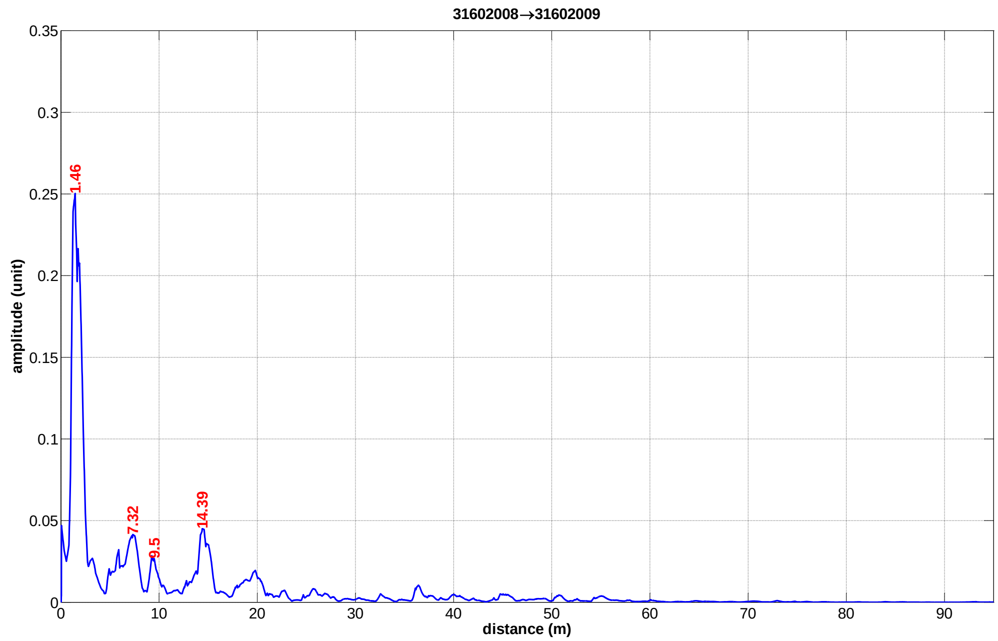
REPORT :

1 : xx at 1.46m

2 : xx at 7.32m

3 : xx at 9.5m

4 : xx at 14.39m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 91.5m. CCTV is recommended.

88.0 Survey 3.14 - 31602008_31602014_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:46:26

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31602008

END MH : 31602014

REPORT :

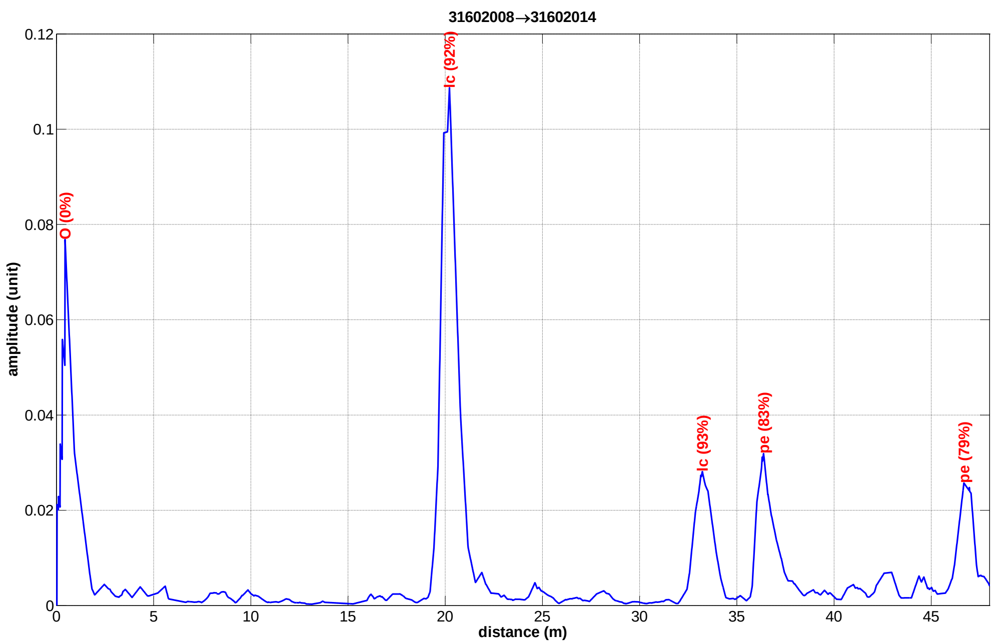
1 : O (0%) at 0.44m

2 : lc (92%) at 20.22m

3 : lc (93%) at 33.22m

4 : pe (83%) at 36.38m

5 : pe (79%) at 46.68m



CONDITION REPORT :

20.22 : lc (crack, infiltration)

33.22 : lc (crack, infiltration)

36.38 : lc

46.68 : pe

ENERGY : 18

PE : 0.03

DE ratio : 0

AUTO CONDITION GRADE – Green.

COMMENT – GIS pipe length = 47m. Pipe is serviceable.

89.0 Survey 3.15 - 31602015_31602009_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:25:42

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31602015

END MH : 31602009

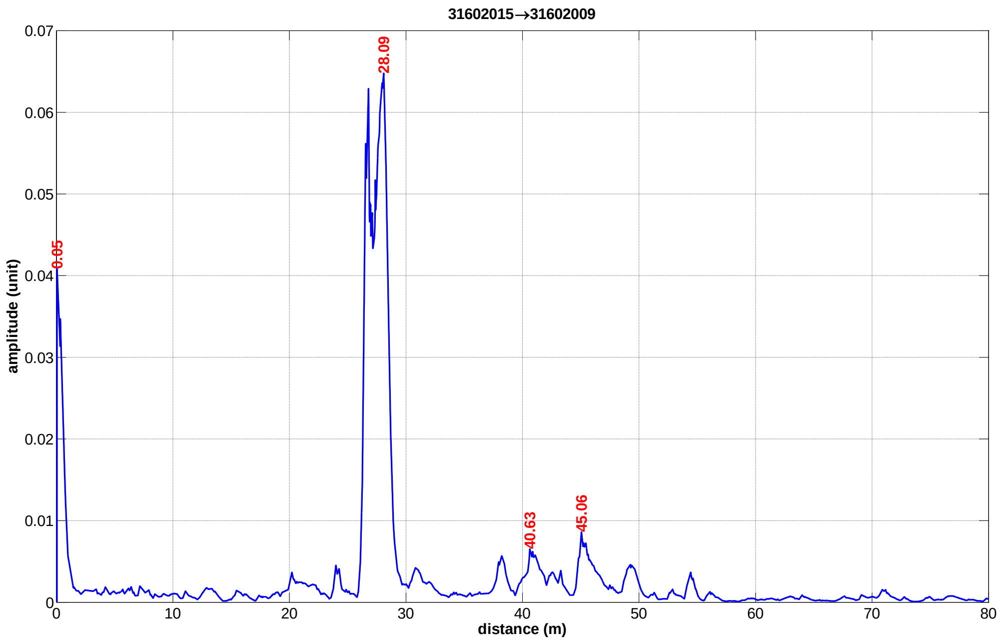
REPORT :

1 : xx at 0.05m

2 : xx at 28.09m

3 : xx at 40.63m

4 : xx at 45.06m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 79.5m. CCTV is recommended.

90.0 Survey 3.16 - 31602015_31714009_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:27:48

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31602015

END MH : 31714009

REPORT :

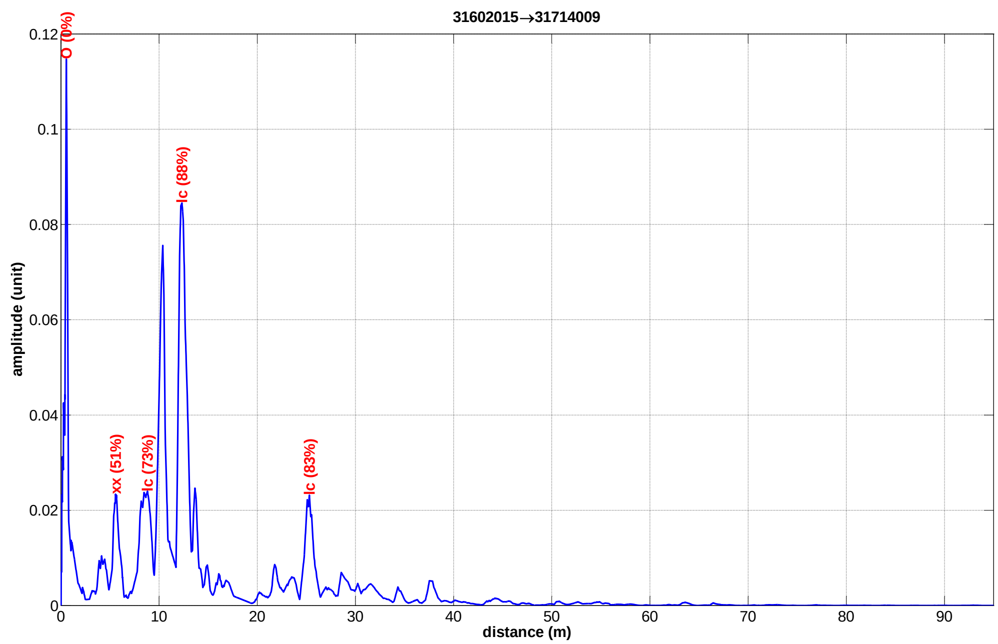
1 : O (0%) at 0.55m

2 : xx (51%) at 5.56m

3 : lc (73%) at 8.82m

4 : lc (88%) at 12.33m

5 : lc (83%) at 25.3m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 92m. CCTV is recommended.

91.0 Survey 3.17 - 31714003_31714002_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:17:31

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714003

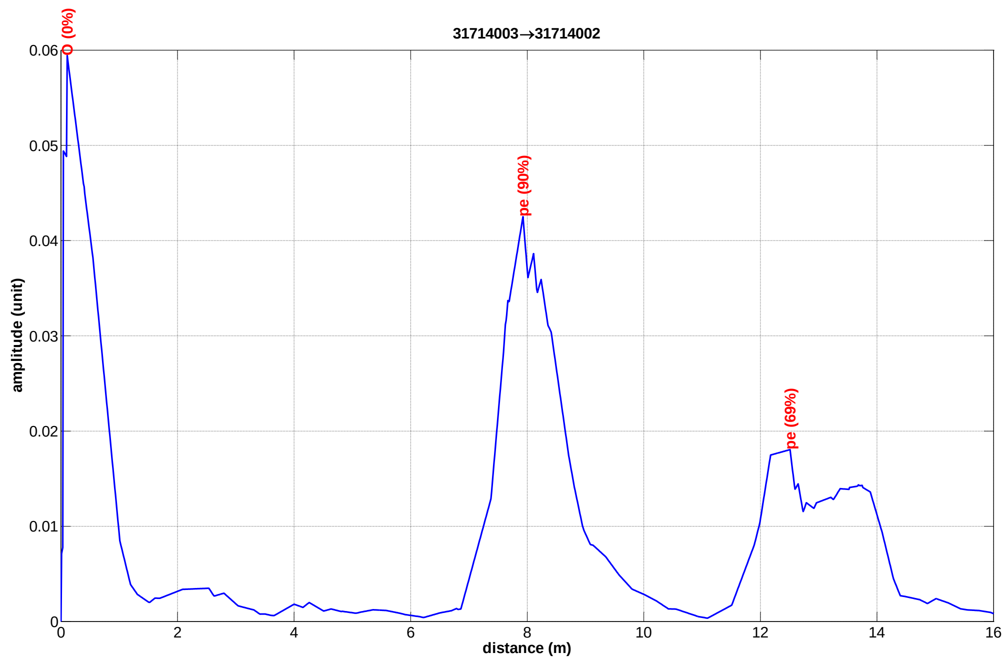
END MH : 31714002

REPORT :

1 : O (0%) at 0.11m

2 : pe (90%) at 7.93m

3 : pe (69%) at 12.51m



CONDITION REPORT :

7.93 : lc (crack, infiltration)

12.51 : pe (Good)

ENERGY : 10

PE : 0.02

DE ratio : 0

AUTO CONDITION GRADE – Green (manual override to red)

COMMENT – GIS pipe length = 15m. Poor data quality from mic 1. Data processed from mics 2 and 3 only. Due to reported condition of lateral (crack, infiltration) and significant attenuation of response from target manhole CCTV is recommended as a precautionary measure.

92.0 Survey 3.18 - 31714003_31714004_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:14:17

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714003

END MH : 31714004

REPORT :

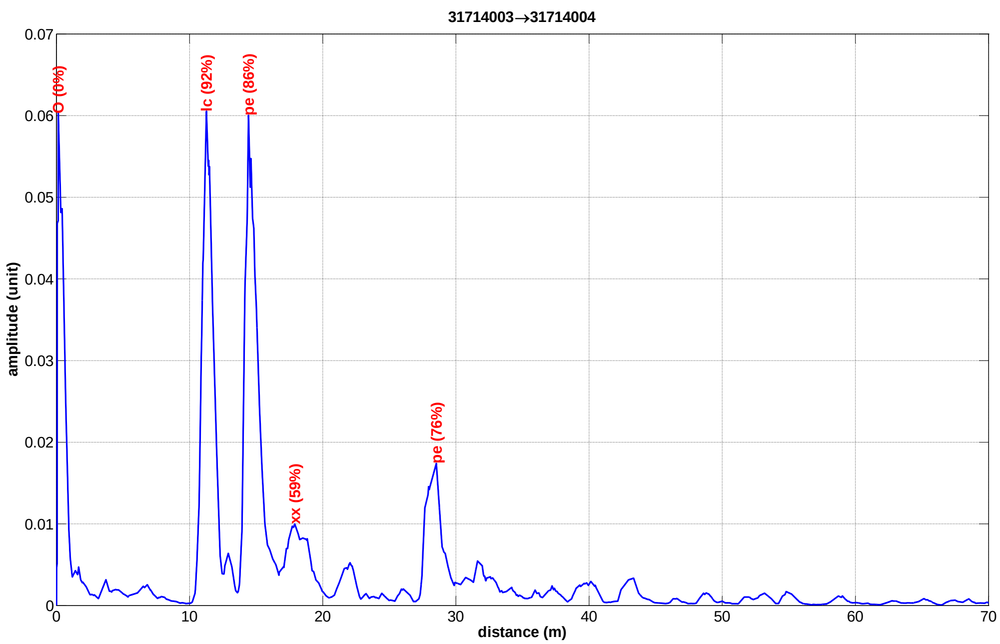
1 : O (0%) at 0.14m

2 : lc (92%) at 11.27m

3 : pe (86%) at 14.43m

4 : xx (59%) at 17.9m

5 : pe (76%) at 28.53m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 69.5m. CCTV is recommended.

93.0 Survey 3.19 - 31714003_31714010_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:15:42

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714003

END MH : 31714010

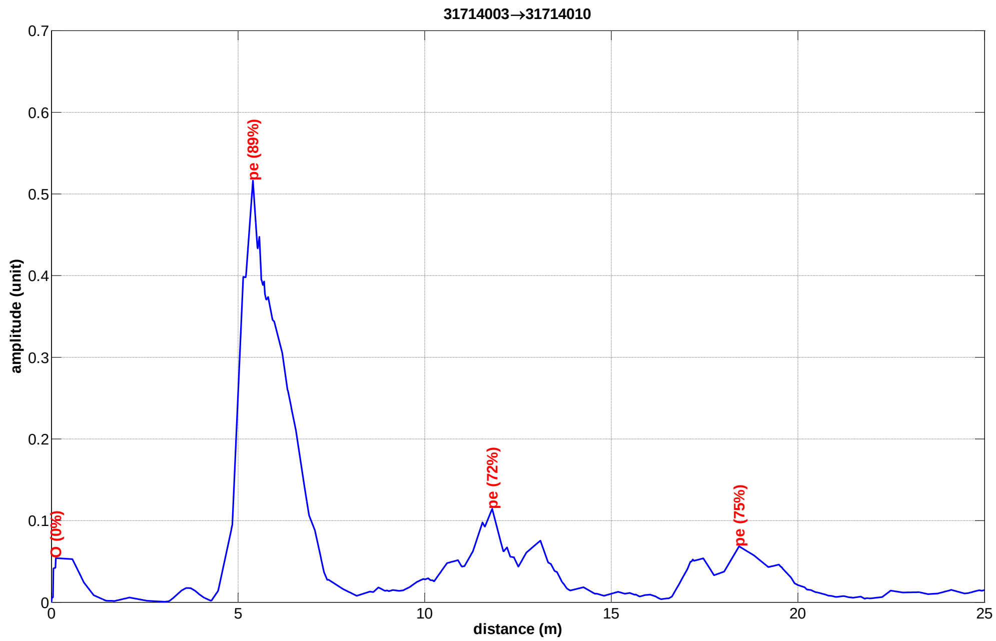
REPORT :

1 : O (0%) at 0.12m

2 : pe (89%) at 5.4m

3 : pe (72%) at 11.81m

4 : pe (75%) at 18.42m



CONDITION REPORT :

11.81 : xx

18.42 : pe

ENERGY : 1366

PE : 0.07

DE ratio : 7.54

AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 26m. CCTV recommended.

94.0 Survey 3.20 - 31714005_31714004_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:25:26

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714005

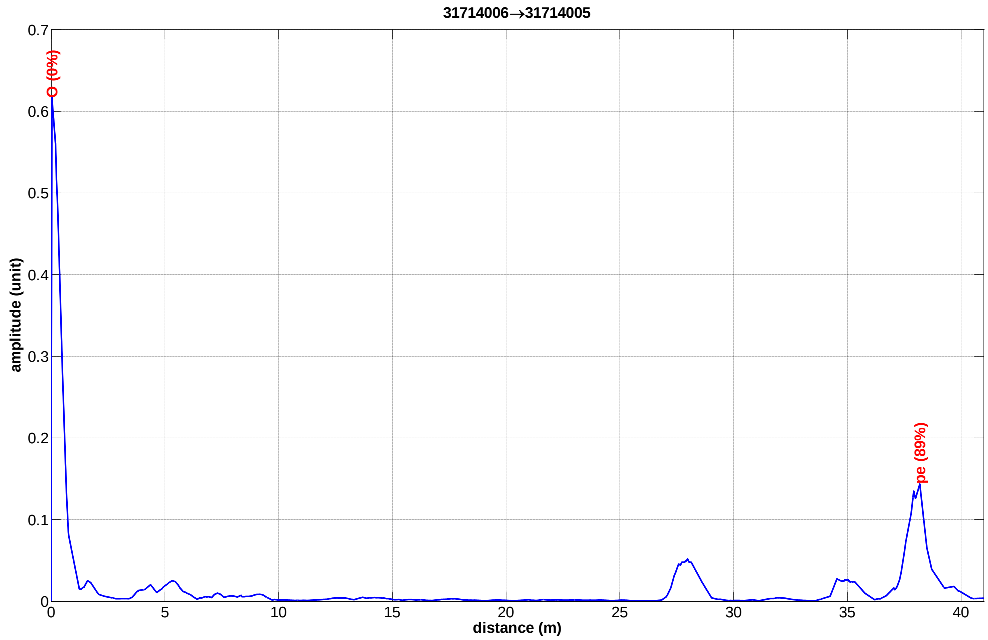
END MH : 31714004

REPORT :

The data from this site is not usable

95.0 Survey 3.21 - 31714006_31714005_200mm-1.mat

SITE : green hillss
TEST DATE & TIME : 09-May-2013 13:30:04
WATER LEVEL : 1mm
DIAMETER : 200mm
START MH : 31714006
END MH : 31714005
REPORT :
1 : O (0%) at 0.03m
2 : pe (89%) at 38.19m



CONDITION REPORT :
38.19 : pe
ENERGY : 83
PE : 0.14
DE ratio : 0
AUTO CONDITION GRADE – Amber

COMMENT – GIS pipe length = 39m. The pipe is serviceable but shows signs of deterioration. It is recommended that the pipe should be logged for reinspection after an appropriate interval.

96.0 Survey 3.22 - 31714006_31714007_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:31:32

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714006

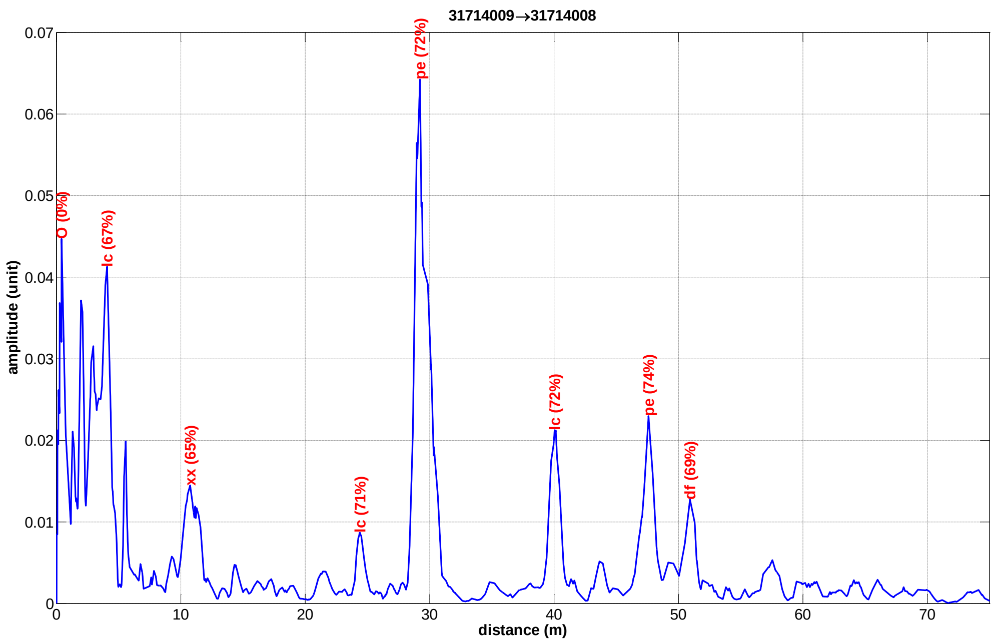
END MH : 31714007

REPORT :

The data from this site is not usable

97.0 Survey 3.23 - =31714009_31714008_200mm-1.mat

SITE : green hillss
TEST DATE & TIME : 09-May-2013 12:32:24
WATER LEVEL : 1mm
DIAMETER : 200mm
START MH : 31714009
END MH : 31714008
REPORT :
1 : O (0%) at 0.41m
2 : lc (67%) at 4.07m
3 : xx (65%) at 10.75m
4 : lc (71%) at 24.4m
5 : pe (72%) at 29.22m
6 : lc (72%) at 40.04m
7 : pe (74%) at 47.59m
8 : df (69%) at 50.92m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 73m. CCTV is recommended.

98.0 Survey 3.24 - 31714009_31714018_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:33:53

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714009

END MH : 31714018

REPORT :

1 : O (0%) at 0.03m

2 : lc (74%) at 2.6m

3 : xx (57%) at 6.65m

4 : lc (66%) at 9.3m

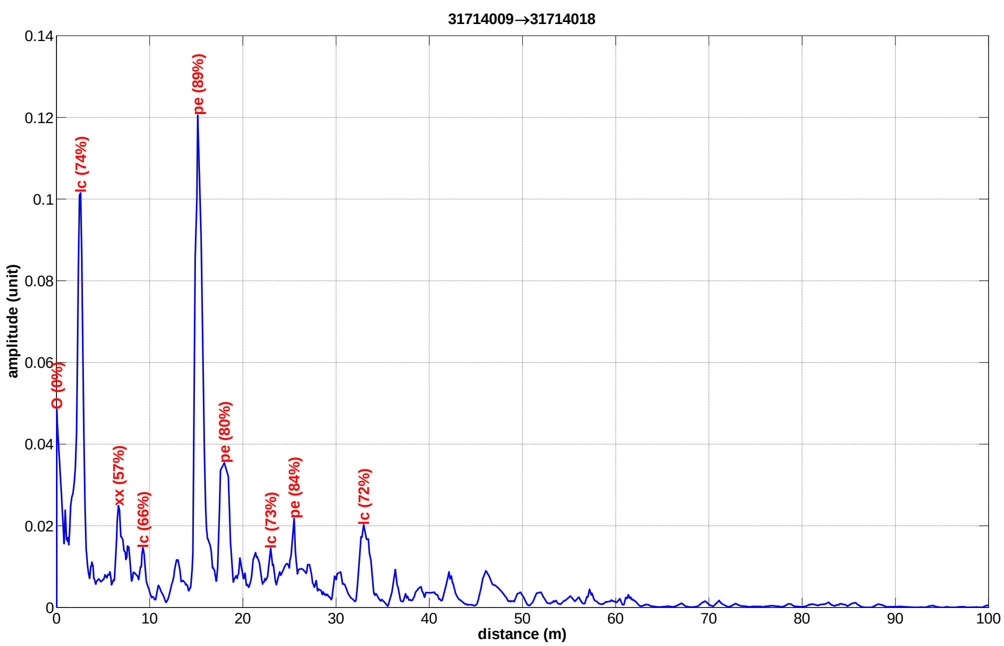
5 : pe (89%) at 15.16m

6 : pe (80%) at 18.02m

7 : lc (73%) at 22.98m

8 : pe (84%) at 25.51m

9 : lc (72%) at 32.96m



AUTO CONDITION GRADE – Red by manual assessment. Not previously graded

COMMENT – GIS pipe length = 91m. Persistent noise in the response along the pipe indicates a general low level of continuous defects such as roots, debris and displaced joints. CCTV is recommended.

99.0 Survey 3.25 - 31714011_31714004_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:09:33

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714011

END MH : 31714004

REPORT :

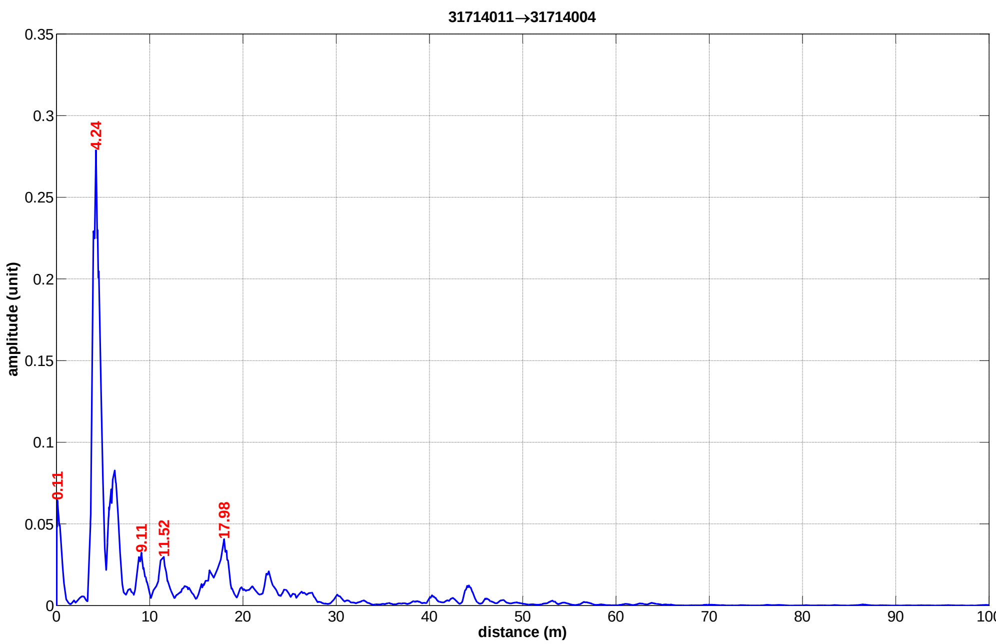
1 : xx at 0.11m

2 : xx at 4.24m

3 : xx at 9.11m

4 : xx at 11.52m

5 : xx at 17.98m

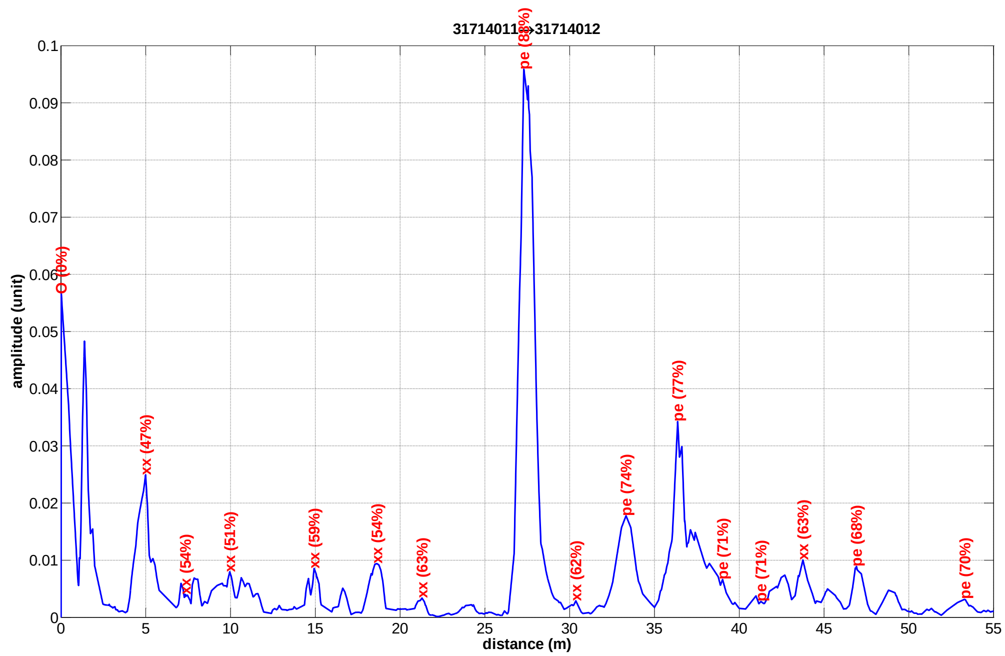


AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 92m. CCTV is recommended.

100.0 Survey 3.26 - 31714011_31714012_200mm-1.mat

SITE : green hillss
TEST DATE & TIME : 09-May-2013 13:08:13
WATER LEVEL : 1mm
DIAMETER : 200mm
START MH : 31714011
END MH : 31714012
REPORT :
1 : O (0%) at 0.02m
2 : xx (47%) at 4.99m
3 : xx (54%) at 7.34m
4 : xx (51%) at 9.96m
5 : xx (59%) at 14.93m
6 : xx (54%) at 18.63m
7 : xx (63%) at 21.29m
8 : pe (88%) at 27.3m
9 : xx (62%) at 30.37m
10 : pe (74%) at 33.33m
11 : pe (77%) at 36.37m
12 : pe (71%) at 39.02m
13 : pe (71%) at 41.28m
14 : xx (63%) at 43.76m
15 : pe (68%) at 46.91m
16 : pe (70%) at 53.32m



CONDITION REPORT :
4.99 : xx
7.34 : xx
9.96 : xx
14.93 : xx
18.63 : xx
21.29 : xx
27.3 : lc (crack, infiltration)
30.37 : xx
33.33 : xx
36.37 : xx
39.02 : xx
41.28 : xx
43.76 : xx
46.91 : xx
53.32 : pe
ENERGY : 42
PE : 0
DE ratio : 10.77
AUTO CONDITION GRADE – Red
COMMENT – GIS pipe length = 53m. CCTV recommended.

101.0 Survey 3.27 - 31714011_31714017_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:06:39

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714011

END MH : 31714017

REPORT :

1 : O (0%) at 0.45m

2 : lc (77%) at 7.41m

3 : xx (64%) at 11.01m

4 : xx (63%) at 13.2m

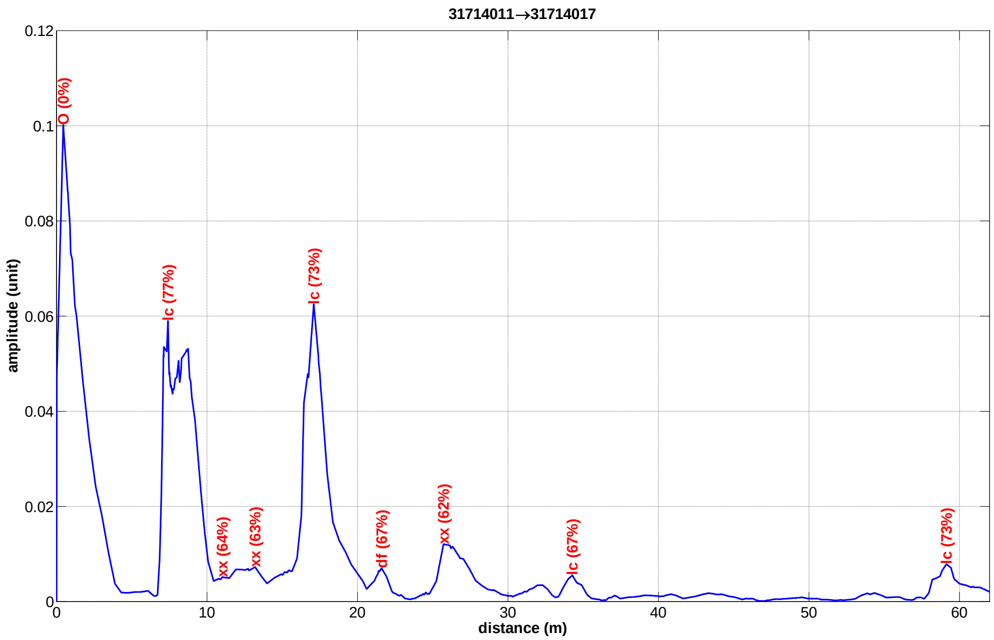
5 : lc (73%) at 17.1m

6 : df (67%) at 21.6m

7 : xx (62%) at 25.72m

8 : lc (67%) at 34.27m

9 : lc (73%) at 59.14m



CONDITION REPORT :

7.41 : xx

11.01 : xx

13.2 : xx

17.1 : lc (crack, infiltration)

21.6 : xx

25.72 : xx
34.27 : xx
59.14 : pe (crack, infiltration)
ENERGY : 74
PE : 0.01
DE ratio : 7.49
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 59m. Analysis based on mics 2 and 3 only. Energy level is in the ‘Amber’ zone but given the nature of several of the identified defects and the level of attenuation of the response from the target manhole CCTV is recommended.

102.0 Survey 3.28 - 31714014_31714013_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 13:00:52

WATER LEVEL : 1mm

DIAMETER : 200mm

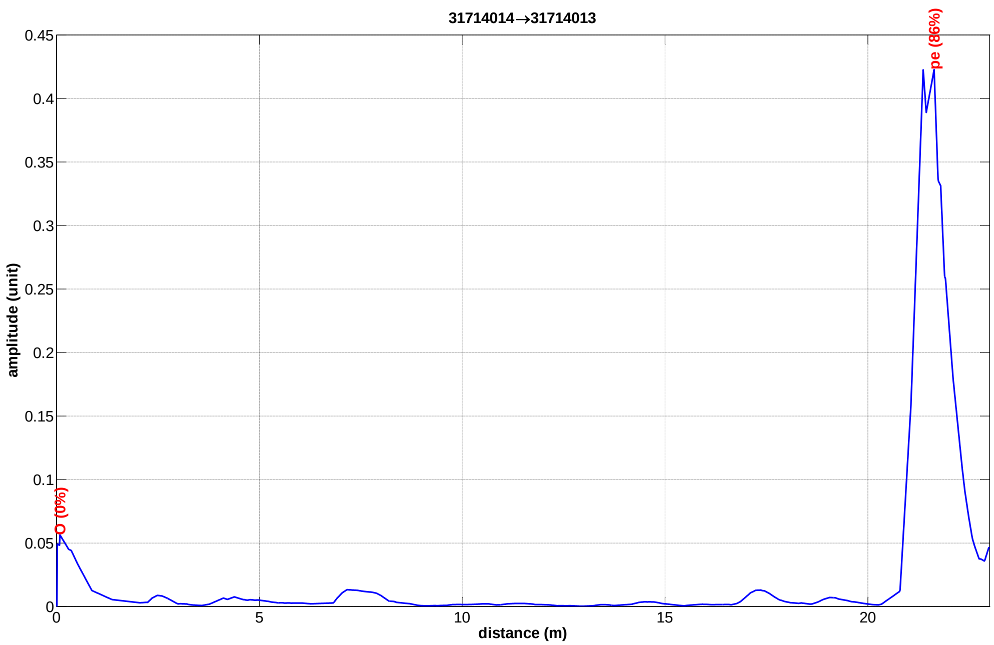
START MH : 31714014

END MH : 31714013

REPORT :

1 : O (0%) at 0.09m

2 : pe (86%) at 21.63m



CONDITION REPORT :

21.63 : pe

ENERGY : 38

PE : 0.42

DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 22m. Pipe is serviceable.

103.0 Survey 3.29 - 31714014_31714015_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:57:52

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714014

END MH : 31714015

REPORT :

1 : O (0%) at 0.11m

2 : lc (86%) at 2.52m

3 : pe (86%) at 6.24m

4 : lc (78%) at 8.87m

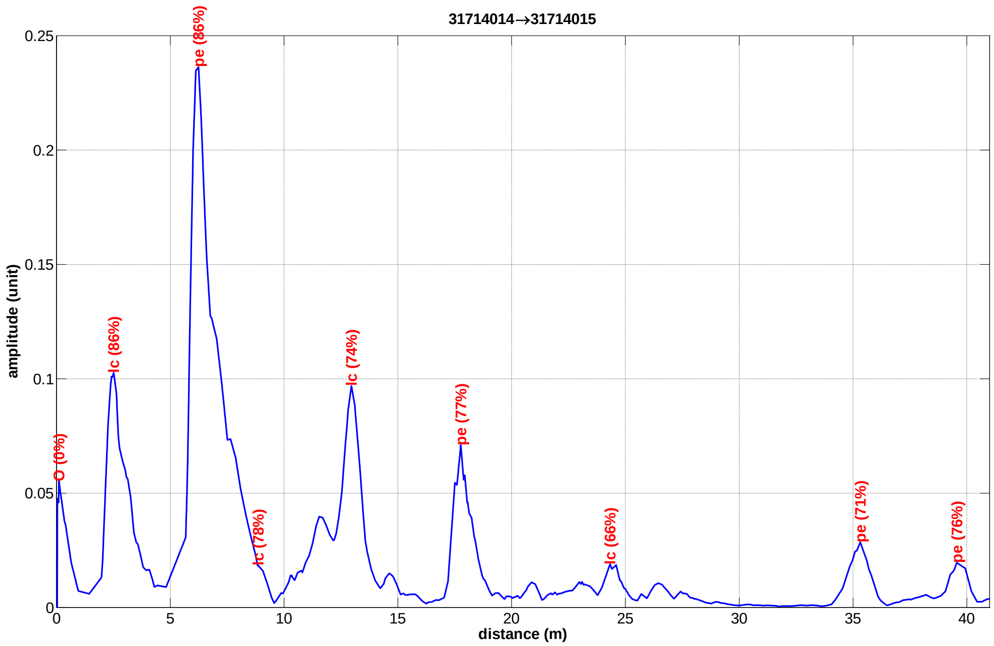
5 : lc (74%) at 12.96m

6 : pe (77%) at 17.77m

7 : lc (66%) at 24.32m

8 : pe (71%) at 35.32m

9 : pe (76%) at 39.56m



CONDITION REPORT :

2.52 : lc (crack, infiltration)

6.24 : xx

8.87 : xx

12.96 : lc (closed)

17.77 : xx

24.32 : xx
35.32 : xx
39.56 : pe
ENERGY : 306
PE : 0.02
DE ratio : 12.06
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 40m. If the many peaks could be identified as lateral connections then an 'Amber' or 'Green' classification could be given to this pipe, but with the present signature library CCTV is recommended on a precautionary basis.

104.0 Survey 3.30 - 31714014_31714019_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:59:15

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714014

END MH : 31714019

REPORT :

1 : xx at 0.46m

2 : xx at 17.04m

3 : xx at 20.96m

4 : xx at 24.41m

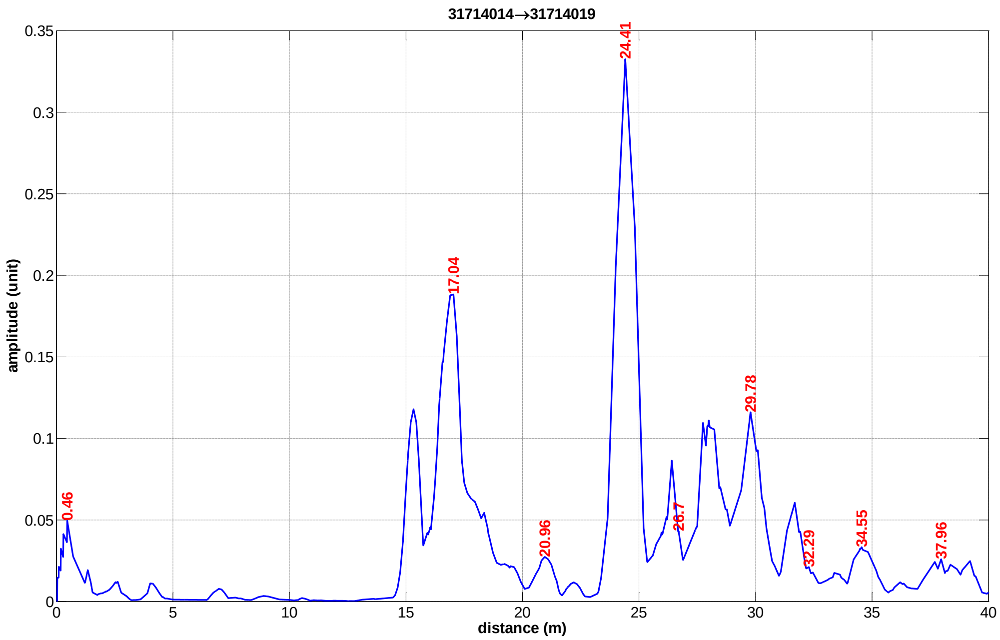
5 : xx at 26.7m

6 : xx at 29.78m

7 : xx at 32.29m

8 : xx at 34.55m

9 : xx at 37.96m



CONDITION REPORT :

17.04 : lc (crack, infiltration)

20.96 : lc (crack, infiltration)

24.41 : xx

26.7 : lc (crack, infiltration)

29.78 : xx

32.29 : lc (crack, infiltration)
34.55 : lc (crack, infiltration)
37.96 : pe
ENERGY : 207
PE : 0.03
DE ratio : 12.79
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 40m. CCTV is recommended.

105.0 Survey 3.31 - 31714016_31714015_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:51:11

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714016

END MH : 31714015

REPORT :

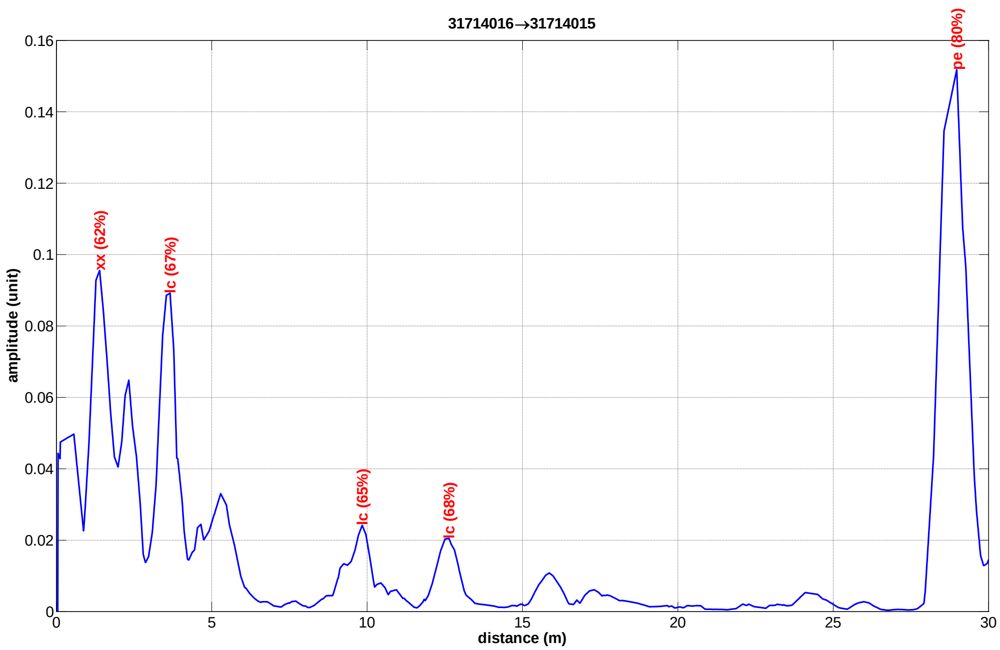
1 : xx (62%) at 1.39m

2 : lc (67%) at 3.66m

3 : lc (65%) at 9.84m

4 : lc (68%) at 12.64m

5 : pe (80%) at 28.98m



CONDITION REPORT :

3.66 : lc (crack, infiltration)

9.84 : lc (crack, infiltration)

12.64 : lc (missing pieces, crack, displacement)

28.98 : pe

ENERGY : 46

PE : 0.15

DE ratio : 0

AUTO CONDITION GRADE – Red

Comment – GIS pipe length = 32m. CCTV recommended to investigate poor conditions reported to be associated with lateral connections and multiple responses in first 5m.

106.0 Survey 3.32 - 31714016_31714017_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:48:55

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714016

END MH : 31714017

REPORT :

1 : O (0%) at 0.54m

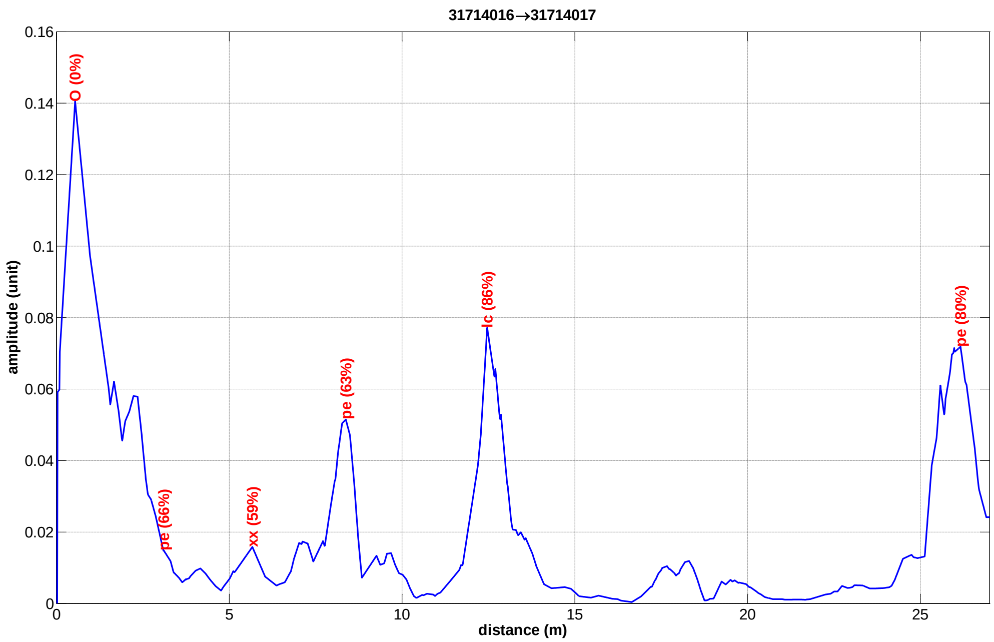
2 : pe (66%) at 3.11m

3 : xx (59%) at 5.67m

4 : pe (63%) at 8.37m

5 : lc (86%) at 12.46m

6 : pe (80%) at 26.16m



CONDITION REPORT :

3.11 : xx

5.67 : xx

8.37 : xx

12.46 : lc (crack, infiltration)

26.16 : pe

ENERGY : 95

PE : 0.07

DE ratio : 0.72

AUTO CONDITION GRADE – Red (manual override to Amber)

COMMENT – GIS pipe length 29.5m. Condition is just into the ‘Red’ zone but appears serviceable. Re-survey after 1 year is recommended to assess whether pipe has deteriorated further.

107.0 Survey 3.33 - 31714016_31714020_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:50:51

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714016

END MH : 31714020

REPORT :

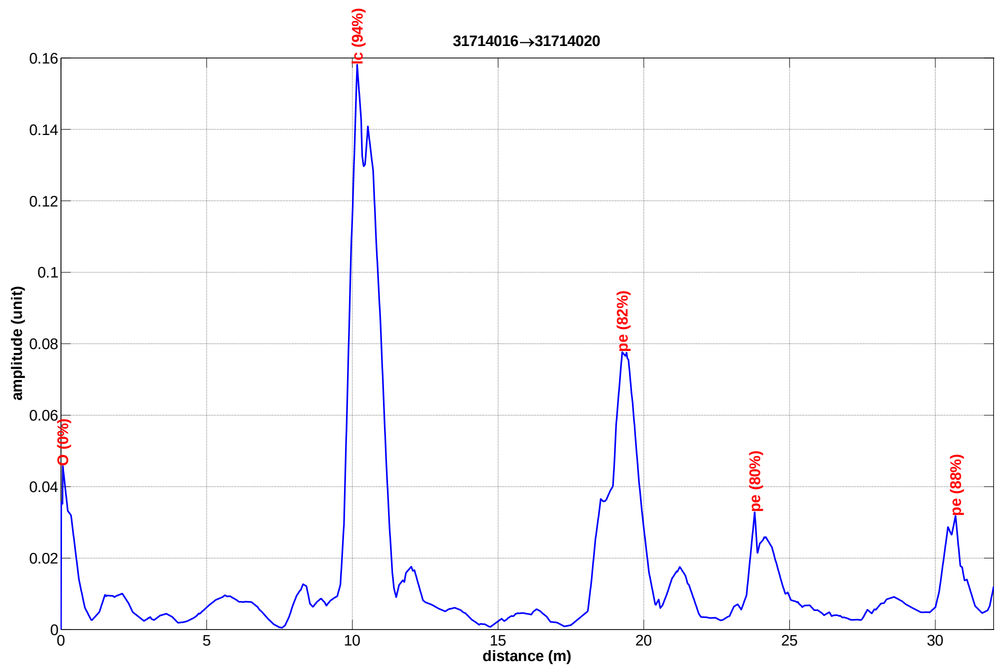
1 : O (0%) at 0.06m

2 : lc (94%) at 10.16m

3 : pe (82%) at 19.26m

4 : pe (80%) at 23.8m

5 : pe (88%) at 30.7m



CONDITION REPORT :

10.16 : lc

19.26 : lc

23.8 : lc (closed)

30.7 : pe

ENERGY : 59

PE : 0.03

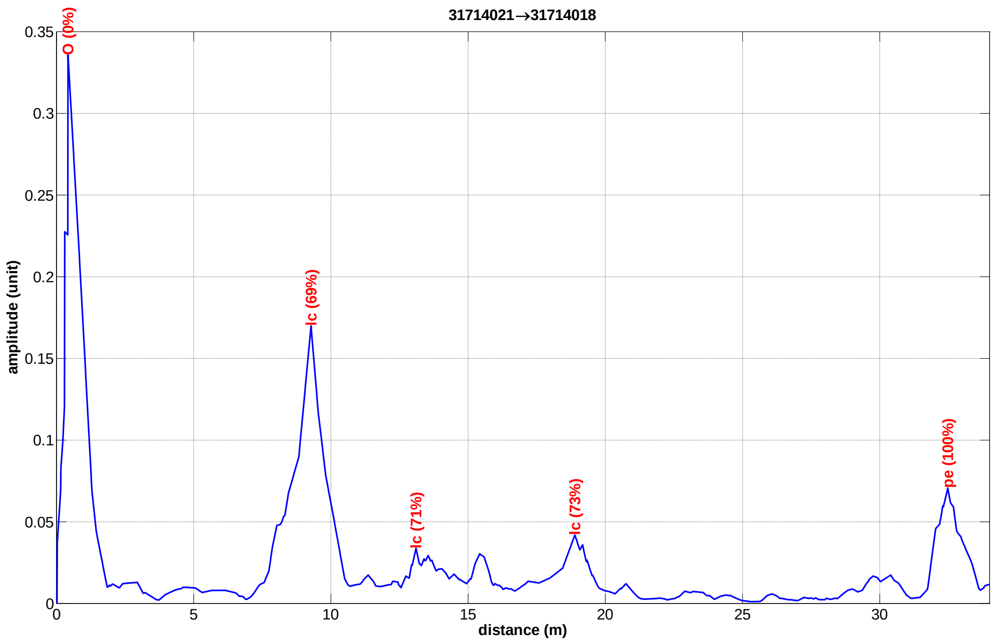
DE ratio : 0

AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 31m. The response from the target manhole is significantly attenuated and there are continuous low-level responses along the pipe. However the pipe appears serviceable and further survey is not recommended.

108.0 Survey 3.34 - 31714021_31714018_200mm-1.mat

SITE : green hillss
TEST DATE & TIME : 09-May-2013 12:38:13
REPORT DATE & TIME : 29-Aug-2013 12:57:34
WATER LEVEL : 1mm
DIAMETER : 200mm
START MH : 31714021
END MH : 31714018
REPORT :
1 : O (0%) at 0.42m
2 : lc (69%) at 9.28m
3 : lc (71%) at 13.1m
4 : lc (73%) at 18.89m
5 : pe (100%) at 32.48m



CONDITION REPORT :
9.28 : lc (crack, infiltration)
13.1 : lc (closed)
18.89 : lc (crack, infiltration)
32.48 : pe
ENERGY : 97
PE : 0.07
DE ratio : 0
AUTO CONDITION GRADE – Red (manual override to Amber)

COMMENT – GIS pipe length = 35m. Energy level calculated by the system is marginally in the red zone but this is affected by the large incident pulse and an ‘Amber’ classification has been applied. It is recommended that the pipe should be logged for resurvey after an appropriate interval.

109.0 Survey 3.35 - 31714021_31714022_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:40:03

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714021

END MH : 31714022

REPORT :

1 : O (0%) at 0.28m

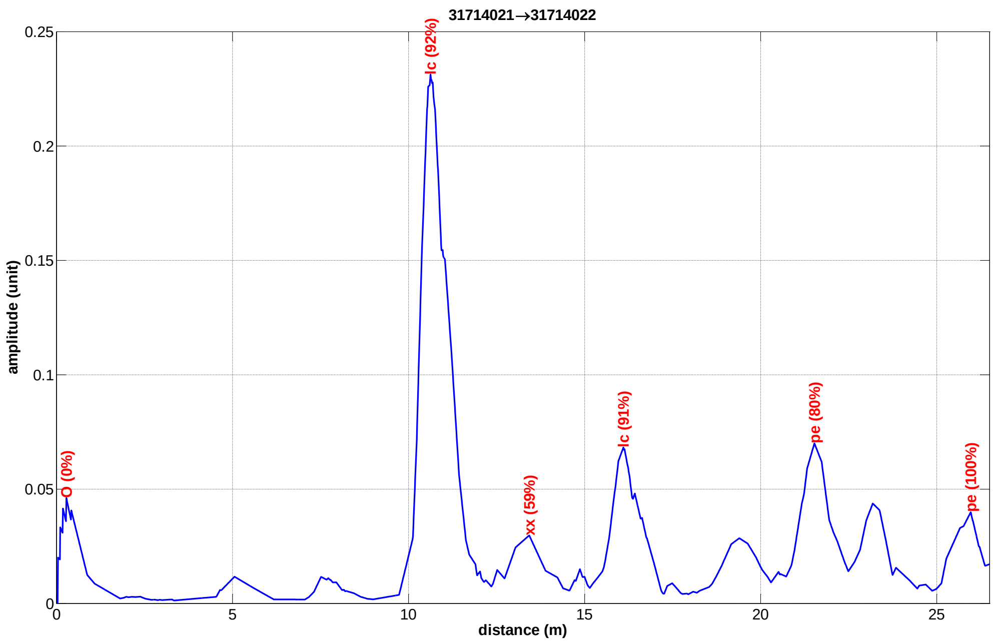
2 : lc (92%) at 10.62m

3 : xx (59%) at 13.43m

4 : lc (91%) at 16.1m

5 : pe (80%) at 21.53m

6 : pe (100%) at 25.97m



CONDITION REPORT :

10.62 : lc (crack, infiltration)

13.43 : xx

16.1 : lc (crack, infiltration)

21.53 : xx

25.97 : pe (Good)

ENERGY : 149

PE : 0.04

DE ratio : 1.75

AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 26m. CCTV is recommended.

110.0 Survey 3.36 - 31714022_31714023_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:43:53

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31714022

END MH : 31714023

REPORT :

1 : O (0%) at 0.12m

2 : xx (52%) at 2.36m

3 : lc (67%) at 13.11m

4 : pe (90%) at 15.36m

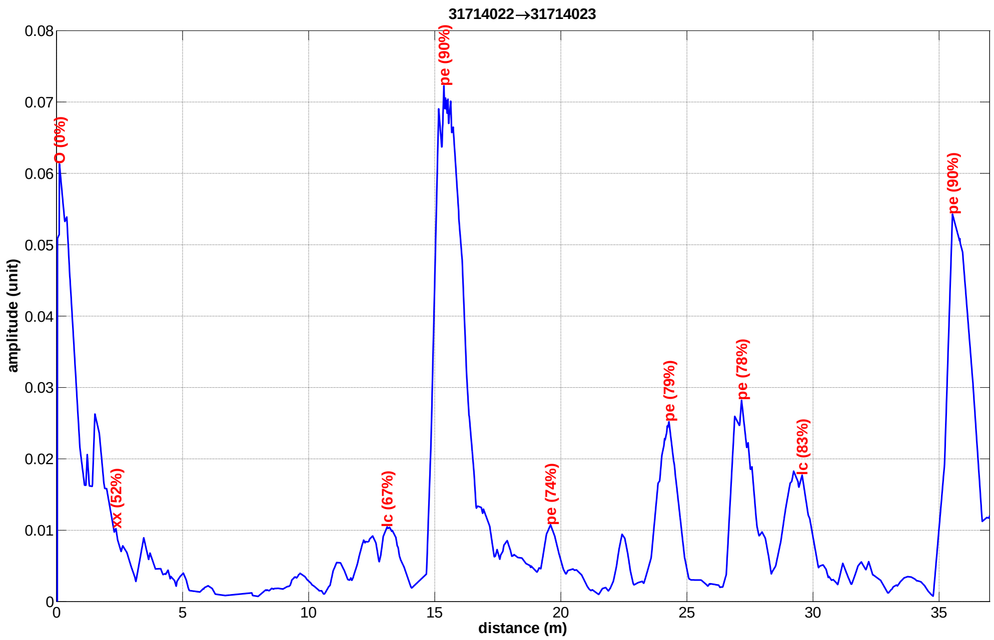
5 : pe (74%) at 19.59m

6 : pe (79%) at 24.29m

7 : pe (78%) at 27.17m

8 : lc (83%) at 29.57m

9 : pe (90%) at 35.53m



CONDITION REPORT :

2.36 : xx

13.11 : xx

15.36 : lc (crack, infiltration)

19.59 : xx

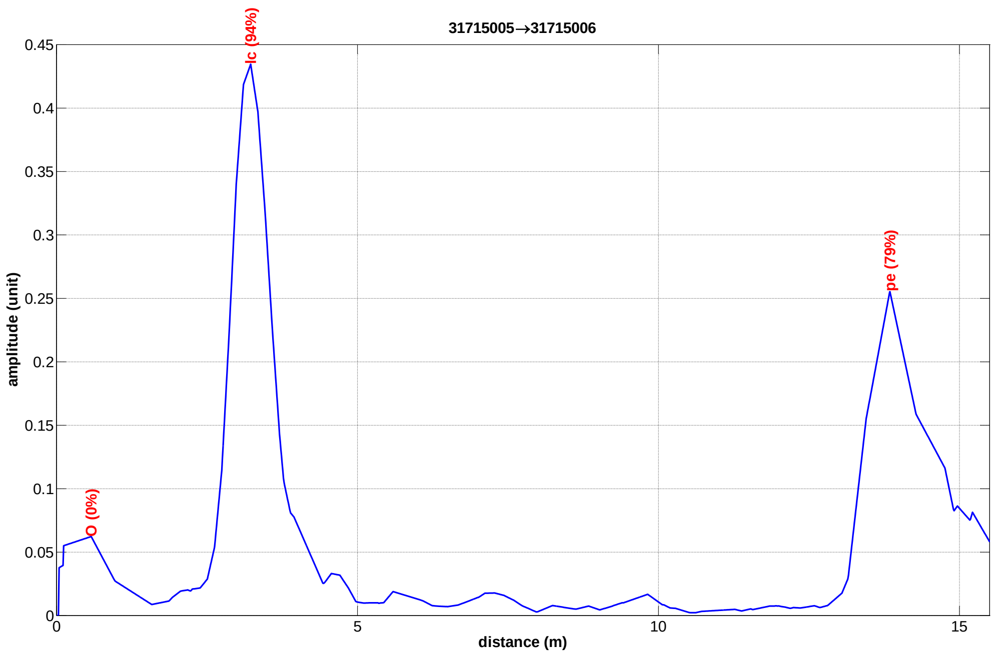
24.29 : xx

27.17 : xx
29.57 : lc
35.53 : pe (Good)
ENERGY : 63
PE : 0.05
DE ratio : 0.52
AUTO CONDITION GRADE – Amber

COMMENT – GIS pipe length = 36m. Pipe appears serviceable but with potential for deterioration. Log for reinspection after an appropriate interval.

111.0 Survey 3.37 - 31715005_31715006_200mm-1.mat

SITE : green hills
TEST DATE & TIME : 09-May-2013 11:24:02
WATER LEVEL : 2mm
DIAMETER : 200mm
START MH : 31715005
END MH : 31715006
REPORT :
1 : O (0%) at 0.58m
2 : lc (94%) at 3.23m
3 : pe (79%) at 13.84m



CONDITION REPORT :
3.23 : lc (crack, infiltration)
13.84 : pe
ENERGY : 72
PE : 0.26
DE ratio : 0
AUTO CONDITION GRADE – Amber

COMMENT – GIS pipe length = 14.5m. Pipe appears serviceable but is deteriorating. Log for resurvey after an appropriate period.

112.0 Survey 3.38 - 31715005_31716014_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:25:29

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715005

END MH : 31716014

REPORT :

1 : O (0%) at 0.57m

2 : lc (79%) at 4.77m

3 : xx (57%) at 9.24m

4 : xx (54%) at 13.36m

5 : pe (76%) at 21.13m

6 : pe (76%) at 26.92m

7 : xx (60%) at 31.67m

8 : pe (71%) at 38.26m

9 : df (69%) at 40.7m

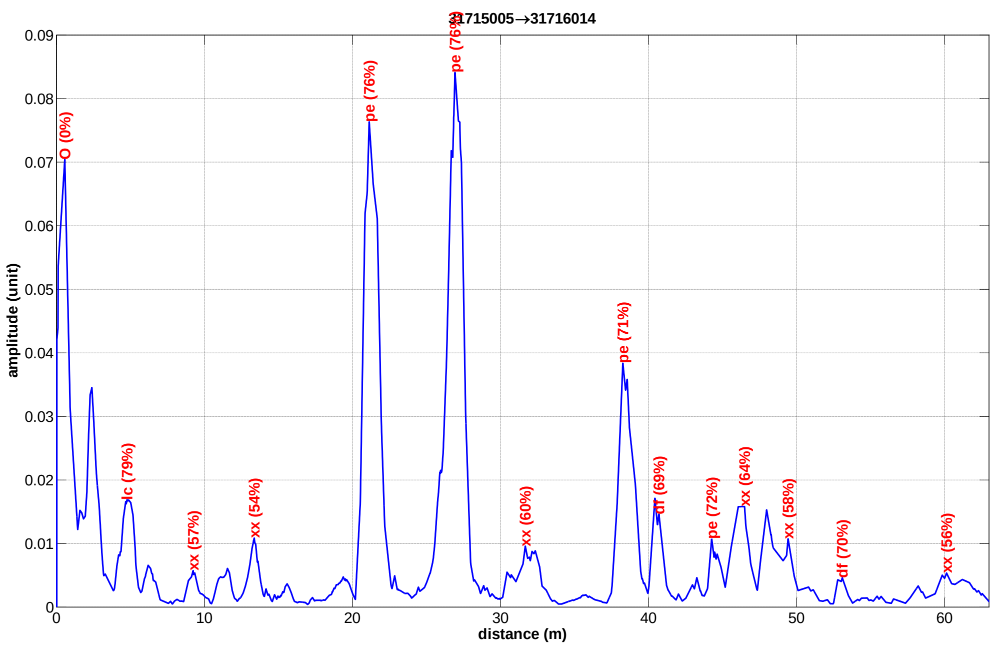
10 : pe (72%) at 44.26m

11 : xx (64%) at 46.48m

12 : xx (58%) at 49.42m

13 : df (70%) at 53.08m

14 : xx (56%) at 60.13m



CONDITION REPORT :

4.77 : lc
9.24 : xx
13.36 : xx
21.13 : lc (crack, infiltration)
26.92 : lc (crack, infiltration)
31.67 : xx
38.26 : lc (crack, infiltration)
40.7 : lc (crack, infiltration)
44.26 : lc (crack, infiltration)
46.48 : xx
49.42 : xx
53.08 : lc (crack, infiltration)
60.13 : pe
ENERGY : 25
PE : 0.01
DE ratio : 2.96
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 61m. CCTV is recommended.

113.0 Survey 3.39 - 31715011_31602016_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:17:07

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715011

END MH : 31602016

REPORT :

1 : xx at 0.09m

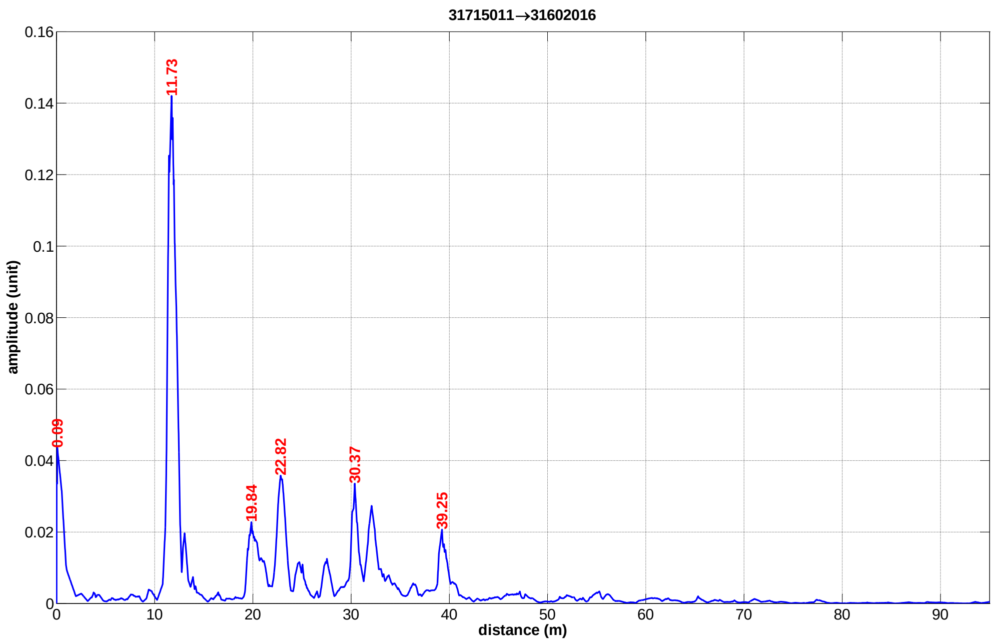
2 : xx at 11.73m

3 : xx at 19.84m

4 : xx at 22.82m

5 : xx at 30.37m

6 : xx at 39.25m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 92m. CCTV is recommended.

114.0 Survey 3.40 - 31715011_31715006_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:19:07

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715011

END MH : 31715006

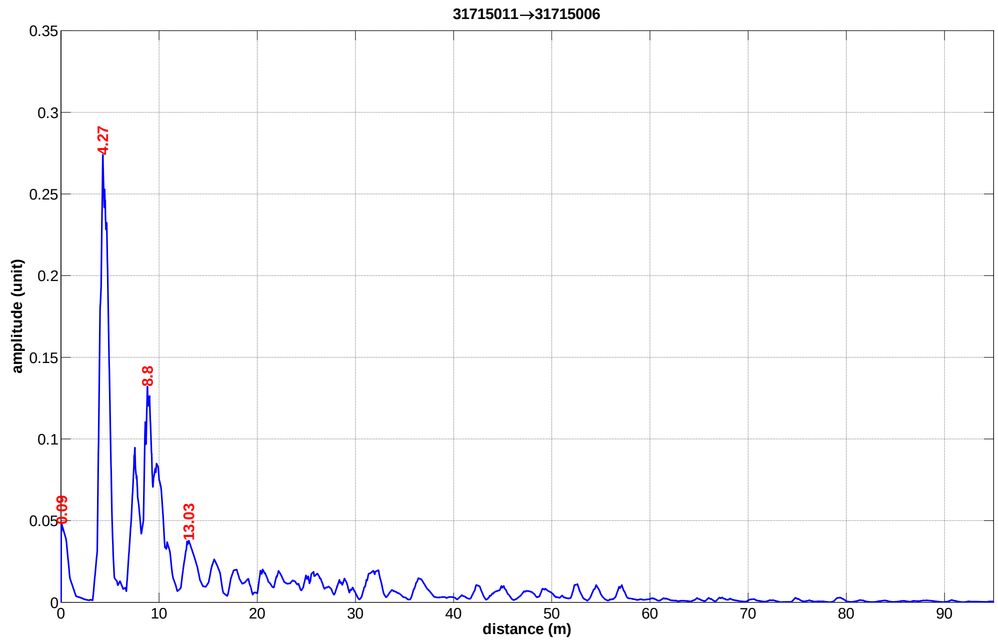
REPORT :

1 : xx at 0.09m

2 : xx at 4.27m

3 : xx at 8.8m

4 : xx at 13.03m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 92m. CCTV is recommended.

115.0 Survey 3.41 - 31715013_31715010_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:30:11

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715013

END MH : 31715010

REPORT :

1 : O (0%) at 0.05m

2 : lc (94%) at 17.99m

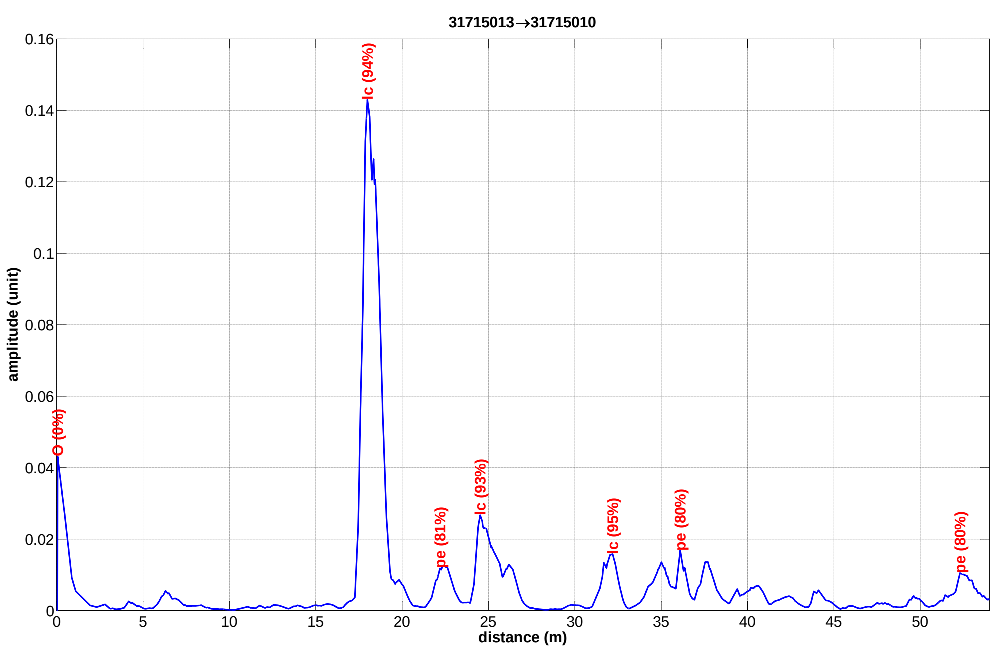
3 : pe (81%) at 22.2m

4 : lc (93%) at 24.52m

5 : lc (95%) at 32.19m

6 : pe (80%) at 36.1m

7 : pe (80%) at 52.3m



CONDITION REPORT :

17.99 : lc

22.2 : lc (crack, infiltration)

24.52 : lc (crack, infiltration)

32.19 : lc (crack, infiltration)

36.1 : xx

52.3 : pe (Good)

ENERGY : 37

PE : 0.01
DE ratio : 1.6
AUTO CONDITION GRADE – Red

COMMENT – GIS pipe length = 52m. CCTV is recommended.

116.0 Survey 3.42 - 31715013_31715016_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:31:37

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715013

END MH : 31715016

REPORT :

1 : O (0%) at 0.08m

2 : xx (49%) at 4.26m

3 : xx (60%) at 6.59m

4 : pe (88%) at 32.33m

5 : pe (70%) at 36.68m

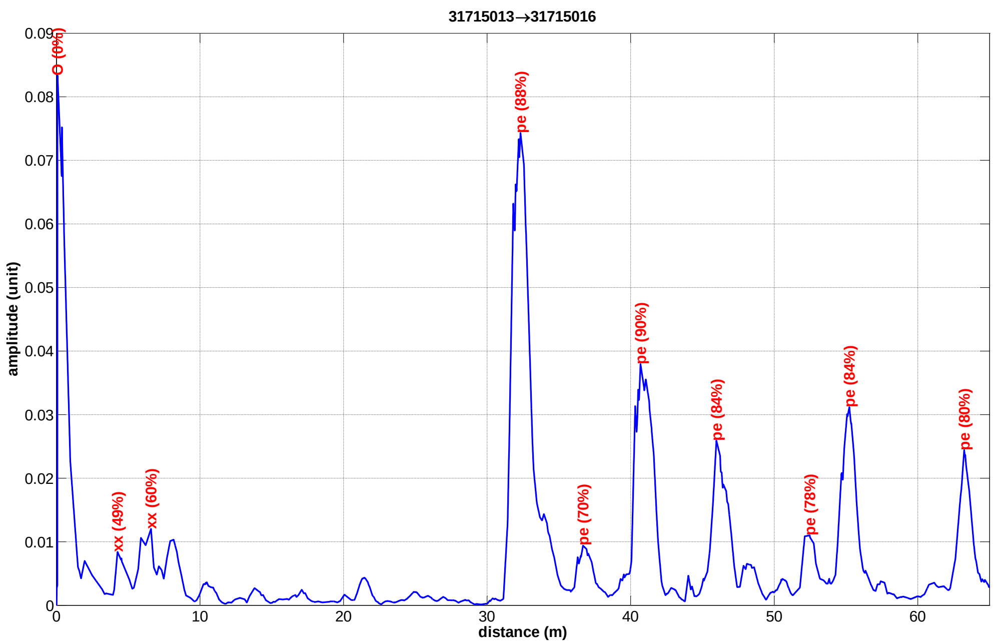
6 : pe (90%) at 40.68m

7 : pe (84%) at 45.97m

8 : pe (78%) at 52.47m

9 : pe (84%) at 55.23m

10 : pe (80%) at 63.23m



CONDITION REPORT :

4.26 : xx

6.59 : xx

32.33 : lc

36.68 : xx

40.68 : lc
45.97 : lc
52.47 : xx
55.23 : lc
63.23 : pe (Good)
ENERGY : 31
PE : 0.02
DE ratio : 0.49
AUTO CONDITION GRADE – Amber

COMMENT – GIS pipe length = 63m. The pipe is serviceable but has potential to deteriorate. I t is recommended that the pipe be logged for reinspection after an appropriate interval.

117.0 Survey 3.43 - 31715016_31715020_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:35:31

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715016

END MH : 31715020

REPORT :

1 : O (0%) at 0.08m

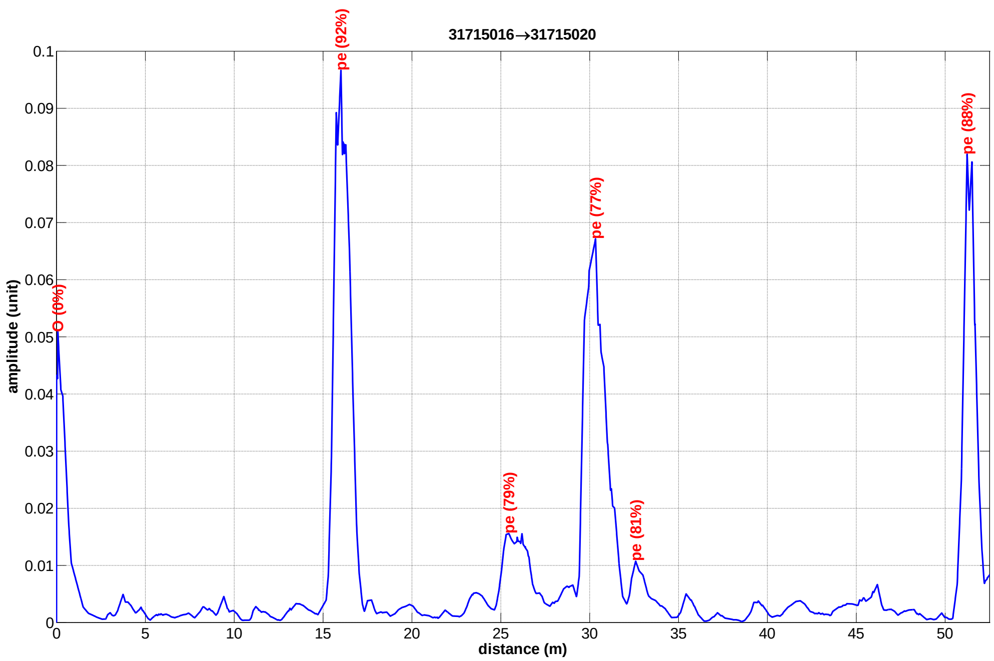
2 : pe (92%) at 16.01m

3 : pe (79%) at 25.46m

4 : pe (77%) at 30.33m

5 : pe (81%) at 32.59m

6 : pe (88%) at 51.24m



CONDITION REPORT :

16.01 : lc (crack, infiltration)

25.46 : xx

30.33 : lc (crack, infiltration)

32.59 : xx

51.24 : pe

ENERGY : 38

PE : 0.08

DE ratio : 0.19

AUTO CONDITION GRADE – Green (manual override to Amber due nature of reported defects)

COMMENT – GIS pipe length = 50.5m. Pipe is serviceable but has potential to deteriorate. It is recommended that it should be logged for reinspection after an appropriate interval.

118.0 Survey 3.44 - 31715016_31715022_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:36:59

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715016

END MH : 31715022

REPORT :

1 : xx at 0.1m

2 : xx at 12.98m

3 : xx at 15.31m

4 : xx at 18.75m

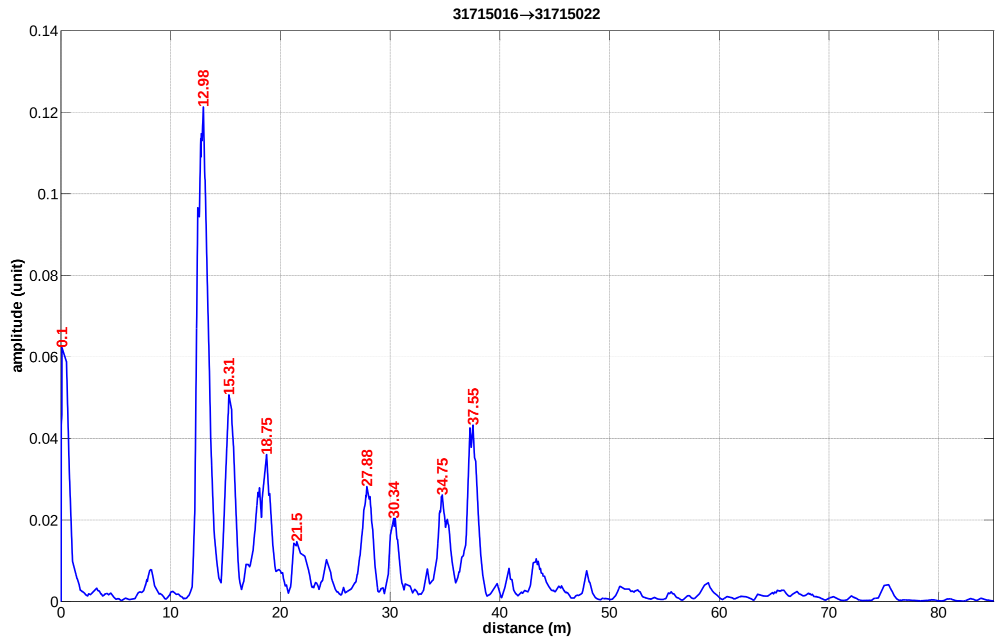
5 : xx at 21.5m

6 : xx at 27.88m

7 : xx at 30.34m

8 : xx at 34.75m

9 : xx at 37.55m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 83m. CCTV is recommended.

119.0 Survey 3.45 - 31715023_31602014_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:42:07

WATER LEVEL : 2mm

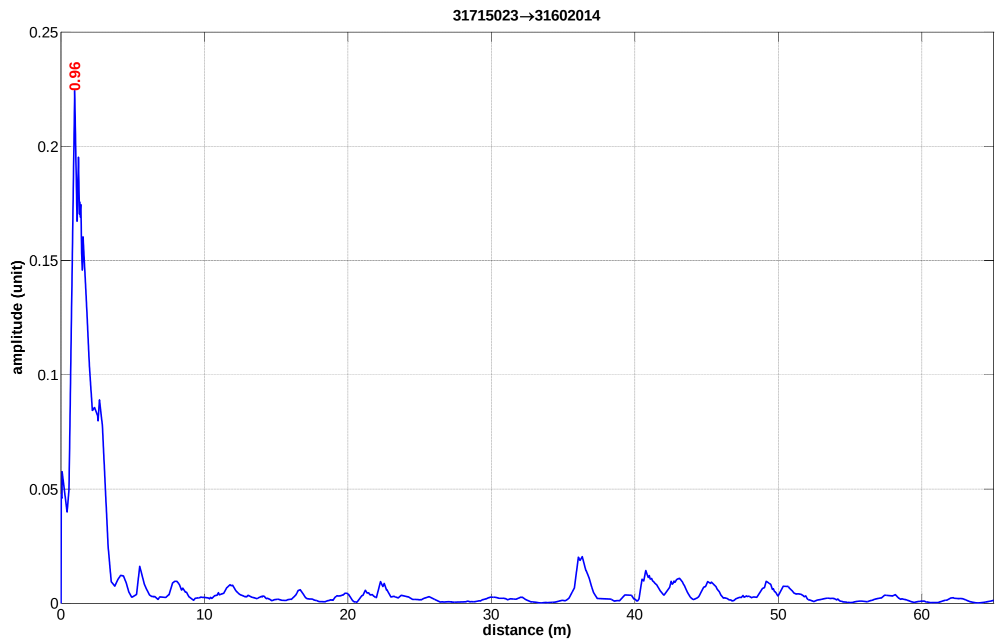
DIAMETER : 200mm

START MH : 31715023

END MH : 31602014

REPORT :

1 : xx at 0.96m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 62m. CCTV is recommended.

120.0 Survey 3.46 - 31715023_31715022_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:40:45

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31715023

END MH : 31715022

REPORT :

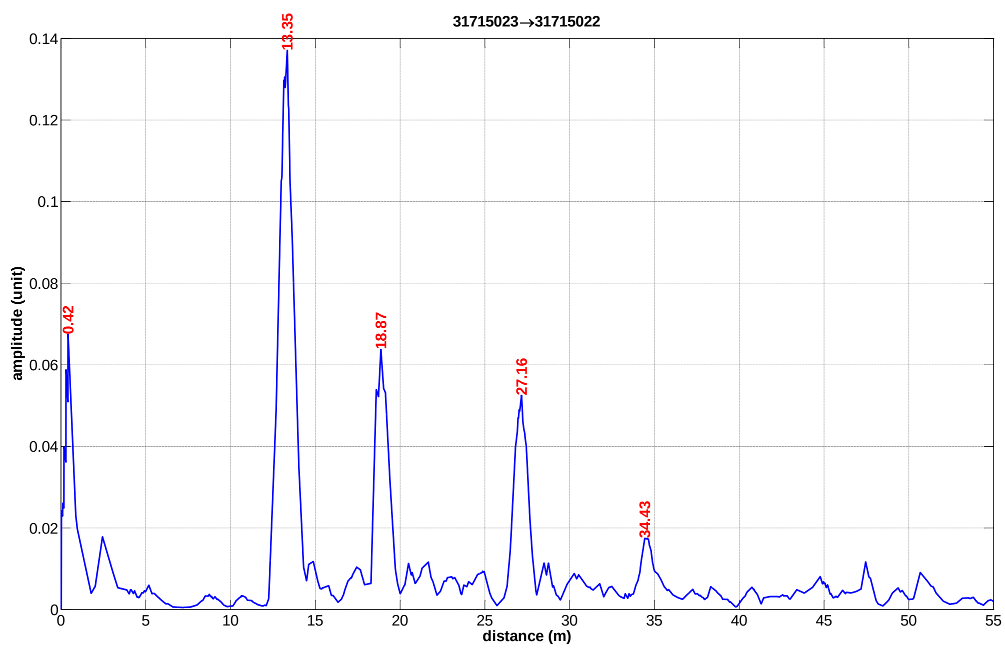
1 : xx at 0.42m

2 : xx at 13.35m

3 : xx at 18.87m

4 : xx at 27.16m

5 : xx at 34.43m

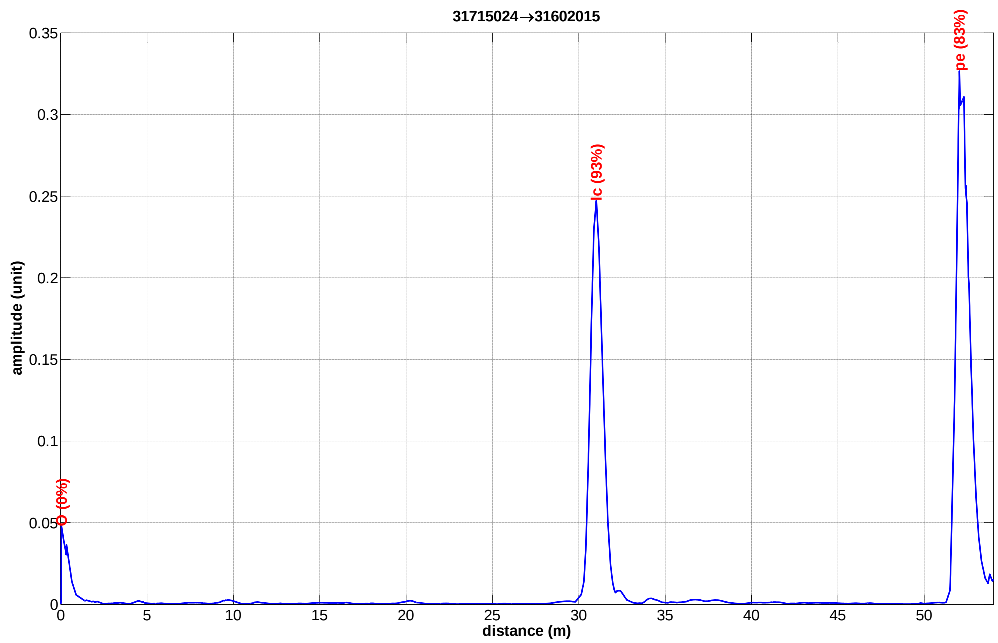


AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 51.5m. CCTV is recommended.

121.0 Survey 3.47 - 31715024_31602015_200mm-1.mat

SITE : green hillss
TEST DATE & TIME : 09-May-2013 12:19:32
WATER LEVEL : 1mm
DIAMETER : 200mm
START MH : 31715024
END MH : 31602015
REPORT :
1 : O (0%) at 0.04m
2 : lc (93%) at 31.02m
3 : pe (83%) at 52.04m



CONDITION REPORT :
31.02 : lc
52.04 : pe (Good)
ENERGY : 8
PE : 0.33
DE ratio : 0
AUTO CONDITION GRADE – Green

COMMENT – GIS pipe length = 52.5m. The pipe is serviceable and no further survey is required at the present time.

122.0 Survey 3.48 - 31715024_31715021_200mm-1.mat

SITE : green hillss

TEST DATE & TIME : 09-May-2013 12:17:34

WATER LEVEL : 1mm

DIAMETER : 200mm

START MH : 31715024

END MH : 31715021

REPORT :

1 : xx at 0.04m

2 : xx at 8.96m

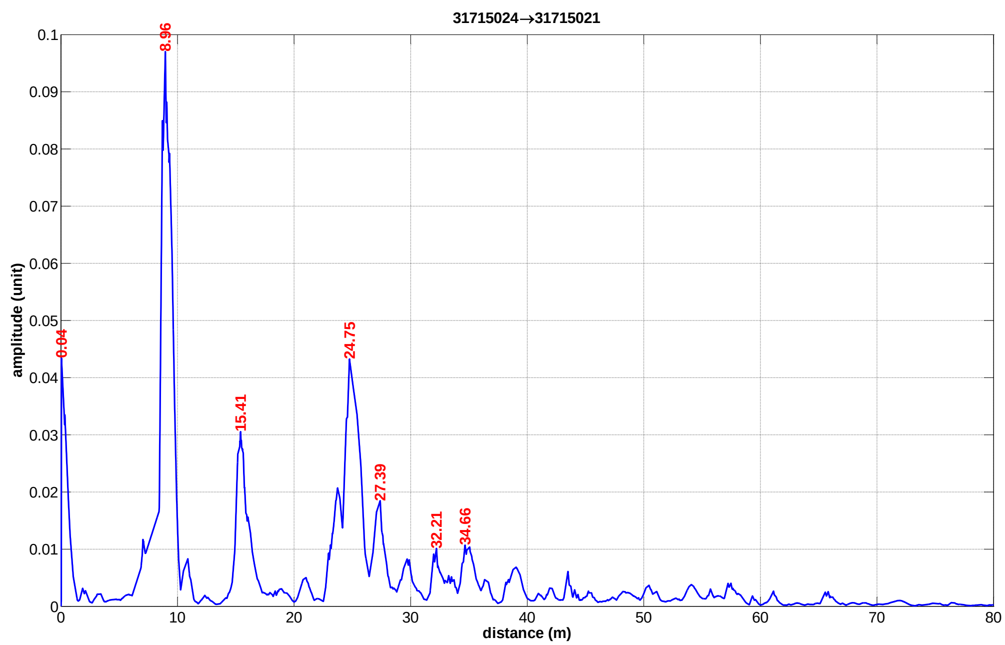
3 : xx at 15.41m

4 : xx at 24.75m

5 : xx at 27.39m

6 : xx at 32.21m

7 : xx at 34.66m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 75.5m. CCTV is recommended.

123.0 Survey 3.49 - 31716012_31716011_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 11:00:58

WATER LEVEL : 2mm

DIAMETER : 200mm

START MH : 31716012

END MH : 31716011

REPORT :

1 : xx at 0.48m

2 : xx at 6.04m

3 : xx at 8.26m

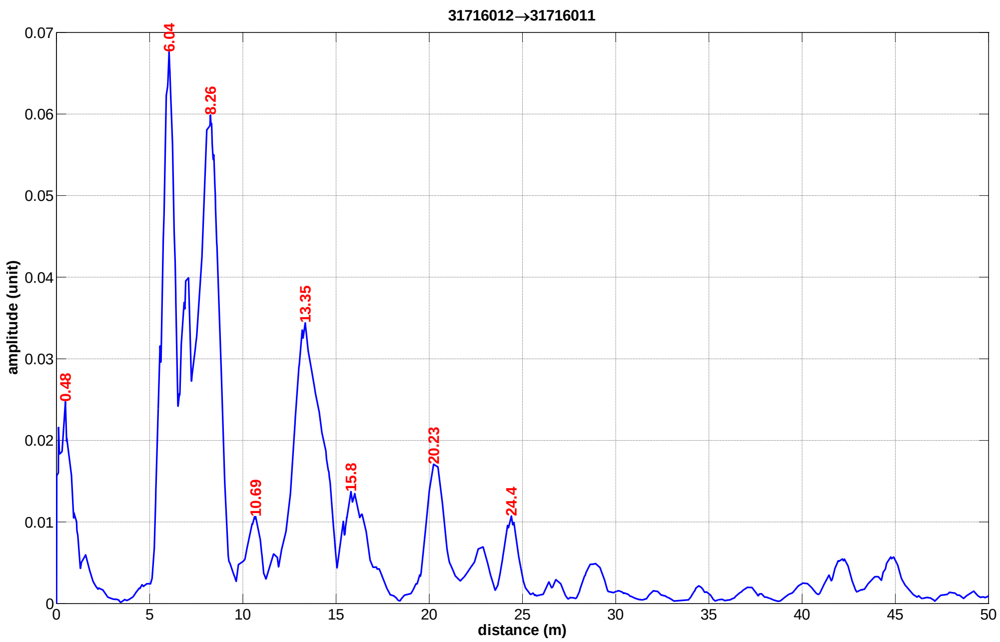
4 : xx at 10.69m

5 : xx at 13.35m

6 : xx at 15.8m

7 : xx at 20.23m

8 : xx at 24.4m



AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 46m. CCTV is recommended.

124.0 Survey 3.50 - 31716012_31716013_150mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:56:08

WATER LEVEL : 2mm

DIAMETER : 150mm

START MH : 31716012

END MH : 31716013

REPORT :

1 : xx at 0.1m

2 : xx at 3.37m

3 : xx at 6.84m

4 : xx at 9.07m

5 : xx at 11.74m

6 : xx at 14.38m

7 : xx at 16.69m

8 : xx at 19.13m

9 : xx at 22.04m

10 : xx at 27.36m

11 : xx at 29.71m

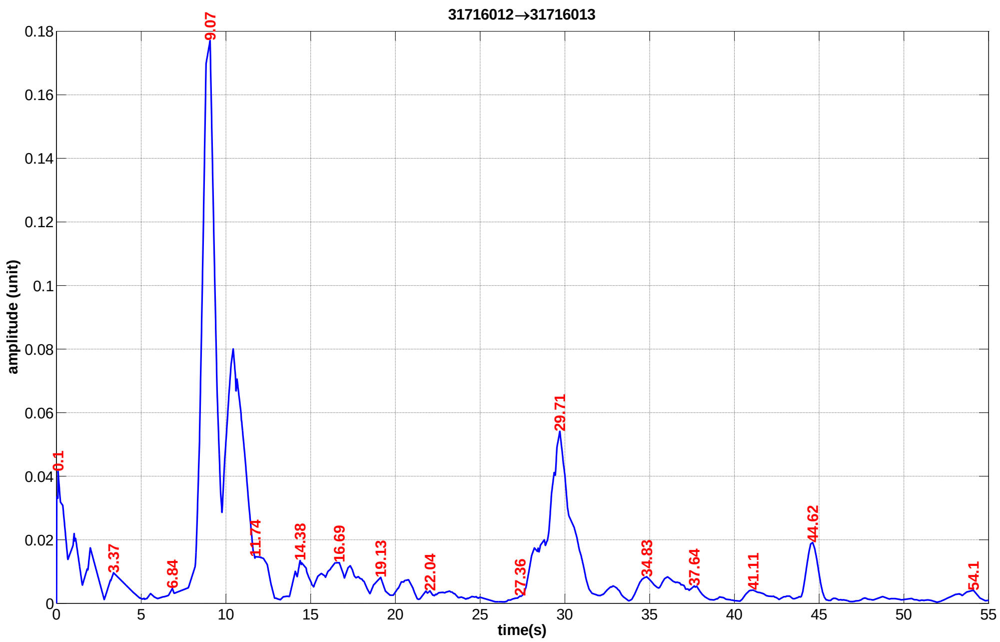
12 : xx at 34.83m

13 : xx at 37.64m

14 : xx at 41.11m

15 : xx at 44.62m

16 : xx at 54.1m



CONDITION REPORT :
3.37 : xx
6.84 : xx
9.07 : lc (good)
11.74 : lc (Good)
14.38 : xx
16.69 : xx
19.13 : xx
22.04 : xx
27.36 : xx
29.71 : xx
34.83 : xx
37.64 : xx
41.11 : xx
44.62 : xx
54.1 : pe (Good)
ENERGY : 91
PE : 0
DE ratio : 13.14
AUTO CONDITION GRADE – Red (Energy is only just in the ‘Red’ zone and the energy loss appears to be caused mainly by low level distributed defects but CCTV is recommended on a precautionary basis)

COMMENT – GIS length = 53.5m. CCTV is recommended.

125.0 Survey 3.51 - 31716015_31716013_200mm-1.mat

SITE : green hills

TEST DATE & TIME : 09-May-2013 10:40:58

WATER LEVEL : 0mm

DIAMETER : 200mm

START MH : 31716015

END MH : 31716013

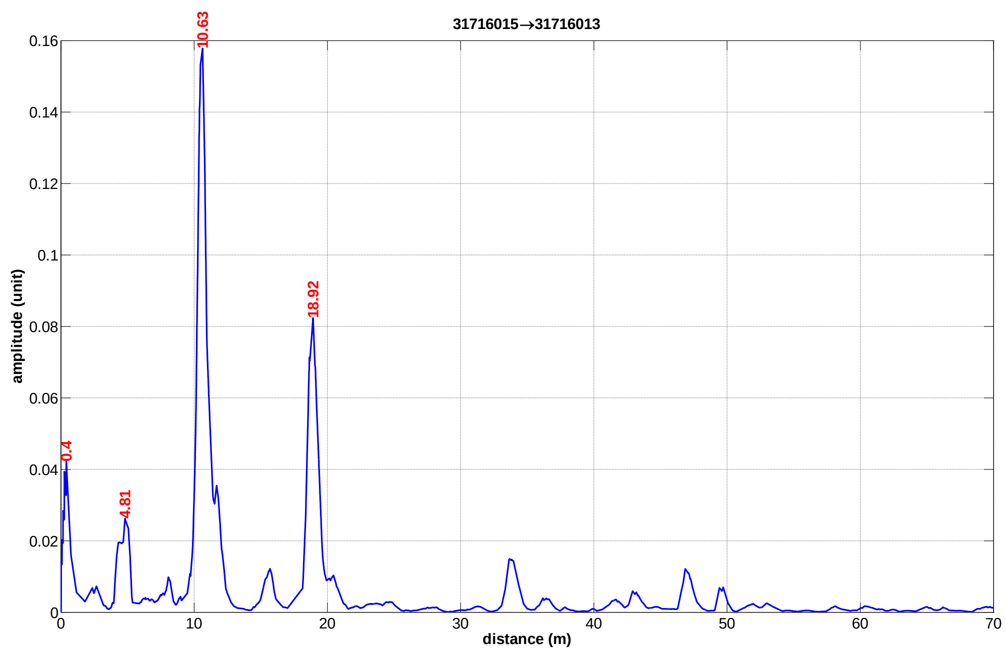
REPORT :

1 : xx at 0.4m

2 : xx at 4.81m

3 : xx at 10.63m

4 : xx at 18.92m

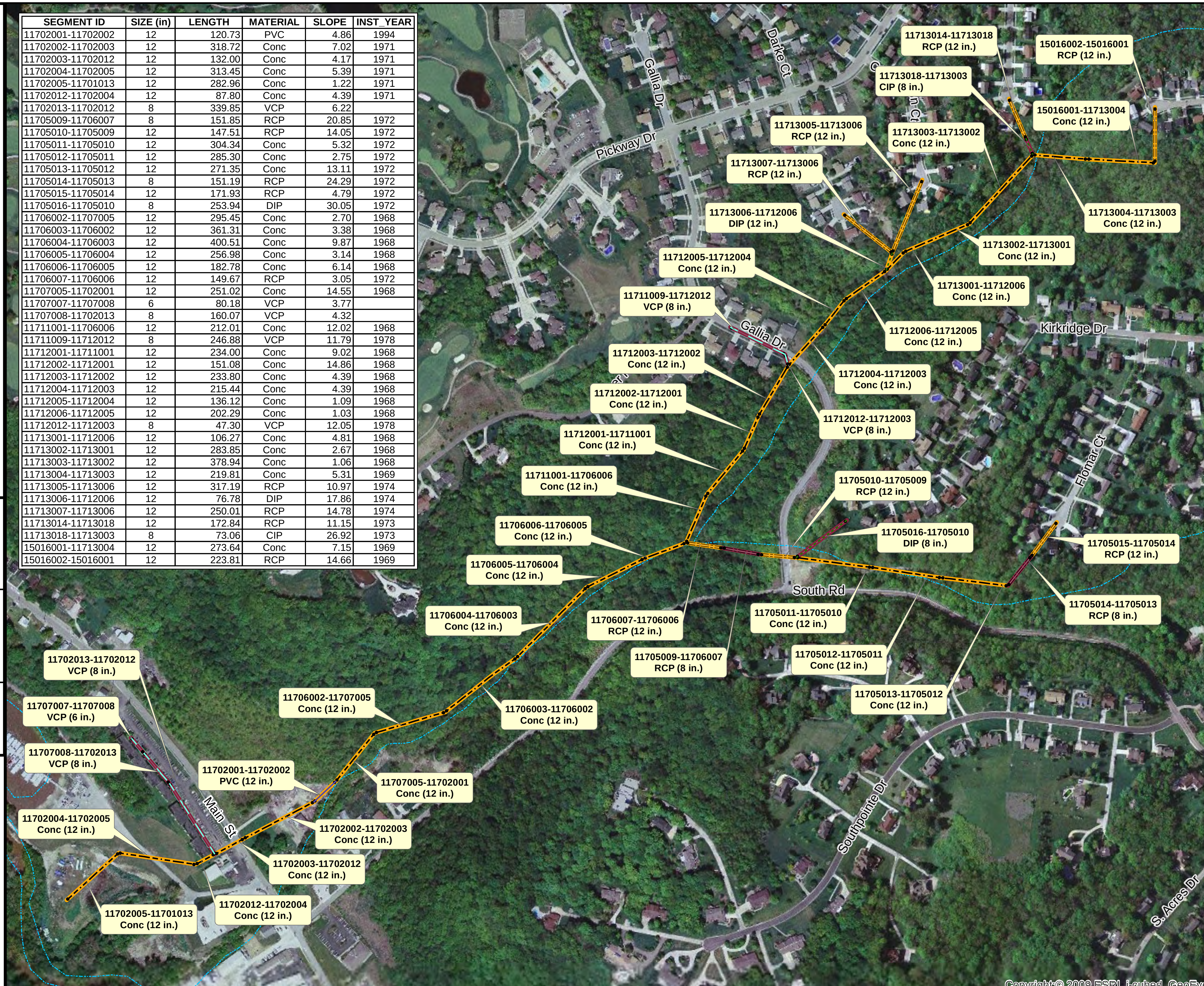


AUTO CONDITION GRADE – Red by manual assessment.

COMMENT – GIS pipe length = 68m. CCTV is recommended.

Appendix B - Study Area Figures

SEGMENT ID	SIZE (in)	LENGTH	MATERIAL	SLOPE	INST_YEAR
11702001-11702002	12	120.73	PVC	4.86	1994
11702002-11702003	12	318.72	Conc	7.02	1971
11702003-11702012	12	132.00	Conc	4.17	1971
11702004-11702005	12	313.45	Conc	5.39	1971
11702005-11701013	12	282.96	Conc	1.22	1971
11702012-11702004	12	87.80	Conc	4.39	1971
11702013-11702012	8	339.85	VCP	6.22	
11705009-11706007	8	151.85	RCP	20.85	1972
11705010-11705009	12	147.51	RCP	14.05	1972
11705011-11705010	12	304.34	Conc	5.32	1972
11705012-11705011	12	285.30	Conc	2.75	1972
11705013-11705012	12	271.35	Conc	13.11	1972
11705014-11705013	8	151.19	RCP	24.29	1972
11705015-11705014	12	171.93	RCP	4.79	1972
11705016-11705010	8	253.94	DIP	30.05	1972
11706002-11707005	12	295.45	Conc	2.70	1968
11706003-11706002	12	361.31	Conc	3.38	1968
11706004-11706003	12	400.51	Conc	9.87	1968
11706005-11706004	12	256.98	Conc	3.14	1968
11706006-11706005	12	182.78	Conc	6.14	1968
11706007-11706006	12	149.67	RCP	3.05	1972
11707005-11702001	12	251.02	Conc	14.55	1968
11707007-11707008	6	80.18	VCP	3.77	
11707008-11702013	8	160.07	VCP	4.32	
11711001-11706006	12	212.01	Conc	12.02	1968
11711009-11712012	8	246.88	VCP	11.79	1978
11712001-11711001	12	234.00	Conc	9.02	1968
11712002-11712001	12	151.08	Conc	14.86	1968
11712003-11712002	12	233.80	Conc	4.39	1968
11712004-11712003	12	215.44	Conc	4.39	1968
11712005-11712004	12	136.12	Conc	1.09	1968
11712006-11712005	12	202.29	Conc	1.03	1968
11712012-11712003	8	47.30	VCP	12.05	1978
11713001-11712006	12	106.27	Conc	4.81	1968
11713002-11713001	12	283.85	Conc	2.67	1968
11713003-11713002	12	378.94	Conc	1.06	1968
11713004-11713003	12	219.81	Conc	5.31	1969
11713005-11713006	12	317.19	RCP	10.97	1974
11713006-11712006	12	76.78	DIP	17.86	1974
11713007-11713006	12	250.01	RCP	14.78	1974
11713014-11713018	12	172.84	RCP	11.15	1973
11713018-11713003	8	73.06	CIP	26.92	1973
15016001-11713004	12	273.64	Conc	7.15	1969
15016002-15016001	12	223.81	RCP	14.66	1969



Legend

Pipe Size (in.)

- 6-8
- 12

Material Type

- CIP; DIP
- Concrete
- PVC
- RCP
- VCP

Segment ID
Material (Pipe Size - in)

N
W E
S

0 200 400

State Plane Feet

OHIO STATE PLANE, SOUTH, NAD83, FEET

Shaw

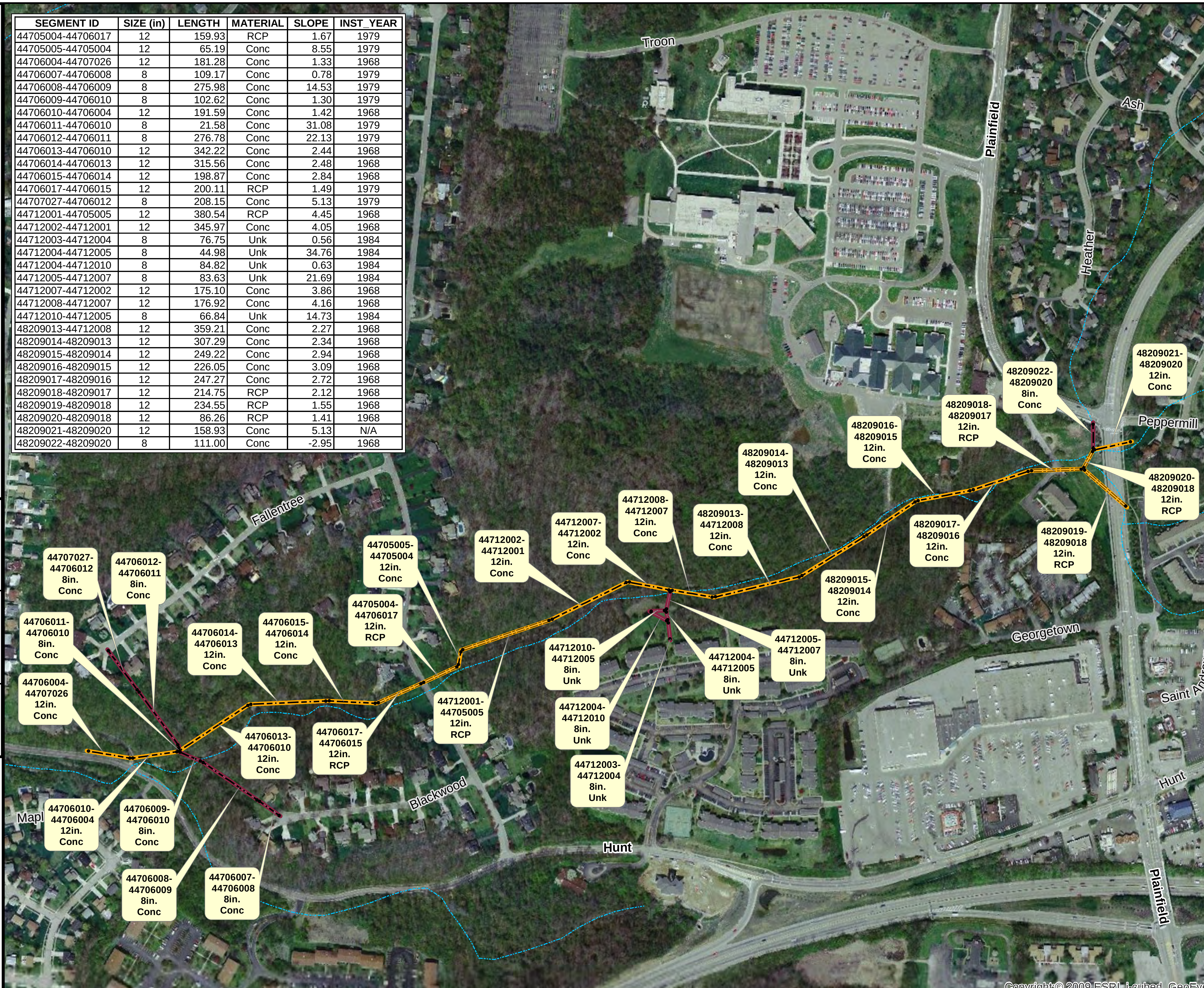
U.S. EPA

FIGURE 1

GALIA DRIVE SEWER PIPE LOCATION

DRAWING NUMBER	147578_GaliaDr_Study_Area.mxd
DRAWN BY	GWT
OFFICE	CINCI
DATE	10/03/12

SEGMENT ID	SIZE (in)	LENGTH	MATERIAL	SLOPE	INST_YEAR
44705004-44706017	12	159.93	RCP	1.67	1979
44705005-44705004	12	65.19	Conc	8.55	1979
44706004-44707026	12	181.28	Conc	1.33	1968
44706007-44706008	8	109.17	Conc	0.78	1979
44706008-44706009	8	275.98	Conc	14.53	1979
44706009-44706010	8	102.62	Conc	1.30	1979
44706010-44706004	12	191.59	Conc	1.42	1968
44706011-44706010	8	21.58	Conc	31.08	1979
44706012-44706011	8	276.78	Conc	22.13	1979
44706013-44706010	12	342.22	Conc	2.44	1968
44706014-44706013	12	315.56	Conc	2.48	1968
44706015-44706014	12	198.87	Conc	2.84	1968
44706017-44706015	12	200.11	RCP	1.49	1979
44707027-44706012	8	208.15	Conc	5.13	1979
44712001-44705005	12	380.54	RCP	4.45	1968
44712002-44712001	12	345.97	Conc	4.05	1968
44712003-44712004	8	76.75	Unk	0.56	1984
44712004-44712005	8	44.98	Unk	34.76	1984
44712004-44712010	8	84.82	Unk	0.63	1984
44712005-44712007	8	83.63	Unk	21.69	1984
44712007-44712002	12	175.10	Conc	3.86	1968
44712008-44712007	12	176.92	Conc	4.16	1968
44712010-44712005	8	66.84	Unk	14.73	1984
48209013-44712008	12	359.21	Conc	2.27	1968
48209014-48209013	12	307.29	Conc	2.34	1968
48209015-48209014	12	249.22	Conc	2.94	1968
48209016-48209015	12	226.05	Conc	3.09	1968
48209017-48209016	12	247.27	Conc	2.72	1968
48209018-48209017	12	214.75	RCP	2.12	1968
48209019-48209018	12	234.55	RCP	1.55	1968
48209020-48209018	12	86.26	RCP	1.41	1968
48209021-48209020	12	158.93	Conc	5.13	N/A
48209022-48209020	8	111.00	Conc	-2.95	1968



Legend

Pipe Size (in.)

- 6-8
- 12

Material Type

- Concrete
- RCP

Segment ID
Pipe Size (in)
Material

N
W E
S

0 200 400

State Plane Feet

OHIO STATE PLANE, SOUTH, NAD83, FEET

Shaw

U.S. EPA

FIGURE 2

HUNT ROAD SEWER PIPE LOCATION

OFFICE: CINCI

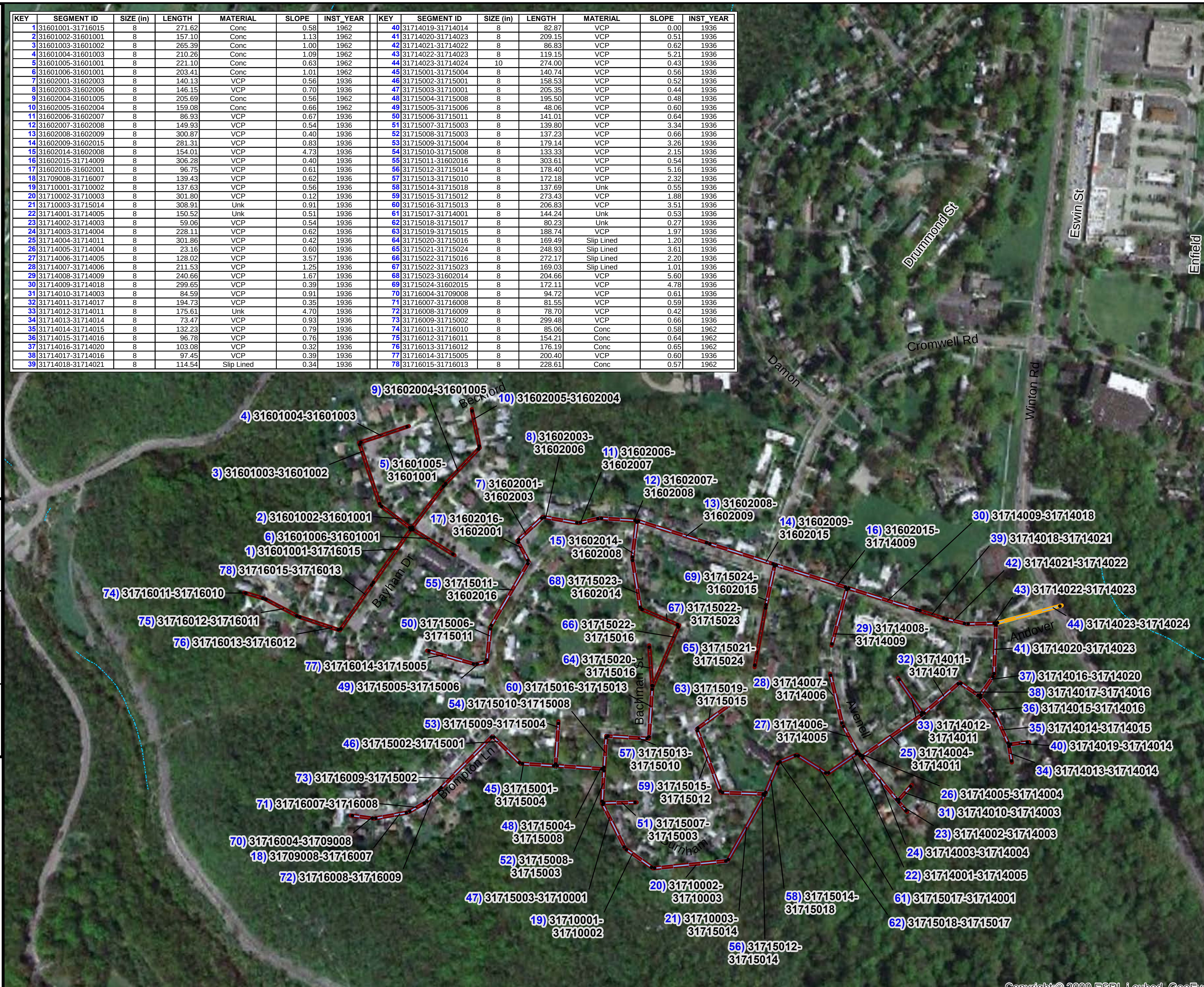
DRAWN BY: GWT

8/29/12

DRAWING NUMBER: *144171_Hunt_Study_Area.mxd*

KEY	SEGMENT ID	SIZE (in)	LENGTH	MATERIAL	SLOPE	INST_YEAR
1	31601001-31716015	8	271.62	Conc	0.58	1962
2	31601002-31601001	8	157.10	Conc	1.13	1962
3	31601003-31601002	8	265.39	Conc	1.00	1962
4	31601004-31601003	8	210.26	Conc	1.09	1962
5	31601005-31601001	8	221.10	Conc	0.63	1962
6	31601006-31601001	8	203.41	Conc	1.01	1962
7	31602001-31602003	8	140.13	VCP	0.56	1936
8	31602003-31602006	8	146.15	VCP	0.70	1936
9	31602004-31601005	8	205.69	Conc	0.56	1962
10	31602005-31602004	8	159.08	Conc	0.66	1962
11	31602006-31602007	8	86.93	VCP	0.67	1936
12	31602007-31602008	8	149.93	VCP	0.54	1936
13	31602008-31602009	8	300.87	VCP	0.40	1936
14	31602009-31602015	8	281.31	VCP	0.83	1936
15	31602014-31602008	8	154.01	VCP	4.73	1936
16	31602015-31714009	8	306.28	VCP	0.40	1936
17	31602016-31602001	8	96.75	VCP	0.61	1936
18	31709008-31716007	8	139.43	VCP	0.62	1936
19	31710001-31710002	8	137.63	VCP	0.56	1936
20	31710002-31710003	8	301.80	VCP	0.12	1936
21	31710003-31715014	8	308.91	Unk	0.91	1936
22	31714001-31714005	8	150.52	Unk	0.51	1936
23	31714002-31714003	8	59.06	VCP	0.54	1936
24	31714003-31714004	8	228.11	VCP	0.62	1936
25	31714004-31714011	8	301.86	VCP	0.42	1936
26	31714005-31714004	8	23.16	VCP	0.60	1936
27	31714006-31714005	8	128.02	VCP	3.57	1936
28	31714007-31714006	8	211.53	VCP	1.25	1936
29	31714008-31714009	8	240.66	VCP	1.67	1936
30	31714009-31714018	8	299.65	VCP	0.39	1936
31	31714010-31714003	8	84.59	VCP	0.91	1936
32	31714011-31714017	8	194.73	VCP	0.35	1936
33	31714012-31714011	8	175.61	Unk	4.70	1936
34	31714013-31714014	8	73.47	VCP	0.93	1936
35	31714014-31714015	8	132.23	VCP	0.79	1936
36	31714015-31714016	8	96.78	VCP	0.76	1936
37	31714016-31714020	8	103.08	VCP	0.32	1936
38	31714017-31714016	8	97.45	VCP	0.39	1936
39	31714018-31714021	8	114.54	Slip Lined	0.34	1936

KEY	SEGMENT ID	SIZE (in)	LENGTH	MATERIAL	SLOPE	INST_YEAR
40	31714019-31714014	8	82.87	VCP	0.00	1936
41	31714020-31714023	8	209.15	VCP	0.51	1936
42	31714021-31714022	8	86.83	VCP	0.62	1936
43	31714022-31714023	8	119.15	VCP	5.21	1936
44	31714023-31714024	10	274.00	VCP	0.43	1936
45	31715001-31715004	8	140.74	VCP	0.56	1936
46	31715002-31715001	8	158.53	VCP	0.52	1936
47	31715003-31710001	8	205.35	VCP	0.44	1936
48	31715004-31715008	8	195.50	VCP	0.48	1936
49	31715005-31715006	8	48.06	VCP	0.60	1936
50	31715006-31715011	8	141.01	VCP	0.64	1936
51	31715007-31715003	8	139.80	VCP	3.34	1936
52	31715008-31715003	8	137.23	VCP	0.66	1936
53	31715009-31715004	8	179.14	VCP	3.26	1936
54	31715010-31715008	8	133.33	VCP	2.15	1936
55	31715011-31602016	8	303.61	VCP	0.54	1936
56	31715012-31715014	8	178.40	VCP	5.16	1936
57	31715013-31715010	8	172.18	VCP	2.32	1936
58	31715014-31715018	8	137.69	Unk	0.55	1936
59	31715015-31715012	8	273.43	VCP	1.88	1936
60	31715016-31715013	8	206.83	VCP	3.51	1936
61	31715017-31714001	8	144.24	Unk	0.53	1936
62	31715018-31715017	8	80.23	Unk	0.27	1936
63	31715019-31715015	8	188.74	VCP	1.97	1936
64	31715020-31715016	8	169.49	Slip Lined	1.20	1936
65	31715021-31715024	8	248.93	Slip Lined	3.61	1936
66	31715022-31715016	8	272.17	Slip Lined	2.20	1936
67	31715022-31715023	8	169.03	Slip Lined	1.01	1936
68	31715023-31602014	8	204.66	VCP	5.60	1936
69	31715024-31602015	8	172.11	VCP	4.78	1936
70	31716004-31709008	8	94.72	VCP	0.61	1936
71	31716007-31716008	8	81.55	VCP	0.59	1936
72	31716008-31716009	8	78.70	VCP	0.42	1936
73	31716009-31715002	8	299.48	VCP	0.66	1936
74	31716011-31716010	8	85.06	Conc	0.58	1962
75	31716012-31716011	8	154.21	Conc	0.64	1962
76	31716013-31716012	8	176.19	Conc	0.65	1962
77	31716014-31715005	8	200.40	VCP	0.60	1936
78	31716015-31716013	8	228.61	Conc	0.57	1962



Legend

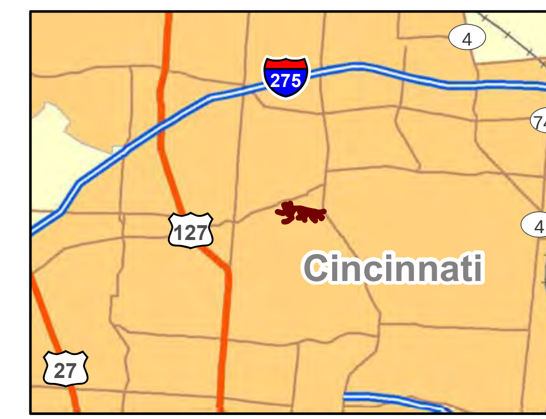
Pipe Size (in.)

- 8
- 10

1) Segment ID

Material Type

- Concrete
- DIP
- RCP
- Slip Lined
- Unknown
- VCP



N
W E
S

0 200 400

State Plane Feet

OHIO STATE PLANE, SOUTH, NAD83, FEET

Shaw

U.S. EPA

FIGURE 3

GREENHILLS SEWER PIPE LOCATION

DRAWING NUMBER: *147578_Greenhills_Study_Area.mxd*

DRAWN BY: GWT 10/08/12

OFFICE: CINCI

Appendix C - SewerBatt Signal Penetration and Excitation Signal Trials

CONDITION ASSESSMENT OF WASTEWATER COLLECTION SYSTEMS

US Environmental Protection Agency

Contract No EP-C-11_006

SewerBatt

Signal penetration and excitation signal trials

Test dates: May 9th and August 9th 2013

Report ref AST001-RT001-01

SewerBatt
acoustic sensing technology

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Issue and approvals log

Report ref	Issue date	Author	Checked	Approved
AST001-RT001-01	03/09/2013	M Tareq Bin Ali R Long	R Long	R Long

Table of Contents

1. Introduction

The United States Environmental Protection Agency (US EPA) is sponsoring a series of investigations into emerging technologies for the assessment of the condition of wastewater collection systems. One of the these technologies is SewerBatt, a system manufactured by Acoustic Sensing Technology (UK) Ltd. SewerBatt uses acoustic technology to determine the condition of sewers and drain pipes.

SewerBatt uses acoustic technology to detect conditions inside sewers and drainage pipes. An acoustic sensor head comprising a sound source and an array of microphones is positioned in one end of the pipe to be tested. An excitation signal is then propagated along the pipe and the response is recorded and then processed. Features (such as lateral connections and the pipe end) and defects (such as broken pipes and sedimentation) affect the sound either by reflecting a part of it back to the SewerBatt sensor, or by absorbing the sound energy. By comparing the responses recorded with a library of known responses the system will seek to identify specific responses. An automated condition assessment system is provided that reviews the acoustic response, makes allowance for the energy loss from the pipe end and lateral connections, and then grades the pipes in a traffic light RAG form.

The Metropolitan Sewer District (MSD)of Greater Cincinnati was supplied with the SewerBatt equipment in April 2013 and has since then been undertaking a series of sewer surveys using the equipment. The project has been supervised for the US EPA by CB&I Federal Services.

The equipment supplied to MSD in April 2013 was prototype equipment, the first batch of production equipment being in manufacture at that time. The initial test results recorded in May 2013 showed that while in most pipes the equipment provided a strong recorded signal, in some longer pipes with many lateral connections the strength of the acoustic signal decayed to an extent that beyond approximately 50m little detail was visible in the recorded results. It was therefore proposed that Acoustic Sensing would return to Cincinnati in August 2013, bringing with them a production unit and some alternative excitation signals to try in several of the pipes where signal decay had previously been noted, to evaluate to what extent the signal penetration could be improved.

Two series of comparative tests were carried out. The first series compared the results from the prototype equipment with those from the production equipment. The results are presented in Section 2 of this report.

The second series of tests compared the results from two different excitation signals (chirp and Gaussian pulse) and different locations of the sensor head within the pipe end cross section (centre, left, right, top and bottom). The results are presented in Section 3 of this report.

Section 4 of the report provides a summary of the conclusions drawn from the work. Finally Section 5 gives information about the measurement units used in compiling the report.

2. Comparison of prototype (May 2013) and production equipment (August 2013)

This section of the report summarises the results of a comparison between SewerBatt tests undertaken in May 2013 and those of August 2013. A total of 10 pipes were resurveyed.

Three of the ten subsequent tests (Nos 3, 7 and 10) were carried out in the reverse direction to the original test. These results are not comparable and cannot be used for the present purpose.

Three of the ten subsequent tests (Nos 4, 5 and 8) appear to have been mis-referenced, though there is clear evidence that the pipes were in fact tested in the correct direction and the results have been included in the comparison.

Five of the ten subsequent tests (Nos 1, 2, 5, 8 and 9) using the small production sensor and chirp excitation show either no improvement or a slight deterioration in signal penetration.

Two of the ten subsequent tests (Nos 4 and 6) using the small production sensor and chirp excitation show an improvement in signal penetration, in the case of test 6 by approximately +200% at the target manhole, although amplitudes at this location remain low.

The most significant gain was obtained by using the large sensor head with a Gauss pulse excitation signal.

The small production sensor with the chirp excitation signal performs in a generally comparable way to the prototype unit. Since it uses essentially the same system, there was to be expected.

The most significant increase in signal penetration appears to come from the use of a Gauss pulse excitation signal coupled with the increased power at lower frequencies offered by the large sensor head.

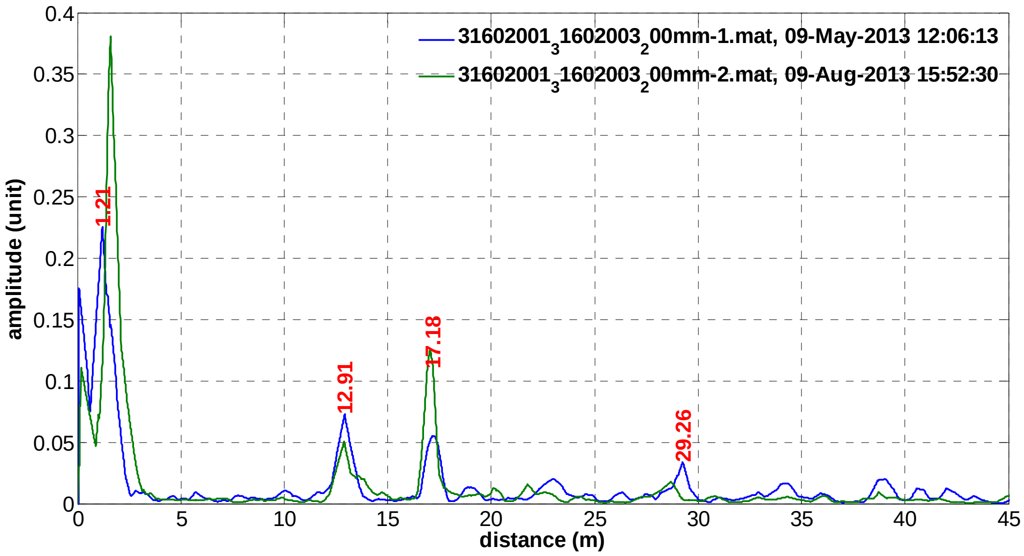
Further investigation of the causes and possible minimisation of the strong incident pulse recorded at some locations will also be carried out. In the case of the present series of tests it will be of use in due course to have the CCTV longhand reports and video, to see if there are any features such as connections and backdrops close to the sensing head.

Comparison 1 – 31602001 – 31602003 Dia =200mm Length = 42m

Tests

1. Original test on May 9th 2013 (31602001_31602003_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602001_31602003_200mm-2.mat)

Figure 1



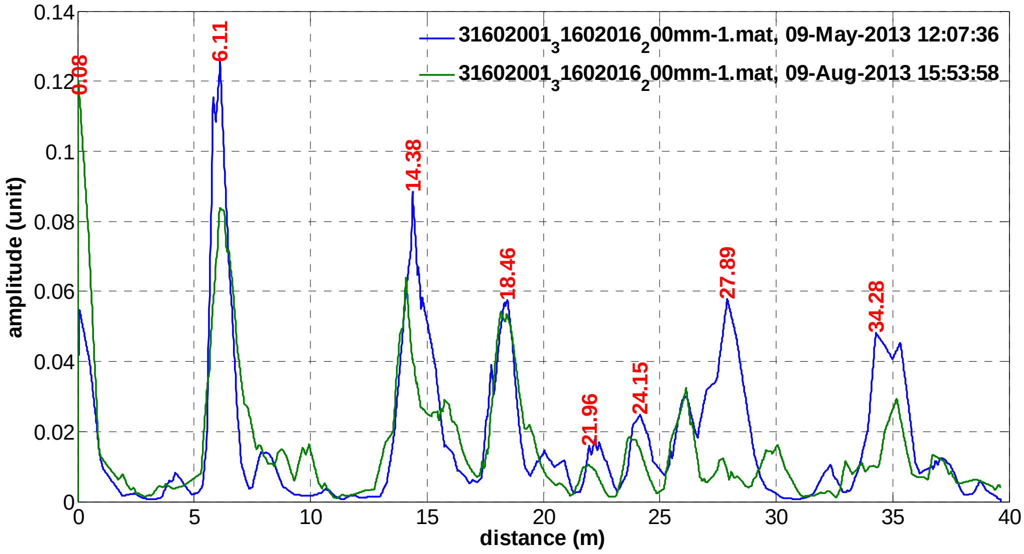
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. It displays a large response at 1.57m. This may be due to a connection close to the location of the sensor head. This appears to have given a strong response, reducing the energy available for onward transmission; hence most subsequent peaks are reduced in amplitude compared to the original test. In this case there is however sufficient energy recorded throughout the length of the pipe for a satisfactory assessment of condition to be made.

Comparison 2 – 31602001 – 31602016 Dia =200mm Length = 29m

Tests

1. Original test on May 9th 2013 (31602001_31602016_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602001_31602016_200mm-1.mat)

Figure 2



The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. It displays a large incident pulse at 0.03m, indicative of poor testing conditions. This has reduced the energy available for onward transmission, hence subsequent peaks are reduced in amplitude compared to the original test. In this case there is however sufficient energy recorded throughout the length of the pipe for a satisfactory assessment of condition to be made.

Comparison 3 – 31602006 – 31602007 Dia =200mm Length = 29m

Tests

1. Original test on May 9th 2013 (31602006_31602007_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602006_31602007_200mm-2.mat)

Figure 3 - Original test on May 9th 2013 (31602006_31602007_200mm-1)

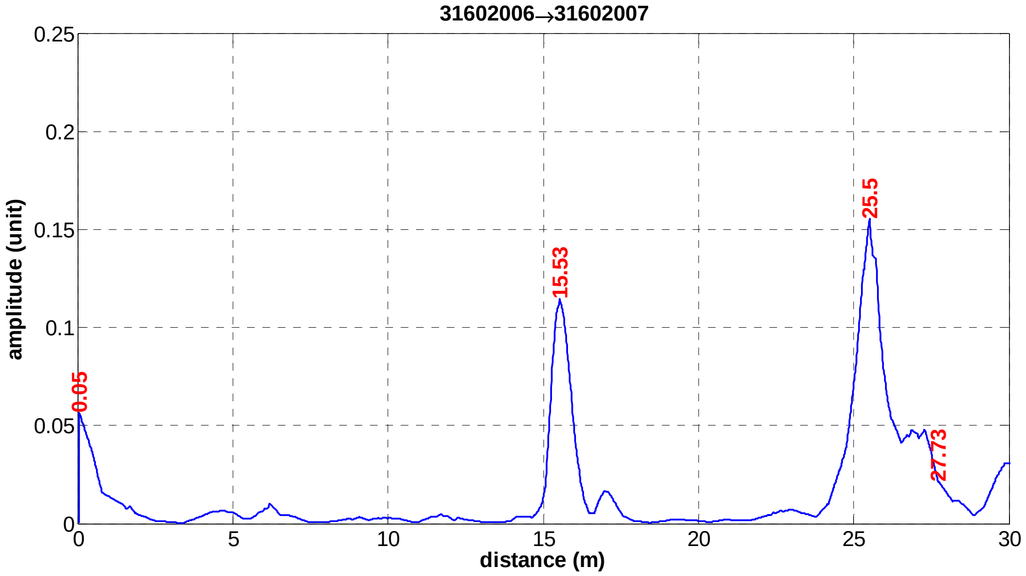
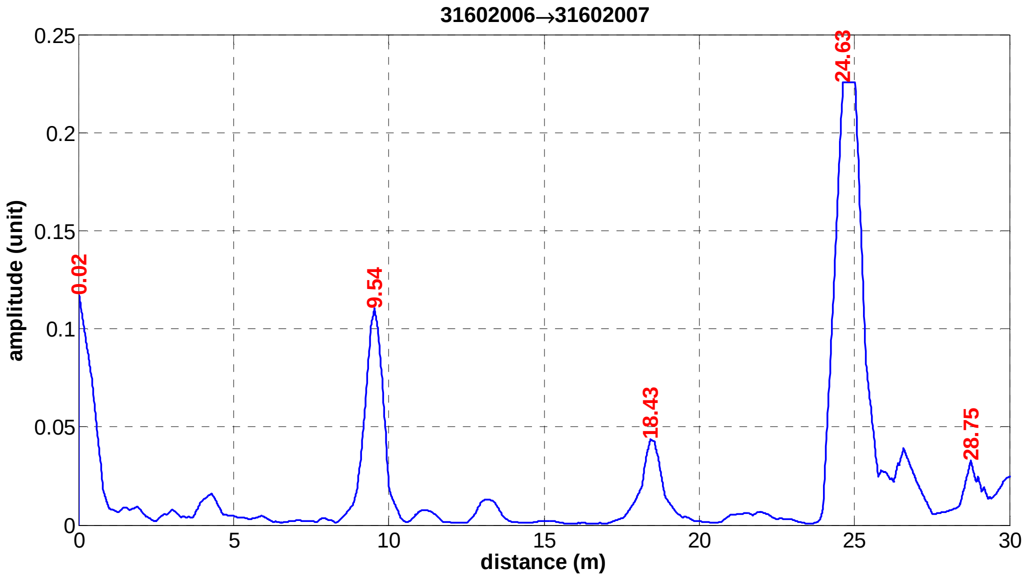


Figure 4 - Subsequent test on August 9th 2013 (31602006_31602007_200mm-2)



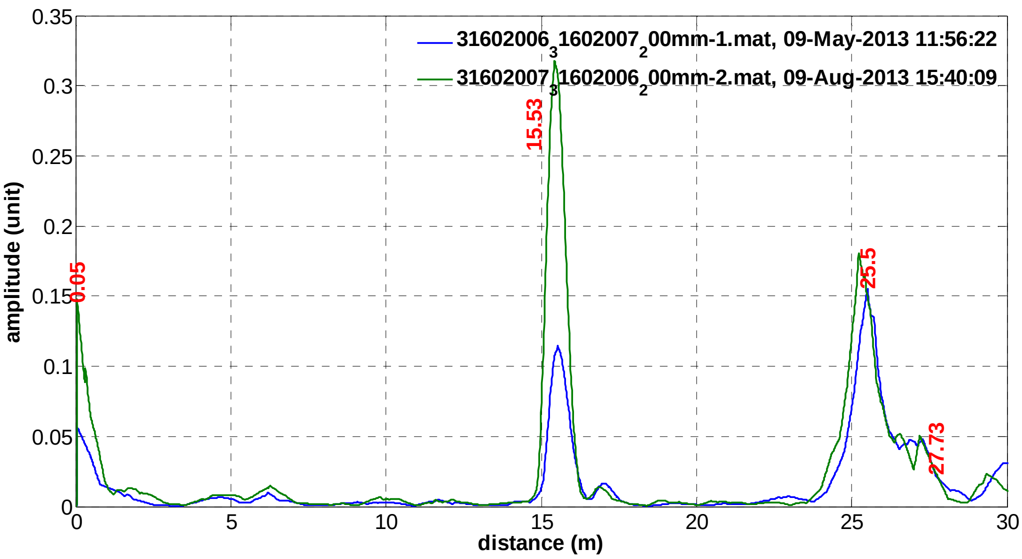
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. Although the file names indicate that the tests were carried out in the same direction, the results clearly show that the tests were done in opposite directions and are therefore not suitable for direct comparison (ref Comparison 4).This can be seen by noting that in the original test there was a strong response at 15.53m (9.97m from the target manhole) which correlates strongly with the strong response at 9.54m in the subsequent test, clearly demonstrating that the readings have been taken in opposite directions and therefore cannot be compared.

Comparison 4 – 31602007 – 31602006 Dia =200mm Length =29m

Tests

1. Original test on May 9th 2013 (31602006_31602007_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602007_31602006_200mm-2.mat)

Figure 5



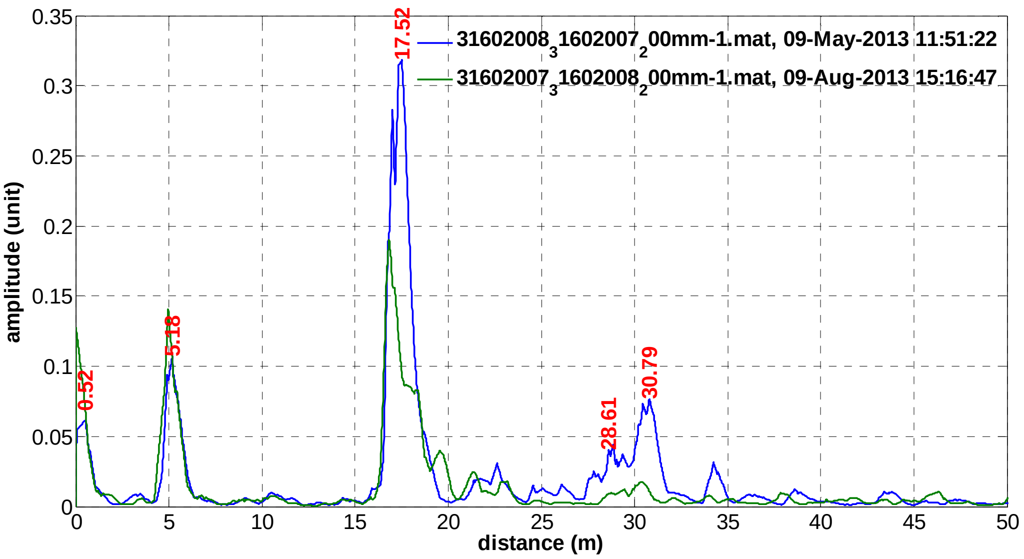
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. Although the file references indicate the contrary, it is clear that these two tests were conducted in the same direction (ref Comparison 3). The strengths of the responses at 15.07m and from the pipe end at 24.64m are both greater than the original results, indicating that improved signal penetration has been achieved.

Comparison 5 – 31602007 – 31602008 Dia =200mm Length = 45m

Tests

1. Original test on May 9th 2013 (31602008-31602007_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602007-31602008_200mm-1.mat)

Figure 6



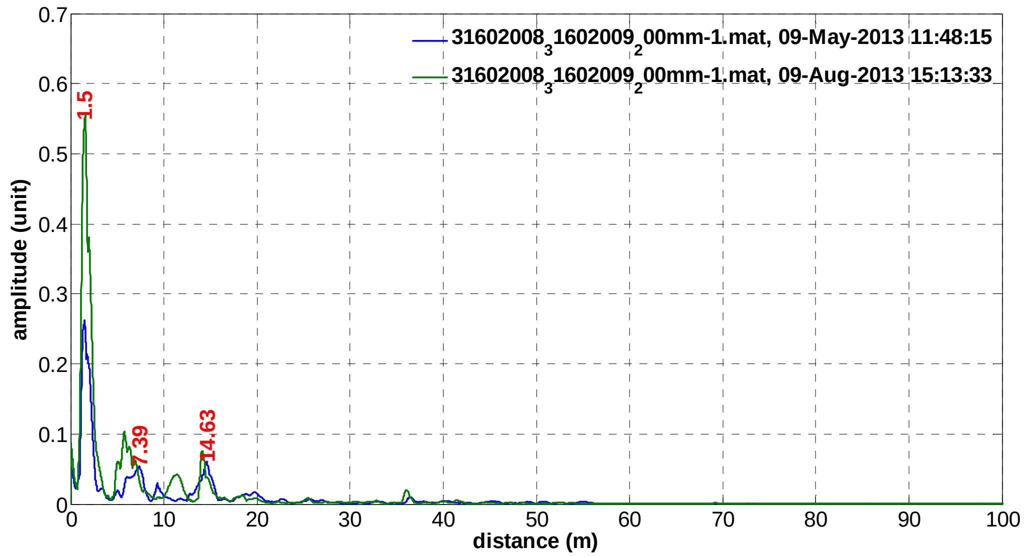
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. Filenames show references reversed but inspection of the test results, with a close match in the distances of the observed peaks, shows that the tests were in fact carried out in the same direction. The larger incident pulse at 0.02m in the subsequent test indicates poor testing conditions and has absorbed acoustic energy, thus reducing the amplitude of the response from the rest of the pipe.

Comparison 6 – 31602008 – 31602009 Dia =200mm Length = 91.5m

Tests

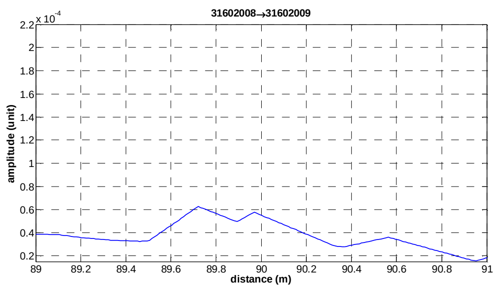
1. Original test on May 9th 2013 (31602008_31602009_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602008_31602009_200mm-1.mat)

Figure 7



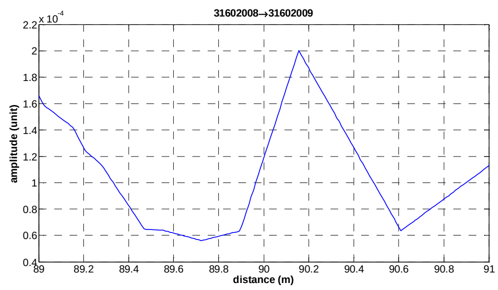
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. It displays a large response at 1.54m. This may be due to a connection close to the location of the sensor head. This appears to have given a strong response, although energy available for onward transmission is still greater than the original test. The following figures compare the response from the target manhole 31602009.

Figure 8



Response from target manhole 31602009 from the original test on May 9th 2013 (31602008_31602009_200mm-1)

Figure 9



Response from target manhole 31602009 from the subsequent test on August 9th 2013 (31602008_31602009_200mm-1), showing improved definition of the response despite the low amplitude of the signal.

Comparison 7 – 31602009 – 31602015 Dia =200mm Length = 79.5m

Tests

1. Original test on May 9th 2013 (31602015_31602009_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602009_31602015_200mm-2.mat)

Figure 10 - Original test on May 9th 2013 (31602015_31602009_200mm-1)

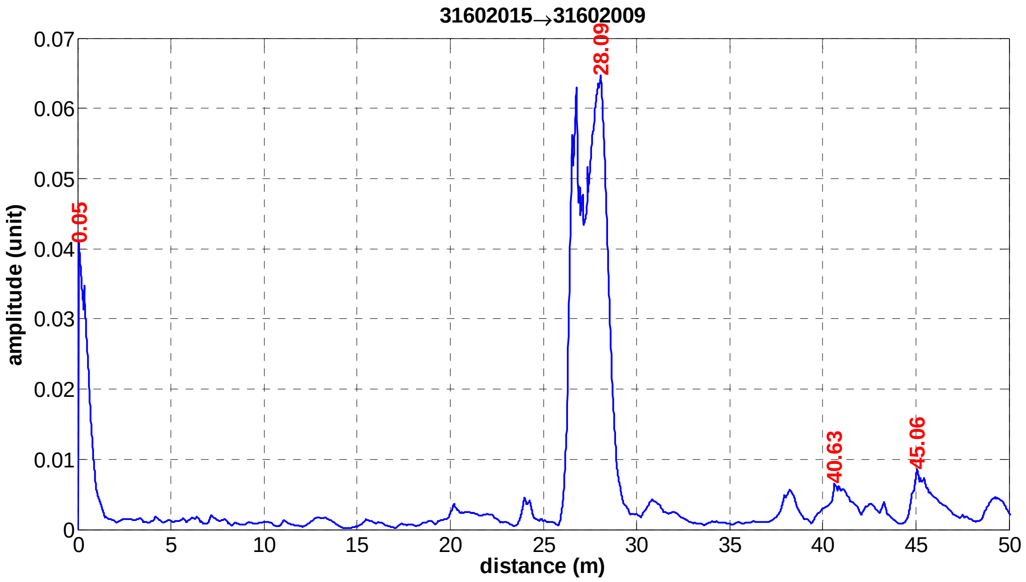
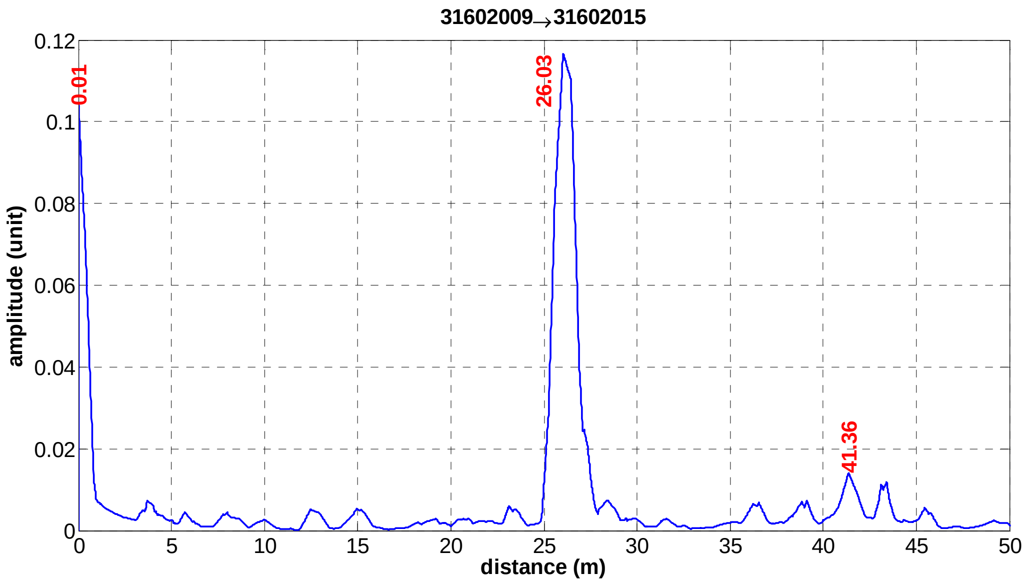


Figure 11 - Subsequent test on August 9th 2013 (31602009_31602015_200mm-2)



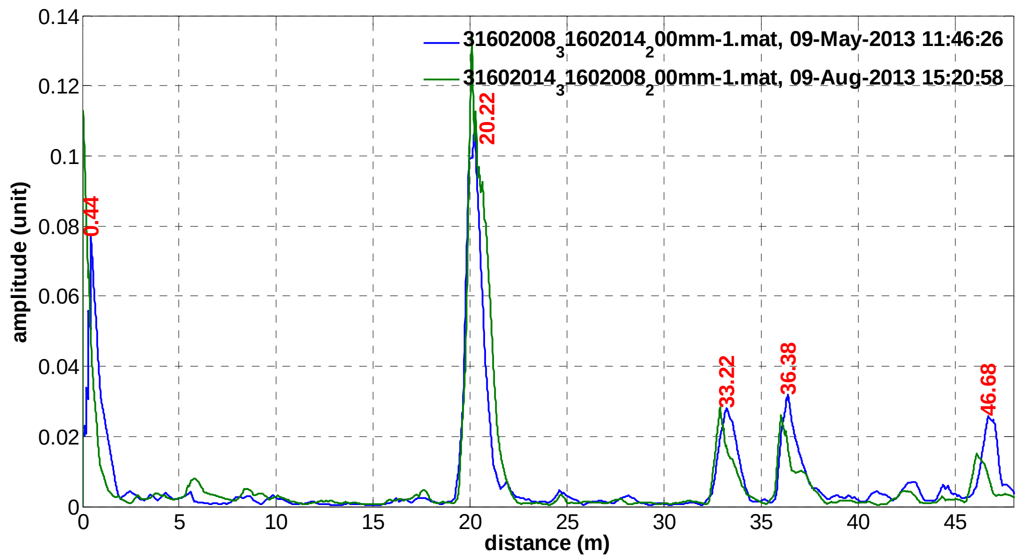
Filenames show references reversed and the test results appear to confirm that the tests were in fact carried out in the opposite direction since the difference in distance to the large response at 28.09m/26.03m is too large to admit otherwise and the shapes are quite different also. Consequently the results are not suitable for comparison.

Comparison 8 – 31602008 – 31602014 Dia =200mm Length = 47m

Tests

1. Original test on May 9th 2013 (31602008_31602014_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602014_31602008_200mm-1.mat)

Figure 12



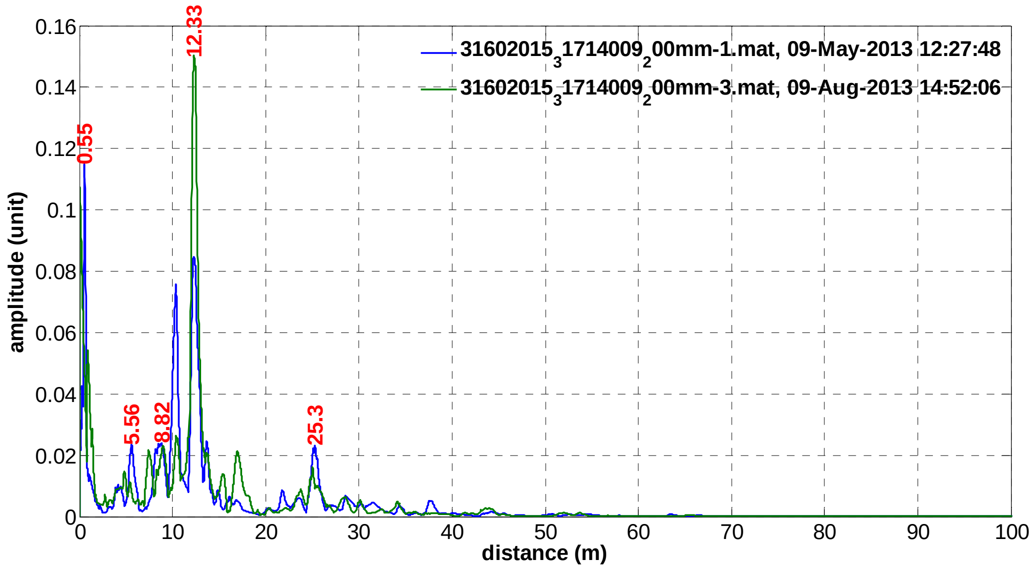
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. Filenames show references reversed but test results appear to show the tests were in fact carried out in the same direction. This is evidenced by the close correlation of the various peaks and the distances between them, which are within 4%. The larger incident pulse at 0.04m in the subsequent test indicates poor testing conditions and has absorbed acoustic energy, thus reducing the amplitude of the response from most of the rest of the pipe.

Comparison 9 – 31602015 – 31714009 Dia =200mm Length = 92m

Tests

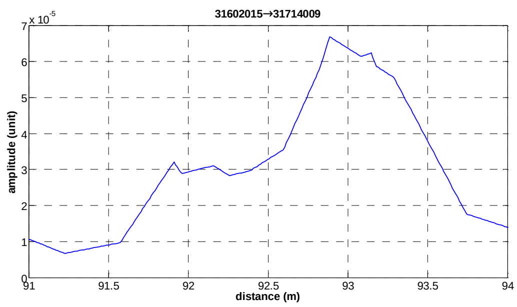
1. Original test on May 9th 2013 (31602015_31714009_200mm-1.mat)
2. Subsequent test on August 9th 2013 (31602015_31714009_200mm-3.mat)

Figure 13



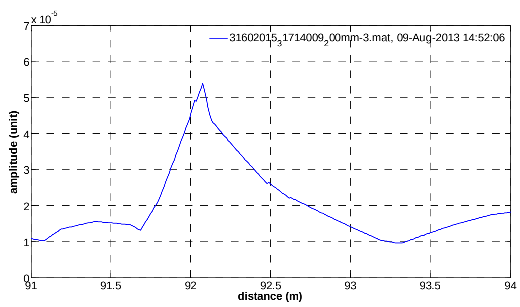
The subsequent test was performed using the production unit and small sensor head and a chirp excitation signal. There are some differences in the two results, and while the response at 12.33m in the subsequent test is larger than the original, the responses from the target manhole 31714009 as shown in the following figures show the subsequent test having a slightly reduced amplitude.

Figure 14



Response from target manhole 31714009 from original test on May 9th 2013 (31602015_31714009_200mm-1)

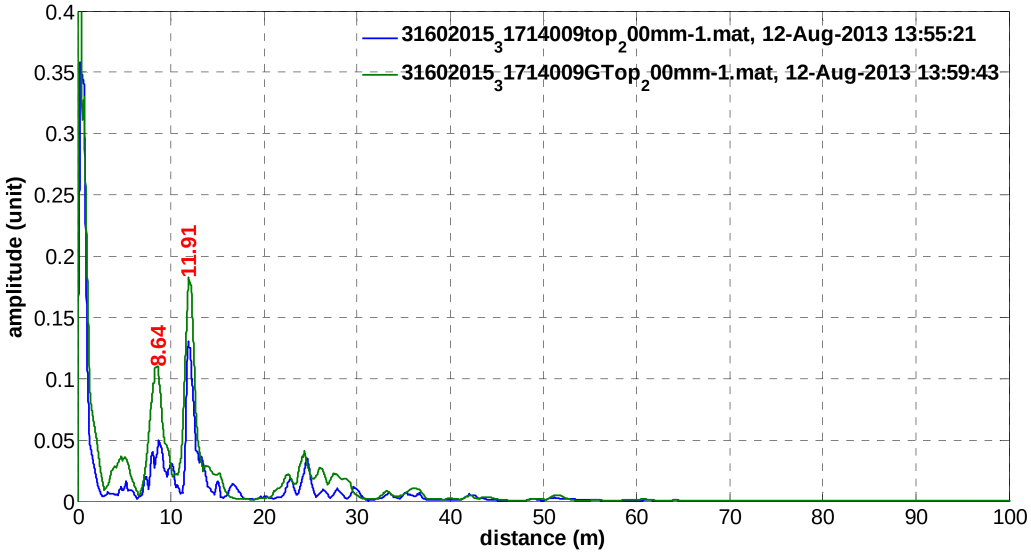
Figure 15



Response from target manhole 31714009 from subsequent test on August 9th 2013 (31602015_31714009_200mm-3

Tests

1. Subsequent test on August 12th 2013 using large sensor and chirp excitation (31602015_31714009top_200mm-1.mat)
2. Subsequent test on August 12th 2013 using large sensor and gauss excitation (31602015_31714009GTop_200mm-1.mat)



For these tests a large prototype sensor head with chirp and gauss excitation signal were used. The response is found to be higher in the case of gauss excitation.

Comparison 10 – 31715024 – 31602015 Dia =200mm Length = 52.5m

Tests

1. Original test on May 9th 2013 (31715024_31602015_200mm-1.mat)
2. Subsequent test on Aug 9th 2013 (31715024_31602015_200mm-1.mat)

Figure 16 - Original test on May 9th 2013

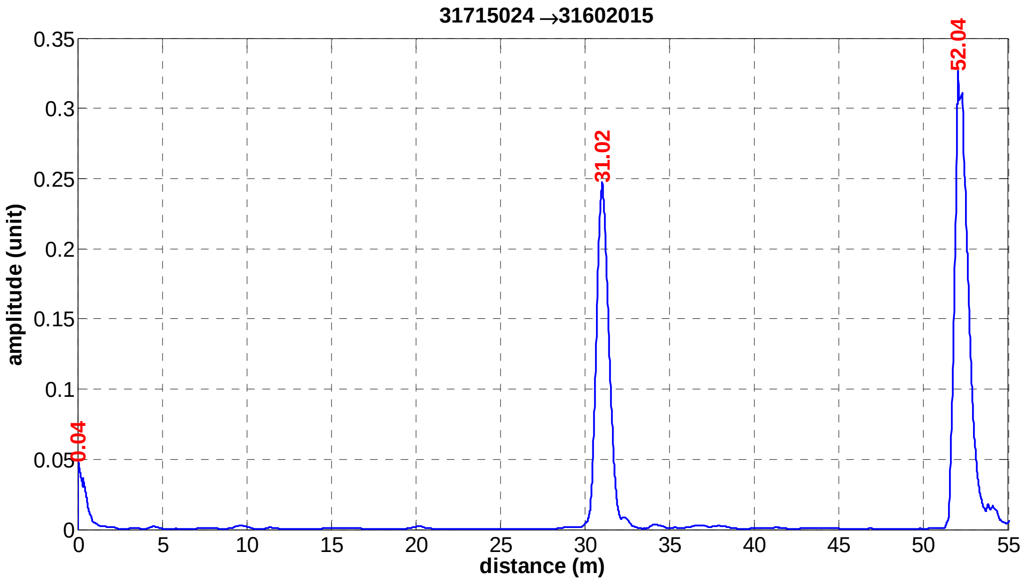
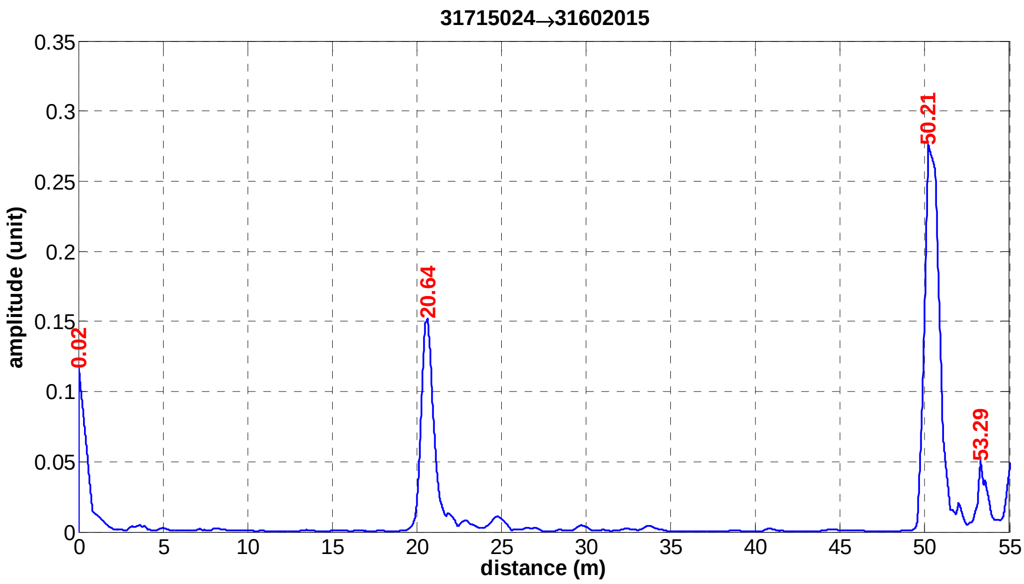


Figure 17 - Subsequent test on August 9th 2013



It appears that pipe has been tested from the opposite direction. This may be inferred by the different location of the response at 31.02m in the original test and 20.64m in the subsequent test, which are almost identical locations if the tests were reversed as surmised. Since the tests have not been taken in the same direction the results are not comparable.

3. Effect of sensor positioning and excitation signal

Several pipe lengths were revisited during the August 2013 visit and tested with two different excitation signals. These were firstly a sinusoidal chirp and secondly a Gaussian pulse. The chirp is a signal that lasts 10 seconds and modulates from low frequency to high frequency over this period. The Gaussian pulse is a short burst of sound, sounding similar to a handclap.

For each excitation signal five different sensor locations were tested. In each case the sensor head was inserted at the pipe end, but the location of the sensor head was moved from the pipe centre to the end of left end of the horizontal diameter, then the right end, then to the pipe soffit and finally to the pipe invert.

The results from two of the tests are presented in this section of the report. In both cases the acoustic envelopes for all the tests for the full pipe length are plotted. The next plot compares the maximum signal amplitude for a particular location where a response was observed in all the tests. Finally the chirp and gauss pulse responses are plotted on separate axes but to the same horizontal and vertical scales so that comparisons can be more easily made.

The testing carried out is insufficient for firm conclusions to be drawn, but from the results of the two tests analysed it does appear that the gauss pulse excitation signal responses are less influenced by sensor position and give incrementally stronger responses.

Pipe section: 31602015 to 31714009

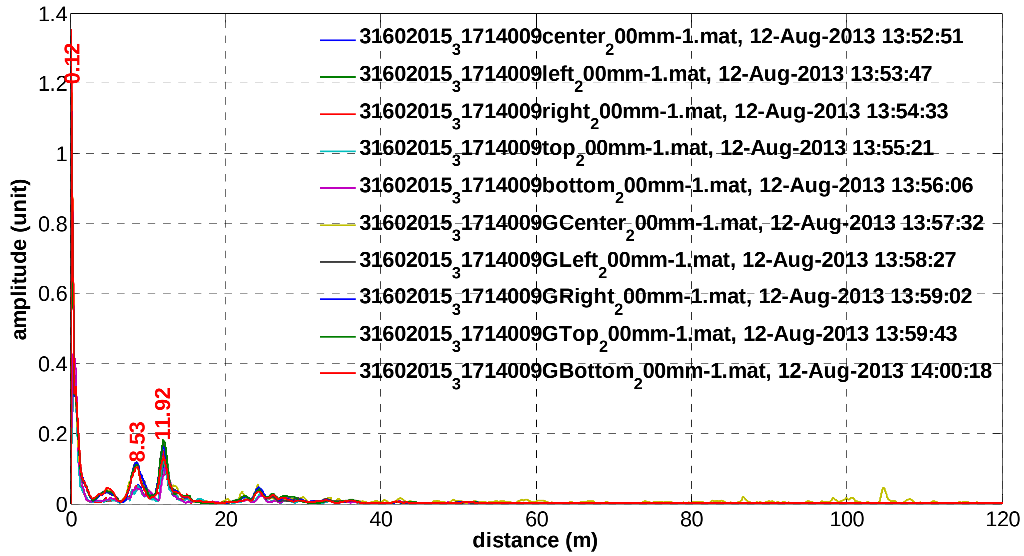


Figure 18 Acoustic responses from pipe section 31602015_31714009 for different sensor position using chirp (first five) and gauss (last five) excitation signal.

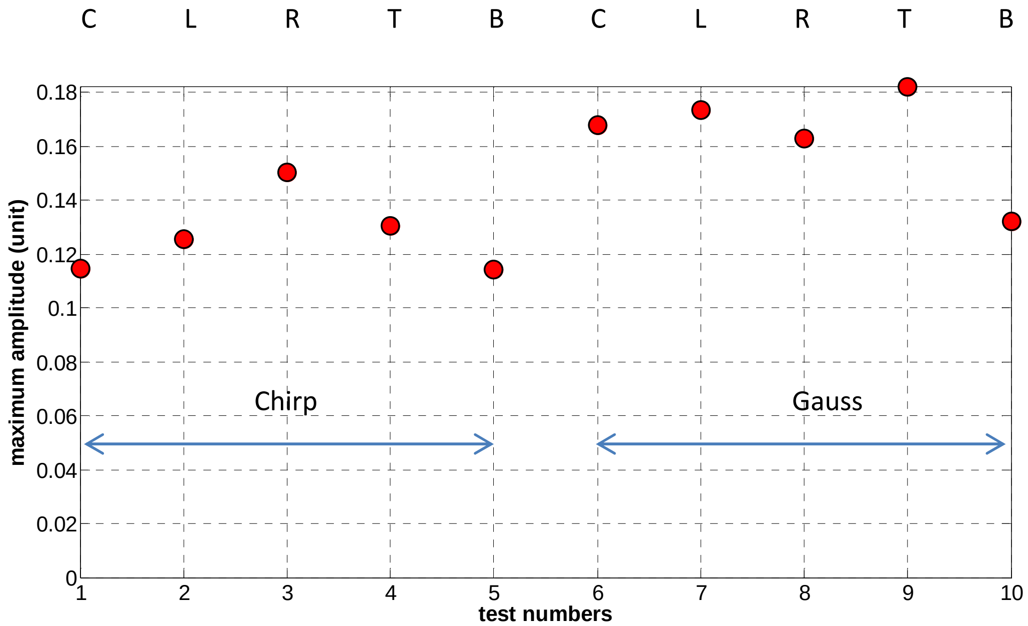


Figure 19 - 31602015_31714009 maximum amplitudes at 11.92m

It can be seen that the responses from the Gauss pulse excitation are slightly higher and generally more consistent than those from the chirp.

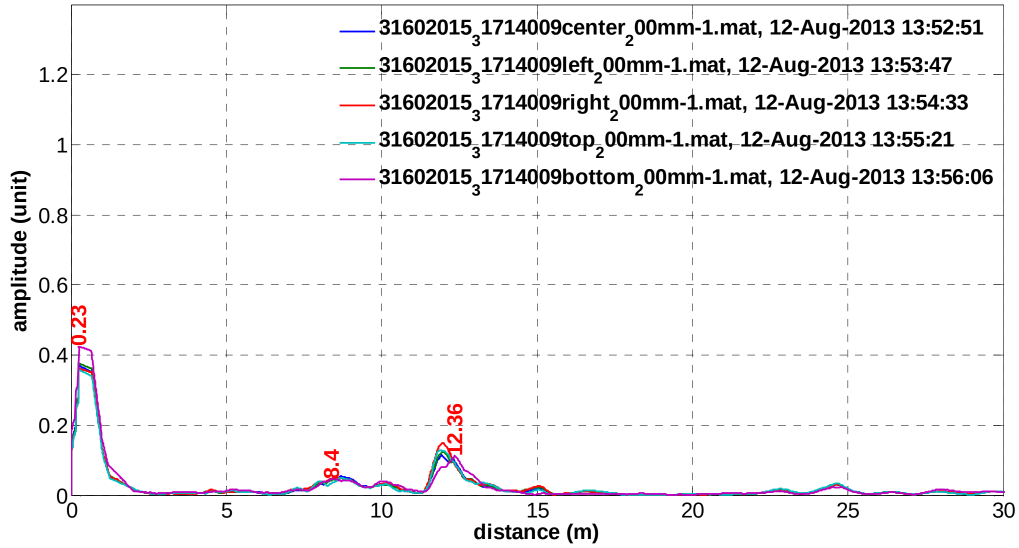


Figure 20 - 31602015_31714009 Chirp excitation, different sensor positions

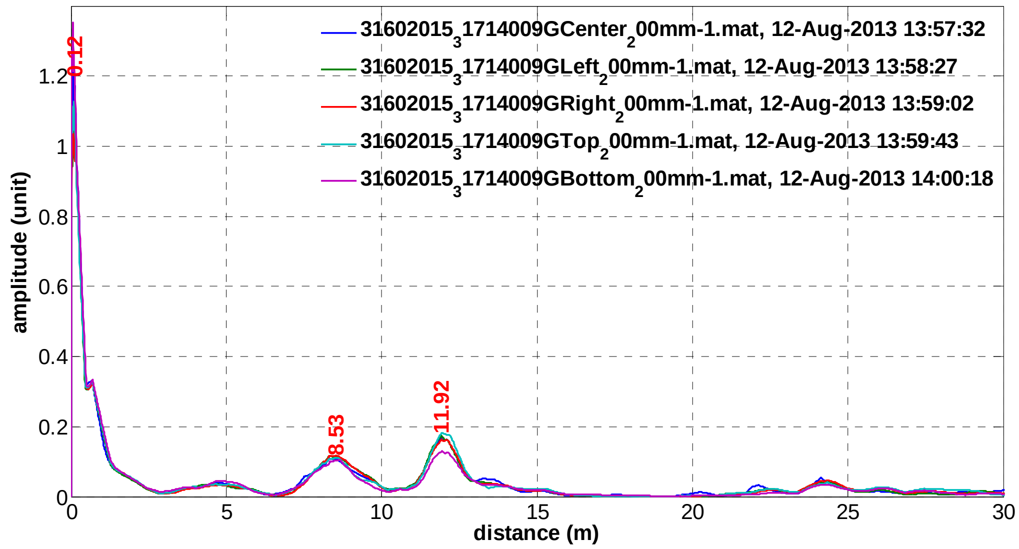


Figure 21 - 31602015_31714009 Gauss pulse excitation signal, different sensor positions

It can be seen that the incident pulse (close to the origin) has greater amplitude when the Gauss pulse is used but the amplitude of the responses at around 8.5m and 12m are stronger for the Gauss pulse too.

Pipe section 31715024 to 31602015

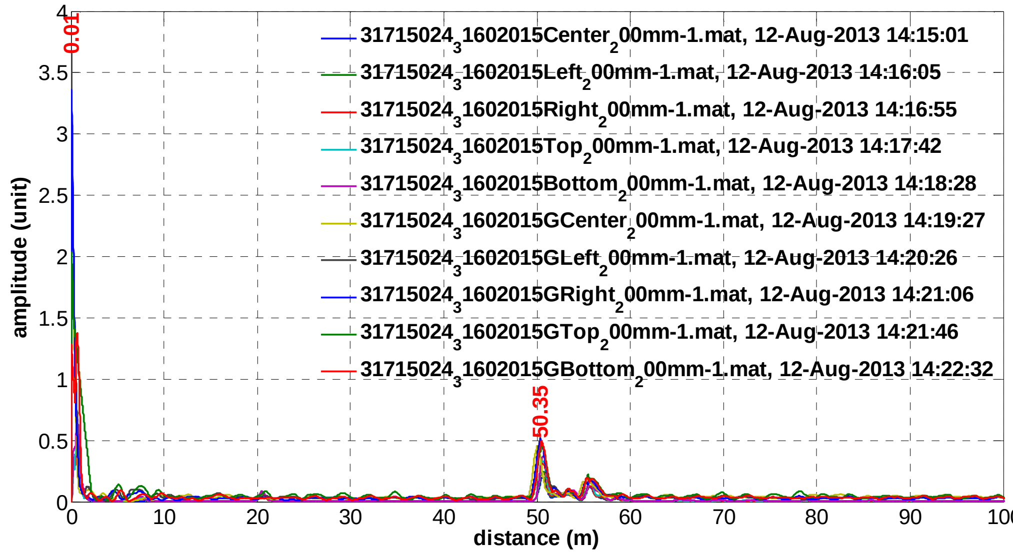


Figure 22 Figure 18 Acoustic responses from pipe section 31715024_31602015 for different sensor position using chirp (first five) and gauss (last five) excitation signal.

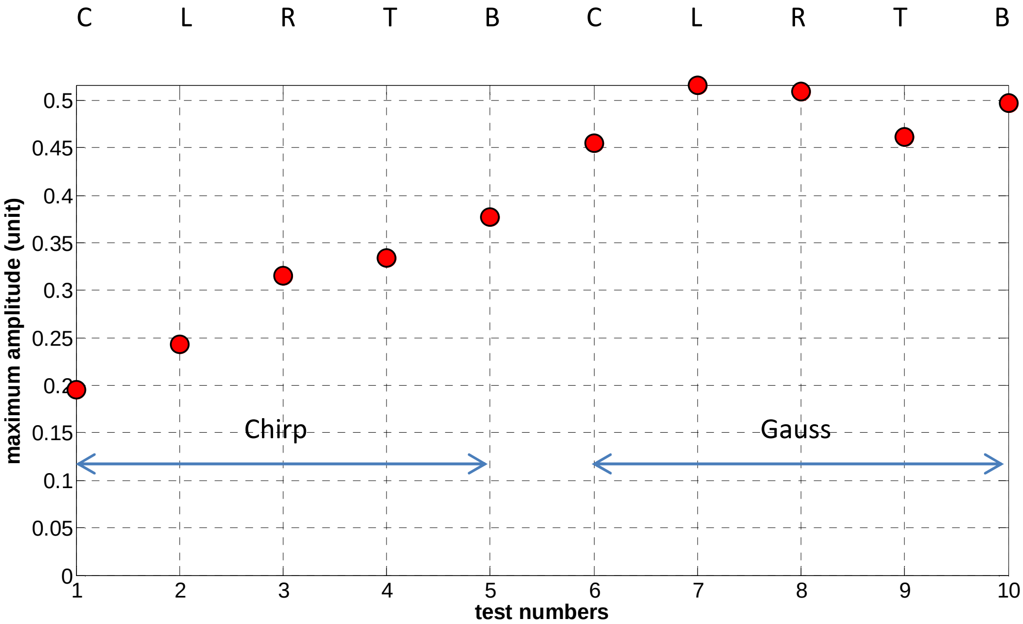


Figure 23 - 31715024_31602015 maximum amplitudes at 50.35m

It can be seen that the responses from the Gauss pulse excitation are higher and more consistent than those from the chirp.

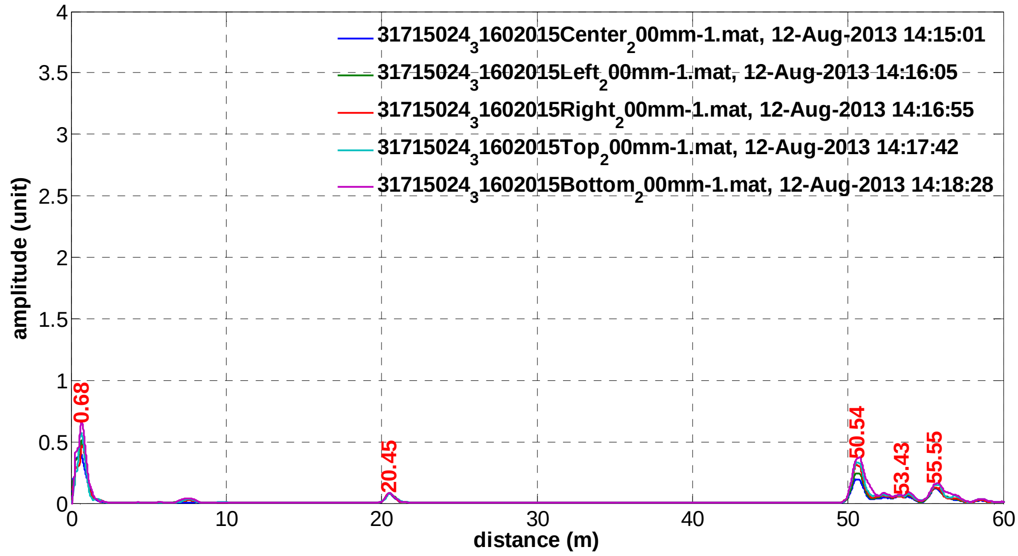


Figure 24 - 31715024_31602015 Chirp excitation, different sensor positions

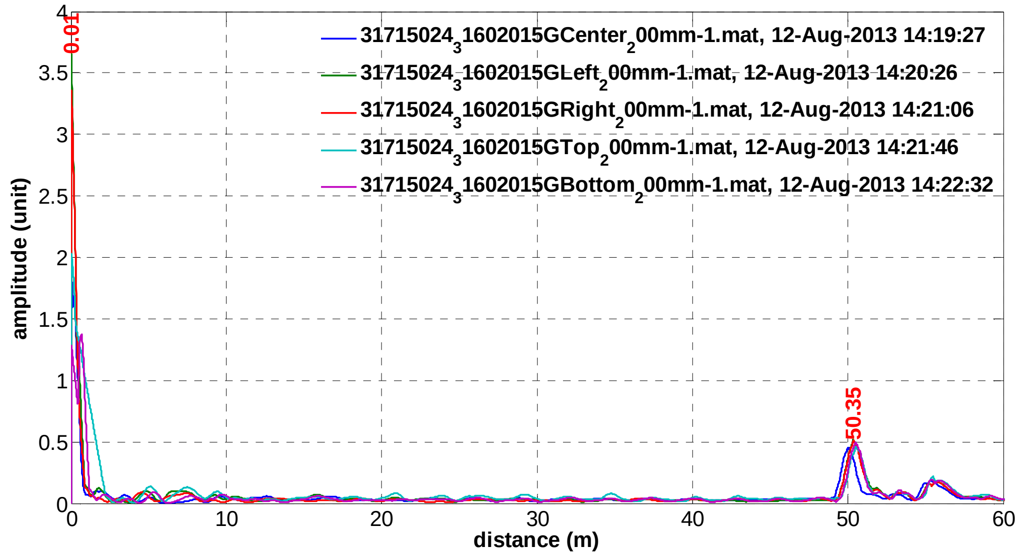


Figure 25 - 31715024_31602015 Gauss pulse excitation signal, different sensor positions

It can be seen that the incident pulse (close to the origin) has greater amplitude when the Gauss pulse is used but the amplitude of the response at around 50m is slightly stronger for the Gauss pulse too.

4. Conclusions

The production SewerBatt equipment was found to work satisfactorily and overall was found to give similar results to the prototype equipment. This is as expected.

The most significant increase in signal penetration appears to come from the use of a Gauss pulse excitation signal coupled with the increased power at lower frequencies offered by the large sensor head.

The Gauss pulse responses were also found to vary less when the location of the sensor within the pipe end was varied.

In the current release of the SewerBatt software the selection of chirp or Gauss pulse for excitation can be made by the user.

Further investigation of the causes and possible minimisation of the strong incident pulse recorded at some locations will also be carried out. In the case of the present series of tests it will be of use in due course to have the CCTV longhand reports and video, to see if there are any features such as connections and backdrops close to the sensing head.

5. Note on measurement units

SewerBatt was originally developed in the UK, using metric units for the many signal processing functions that are performed during its operation. The option to display results in US customary units (in this case distances in feet) is provided in the interface, but at present the internal calculations function correctly only if metric units are selected. For this reason this report has been written using metric units. The option to run the software in US customary units will be included in a later release. Multiply metres by 3.281 to convert to feet.