Water Loss Control

North American water utilities increasingly are mandating water audits and other initiatives to improve water supply efficiency. But before selecting the best water loss reduction strategy, a utility must understand the nature and extent of its losses. Numerous technologies are available to assist with an active leakage management program.

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SOUND PRACTICE
EXPLORING OPTIONS FOR PIPE LOCATION AND LEAK DETECTION

RECENT WATER RESEARCH Foundation project was designed to create a technical guidance document to assist small system operators in locating their buried infrastructure, identifying water loss, and locating leaks. A project team reviewed available technologies and provided recommendations for applying them to help utilities improve the efficiency of distribution system operation.

The following steps were identified as key to successful leakage management programs:

- Periodically assess leakage through water audits
- Improve data quality
- Establish district metered areas and pressure management
- Reduce response and repair times to leaks that have been reported or actively detected
- Apply leakage management as an effective part of asset management

By implementing these practical approaches, utilities can develop an effective leakage management policy that will help reduce real losses, maximize water resources, and improve public health protection.
It has become essential for water utility operators to know where and how much water loss is occurring. Acoustic techniques with sensitive listening devices are used to detect the sound of water escaping from a pressurized system. Electromagnetic technology is commonly used to locate pipes.
PIPE-LOCATING TOOLS
The project team reviewed a wide variety of resources on pipe-locating tools. One of the most comprehensive is the recently published Water Research Foundation (WaterRF) report Underground Facility Pinpointing. The report provides an independent evaluation of a variety of locating tools for metallic pipe, including electromagnetic locators and ground-penetrating radar.

The report concludes that electromagnetic technology is the most cost-effective, efficient, easiest-to-use, and fastest locating method for 80–90 percent of locates. Given the longstanding success of electromagnetic techniques for locating metallic pipe, the project team focused on technologies for locating plastic and other nonmetallic pipes. Information was checked from multiple sources, including well-known equipment distributors and multiple Web searches, and updated using acquired knowledge from team members’ personal experience.

A nonmetallic pipe-locating method used by many utilities (and confirmed by attendees at project workshops) is divining rods, also called dowsers or witching sticks. There are few papers written about this subject, but the few that exist seem to conclude that the technique has no merit. However, given the extensive positive experience of water industry operators, including the researchers on this project, further testing and investigation seems warranted.

The project team prepared a comprehensive locating-equipment matrix of metallic and nonmetallic pipe-locating methods by vendor and type, including the following:

- **Magnetic locators**—nonelectronic devices used to find ferrous valve boxes and manholes near the surface.
- **Metal detectors**—electronic devices used to find various metals, generally at relatively minimal depths.
- **Inductive/conductive locators**—electronic devices used to conduct or induce an electronic signal into a metal pipe or tracer wire via a transmitter that can be found by a separate receiver.
- **Split-box locators**—a variation of the inductive/conductive locator in which the two units are often attached by a connecting rod to induce a signal into pipe the device crosses.
- **Ground-penetrating radar/ultrasonic/infrared/microwave**—devices that bounce various radio signals penetrating the ground, which provide feedback on possible underground structures. Some systems are aided by infrared sensors that provide feedback on temperature variations as the pipe and water in it may have a temperature different from the surrounding soil’s (and might aid in finding leaks).
- **Divining rods**—a traditional practice, using divining rods or witching sticks, that has no accepted scientific rationale but is commonly used successfully to locate buried pipe.
- **Pulse-generating units**—devices advertised as the method of choice for locating nonmetallic pipe, but range is limited. Such devices induce a signal into the water that can be found acoustically only a few hundred feet away.
- **Sonde-insertion locators**—devices that can be inserted into a pipe that can be traced aboveground. Such devices are generally used for sewer pipe, but they’ll work effectively in a water main with proper disinfection and a depurified line. However, sonde-insertion locators are limited by how far they can be maneuvered down a pipe.
- **Electronic markers**—a relatively new method in which markers are installed underground along the pipe (usually at key locations such as service connections and pipe bends). The markers can be activated by an aboveground device that can “read” the information stored in the marker.
- **Pipe-travelling units**—devices that are inserted into a pipe and often equipped with camera units and acoustic monitoring.

An underappreciated alternative to locating equipment is to use an operator’s working knowledge of pipe layout and located surface objects (hydrants, valve boxes, curb boxes, etc.) to “connect the dots.” For example, if an operator knows a new main was added and the main started with a tapping valve that has a known distance between the tapping valve nut to the pipe that was tapped, it should be possible to locate the old pipe running perpendicular to the tap. This approach also can be applied for depth, as there are typically fixed distances between the top of the valve nut and the invert of the valve as well as the adjoining pipe.

The use of tracer wire on nonmetallic mains has been documented to be effective and is practiced at many utilities. Years ago, wire was laid in the ground on top of the pipe. This proved problematic, as the wire was broken easily or wasn’t conductive enough at depth to be detected. More recently, more robust materials, such as copper-clad steel cable, have made the tracer wire more durable. Now, it’s common practice to bring the wire to the surface through valve boxes to provide a conductive trace.

A method more commonly practiced in the United Kingdom is the electronic marker ball. These devices can identify key buried fittings such as service connections, tees, and bends. The marker balls are placed adjacent to the site described and “programmed” to provide information, such as an object’s description, size, and age. The item can be located by a corresponding tracking unit operated at ground level, and the marker can be activated to provide the programmed information.

One company is developing methods to trace plastic pipe more directly with a tape and a rope-like material impregnated with sensors at about 6-ft intervals that respond like a marker ball. A companion surface unit activates the buried markers to imitate a conductive pipe locator with an acoustic signal that gets louder as the unit passes directly over the markers. The company
is already talking to manufacturers about integrating sensors into polyvinyl chloride (PVC) pipe during manufacture.

**LEAK DETECTION OPTIONS**

Most leak detection devices fall into the following groups:

- **Listening rods**—acoustic devices designed to listen by being in direct contact with pipe or its appurtenances. Listening rods or sticks can be used by drilling at or near the pipe to listen underground and have become electronic with amplification and filtering capabilities. In terms of applicability for small system operators, manual listening rods are basic and essential tools. Placing the unit on an exposed pipe, valve, or hydrant can give a characteristic sound if a leak is nearby. They're commonly placed on curb or valve shut-off keys that are on the valves, which also effectively transfer the leak noise. A leak survey generally uses these devices as technicians walk the system, listening on accessible points as they travel.

- **Ground microphones**—acoustic devices designed to be placed on a surface to listen to sound below. Originally these devices weren't electronic, but currently most are electronic to amplify and filter sound. The units can be sensitive to a listening range better than the human ear. Ground microphones provide a reasonably accurate location, with the loudest noise commonly being found directly over the top of the break. Although there are exceptions, especially when surface cover varies, this can be as reliable as more sophisticated methods such as pipe correlators. Ground microphones and electronic listening rods can be packaged together, as they can share common parts. Such devices can't overcome some noises like heavy traffic and normal active water use.

- **Correlators**—acoustic devices that work together to determine the presence and location of a leak. Two monitoring units placed on each side of a suspected leak location can listen simultaneously and, if the characteristics of the pipe between the units are known, a computer with correlating software can receive the signals, display the sound, and calculate the leak location. A recent variation of these devices allows multiple units to be placed overnight in a larger area to find leaks. Correlators are becoming an instrument of choice, as they can quickly reduce leak search time by pinpointing leaks with accuracy. Though much more expensive than microphones, correlators quickly prove their value in directing an experienced user in the direction and to the location of a leak as well as eliminate potential leak candidates.

- **Noise loggers**—acoustic devices that are placed at specific locations permanently to listen during the night, taking the place of the survey team approach and performing the function daily. The devices can provide some indication of whether a leak is present based on the noise it records and then can be interrogated by a passing radio receiver to download data. A variation on this technique is to move the units around to detect changes in temperature and calculate the leak location. Correlators are becoming an instrument of choice, as they can quickly reduce leak search time by pinpointing leaks with accuracy. Though much more expensive than microphones, correlators quickly prove their value in directing an experienced user in the direction and to the location of a leak as well as eliminate potential leak candidates.

- **Intrusive acoustics**—a rough equivalent to the sondes in line locating, listening devices inserted into the pipe can record location and leak noise. Some units provide a camera or other sensors that provide condition assessment feedback. These devices also provide a way to locate pipe if needed. This list doesn't include some more sophisticated methods that have been used in the industry, including fiber-optic cable placed inside the pipe to hear sound or placed outside the pipe (during installation) to detect changes in temperature between the leaking water and the soil temperature. Another available, but costly, method is hydrogen or helium gas locating.

Many of these techniques aren't practical for daily use in smaller systems. However, an awareness of such techniques may be useful, as vendors or consultants may propose such services for emergencies.

**THE STARTING POINT**
Project team members agreed that a water audit is the best starting point for assessing leakage and other water loss in a small system. AWWA's Manual M36 provides a standardized, best practice water audit methodology for identifying and quantifying water losses. AWWA recommends that water utilities compile a standard water audit and water balance annually as a standard business process.

**RESOURCES**