To determine the sources of excess inflow, smoke testing was performed in nine subareas deemed significant contributors to I/I.

Concord, N.C.

A Proactive Approach to Beginning a CMOM-Based Program

Historically, most wastewater collection and treatment facilities have reacted to capacity, management, operations and maintenance (CMOM) problems as they occurred instead of taking a proactive approach by reviewing their system periodically, predicting where problems might occur and then taking action to prevent such problems in the first place.

Times are changing. The federal government is in the process of establishing a CMOM philosophy for wastewater collection and treatment facilities that hinges on an aggressive, proactive approach, calling for utilities to act like investigative reporters rather than firefighters. Eventually, utility providers will have to follow federal CMOM guidelines, and states may establish similar guidelines. The result will be a holistic approach to service and protection.

"CMOM is going to help all municipalities take a very close look at their systems," said Mark Fowler, wastewater resources director for the City of Concord, N.C. "In the wastewater industry right now, it's 'out of sight, out of mind.' You don't worry until you have a problem. CMOM will force us to evaluate our systems and get a better handle on the assets we have."

Because of its focus on prevention, CMOM ultimately will change the way municipalities operate and maintain wastewater collection and treatment facilities. A successful CMOM program promises to produce better water quality, prevent sewer system overflows (SSOs), eliminate environmental impacts from infiltration/inflow (I/I) and SSOs and maintain wastewater systems at a higher level of service.

Nevertheless, many cities and states are waiting cautiously on the sidelines, making little or no changes until the unfunded federal mandate for CMOM is officially issued. Other municipalities are indicating they want to start a CMOM-type program, but they cannot do much more with the staff, resources or funding they currently have.

This is not the case in North Carolina, which is on the verge of establishing a statewide program that embraces the

CMOM philosophy and requires municipalities and utility providers to comply with new collection permit requirements. Some of these requirements include frequent visits to inspect system condition and operation, internal inspections to ensure no blockages exist and strict enforcement of I/I regulations.

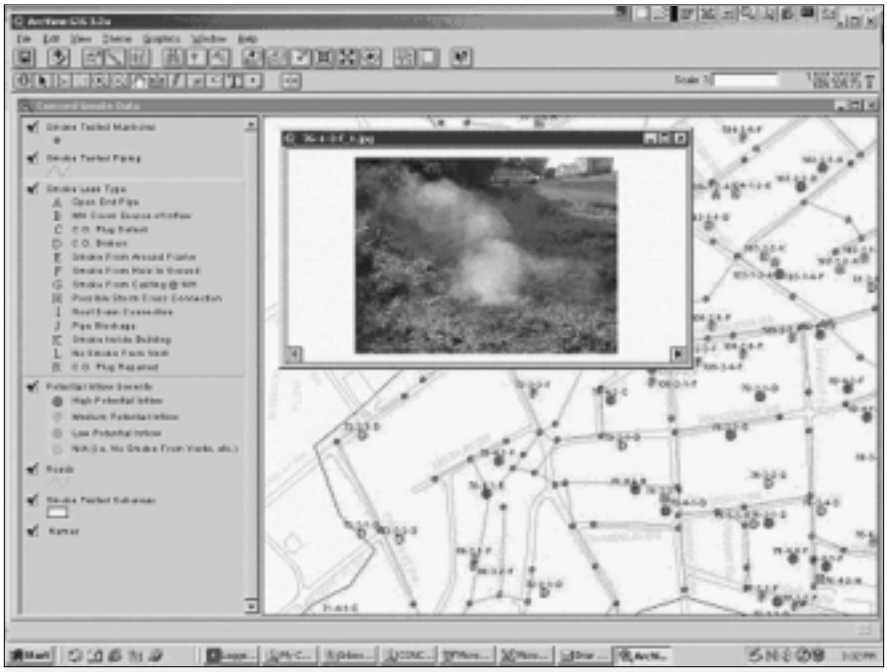
"We want to get a step ahead," Fowler said. "We realize there are many environmental impacts, and we don't want to wait on the EPA mandate. There's just no reason to wait."

Proactive, Systematic Measures

Some municipalities may be waiting because they are not sure how to tackle such an enormous task. The answer is a systematic approach, with municipalities not needing to fix all their problems tomorrow. Instead, they will be expected to have a plan for preventing SSOs and routinely addressing problems. They will be expected to take initial steps to understand the condition and operation of their system, to identify and fix the worst problems first and to follow a course of action outlined in a five-, 10- or 15-year rehabilitation plan—something many wastewater utilities have never developed before.

For most communities, addressing the magnitude of I/I (a major contributor to high wastewater flows) is an important first step to beginning a CMOM-type program. "By reducing I/I, we are trying to reduce our cost obligation to the treatment authority in Cabarras County," Fowler said. "I don't want to pay the county to treat stormwater getting into our system."

The city of Concord maintains more than 2.3 million lineal feet of sanitary sewer lines and has a collection system that ties into the countywide wastewater system owned and maintained by the Water and Sewer Authority of Cabarras County (WSACC). Like Concord, many municipalities have wastewater systems that are 50 or more years old. Some portions of Concord's system are more than 100 years old. Thus, parts of the structural system have reached the end of their useful life. However, if the structural condition can be rehabilitated, operational performance will still be adequate for another 40 or 50 years.



Smoke testing data was organized in a database and linked to the GIS.

According to Fowler, Concord had experienced significant maintenance problems (e.g., failing pipes, root intrusions and chronic blockages) since the early 1990s. Customers were calling to complain. In-field CCTV investigations revealed severe defects. Spot repairs had been performed routinely, but Fowler knew the problem was getting worse.

"We were tracking it—monitoring where our blockages were occurring," he said. "During wet weather events, our peak flows were well over 100 percent of our average daily flows. We knew we had to do something."

City crews focused on the oldest parts of the system, visually inspected major trunk sewers and tributary lines and found significant I/I problems.

"We decided to replace these lines to get back the structural integrity, accessibility and capacity we might have lost through root intrusion and pipe degradation," Fowler said.

Using its own staff and equipment, the city has replaced an average of 20,000 linear feet of pipe a year since 1994. But that still was not enough. Were these repairs providing the greatest benefits?

"We were expecting better results after storm events, so we knew we had not captured or repaired all the problems," Fowler said. "By then we had exhausted all our in-house methods of determining where the problems were … we knew we had to go to the next level."

The city's proactive, aggressive approach involved a Sanitary Sewer Evaluation Study (SSES), performed by Woolpert LLP, to address the system's structural condition and operating performance, and answer questions such as the following.

- What pipes are cracked?
- Are roots causing blockages in the system? Where?
- Is grease buildup restricting flow? Where?
- Are illicit connections causing I/I during rain events? Where?

The goal of the SSES was to identify the worst problems first (the greatest contributors to I/I) to ensure the city would get maximum benefit from its investment. This information would become the basis for a rehabilitation program that involved ongoing maintenance activities.

Concord's I/I reduction program not only addressed its own collection system piping but also the WSACC interceptor system. The three-phase SSES program was designed to review the overall system, focus on smaller areas contributing most significantly to the I/I problem and

Nine dye tests were performed in conjunction with CCTV to investigate the precise locations of inflow sources.

then locate inflow sources so rehabilitation recommendations could be made.

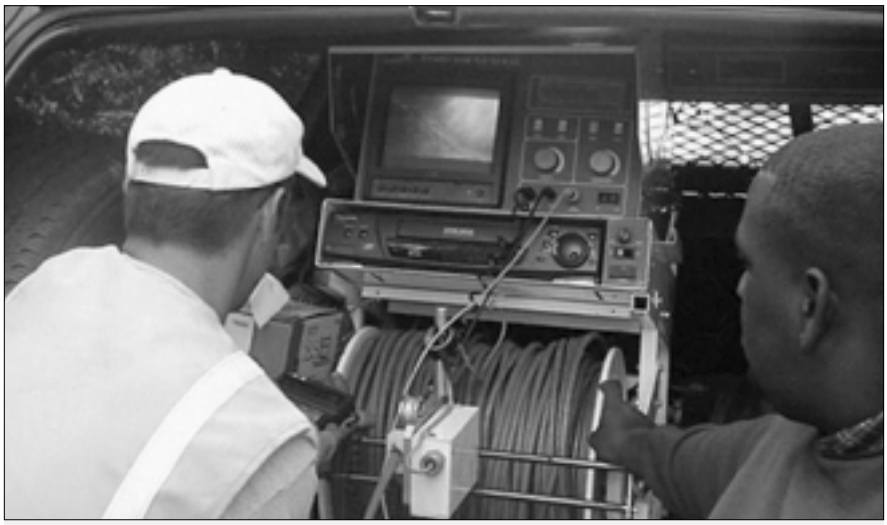
Phase I: Flow monitoring. Woolpert located 49 flowmeters to capture data during dry weather and wet weather conditions for 45 days. Major priority areas contributing the most I/I to the system were identified.

Phase II: Additional flow monitoring. Once major priority areas were identified, 31 flowmeters were relocated for 30 days to further define locations of the most significant problems.

Phase III: Smoke and dye testing. Of the subareas monitored, nine were deemed significant contributors to I/I and selected for smoke testing to determine the sources of excess inflow. Nine dye tests were performed in conjunction with CCTV to investigate the precise locations of inflow sources and pinpoint improvements necessary to reduce I/I.

The SSES produced the following findings.

- 75 percent of Concord's system experienced significant stormwater inflow.
- 15 percent of the system was defined as top priority and investigated further through smoke testing and dye testing to identify sources of defects.
- More than 600 defects were observed, representing 50 percent of the inflow problem in the top 15 percent of the system (46 million gallons per year).
- Defects existed not only in older portions of the system but in newer areas where Concord did not expect to find defects.
- Private sewer laterals contribute significantly to I/I—more than the city initially believed. "Typically it's a small problem with a private system that creates a large I/I problem for us," Fowler said.



CCTV footage is reviewed to observe the inflow of stormwater into a cracked sewer line.

In the end, Woolpert recommended $252,875 in rehabilitation efforts with a five-year return on investment. These recommended improvements had the potential to reduce I/I up to 46 million gallons per year (savings that would produce more than $500,000 in savings over the life of a 40-year system.

Besides implementing the recommended rehabilitation measures, Woolpert suggested the city perform further investigation to locate additional defects, maintain its ongoing maintenance program and monitor results from improvements. All efforts are on track. Almost all the repairs have been identified, with the exception of major infrastructure replacements.

Collaborative Efforts

Before the project began, Woolpert recommended several collaborative efforts to not only save the city money ($57,000) but also give Concord staff a deeper level of knowledge and understanding about their system. "By allowing our staff to participate, we could double our efforts," Fowler said. "To get the most benefit from this type of analysis, it's important that the staff be exhaustively involved."

Flow Monitoring

During flow monitoring, city crews assisted with periodic meter maintenance. Crews checked and cleaned sensors to ensure debris had not accumulated and that meters were recording data properly. Parameters being collected

such as velocity and depth were verified to ensure accurate data collection. City staff recalibrated flowmeters as needed.

During meter maintenance, city crews observed problems in the field such as surcharging of manholes that led to debris accumulation. "The flow monitoring gave our crews good insight into how to track down I/I problems on the system," said Aaron Cook, wastewater maintenance superintendent for the city. "They saw the severity of defects. Now they know how much stormwater can actually enter the system with these types of defects and what impact they have on our system."

Smoke Testing

City crews assisted by maintaining the smoke-blowing machines, making observations during the tests, completing data log sheets, identifying the severity of problems observed, estimating inflow sources and photographing defects.

"We had done smoke testing for many years," Cook said, "but these tests gave us the opportunity to quantify how much flow can be attributed to a particular defect. Previously when we found a defect, we just fixed it; we didn't look at how much flow it contributed. But if you don't start determining an amount, you don't know if you have fixed the problem or not."

Dye Testing

The city collaborated during dye testing by providing city staff and equipment to determine the precise points (at either direct or indirect connections) where inflow was occurring. During one dye test, crews observed that a storm pipe under a road had been installed perpendicular to and on top of an existing sanitary line. During a rain event, the weight of the stormwater cracked the sanitary pipe underneath, the joints in the storm pipe separated, and a flood of stormwater was seen seeping into the sanitary line. By observing precise inflow sources such as these, Woolpert could identify how many feet of pipe had to be repaired and the rehabilitation cost for eliminating this condition.

Fowler said the collaborative effort gave city staff a deeper, more global understanding of system performance and more knowledge about how the system will react during a rain event. Now crews can anticipate which areas might need close observation if rain is imminent. The SSES experiences also are helping crews establish proactive maintenance and inspection priorities and take more ownership of the system.

Data Integrity and Leveraged GIS

Collecting and reporting accurate data during field work is crucial. If flowmeters are not maintained routinely, if smoke test defect data is not recorded objectively and consistently, and if dye test procedures are not followed precisely, then not all defects will be apparent, or defects may be represented. Thus, inaccurate data may be used to make decisions about rehabilitation, and the extent of recommended improvements could be overestimated or underestimated.

City crews assisting with the flow monitoring and dye testing received in-the-field training to ensure the integrity of data collected. Before the smoke tests, Woolpert and city crews spent a half day reviewing written procedures and evaluation standards to ensure objective data recording in the field. For example, defects observed had to be photographed similarly from defect to defect; a naming convention was adopted so photographs could be identified and referenced based on their location. City staff received training on leak codes (i.e., which set of conditions defined a defect as minor, moderate or severe). Staff also learned procedures for estimating inflows so flow monitoring results could be verified.

During the SSES project, Woolpert enhanced and used the city's GIS to manage, analyze and simplify data collected and produce maps of problem areas. For example, smoke testing data including digital photographs of defects were organized in a database and linked to the GIS that displayed the locations of defects based on color-coded severity ratings. GIS maps showing dye testing results also were used to make rehabilitation recommendations and estimate costs.

A Systematic Approach

As stated earlier, it is important to adopt a systematic method for addressing issues related to capacity, management, operations and maintenance. The following systematic approach will help a municipality begin addressing all four areas.

Capacity

Beginning to understand and address capacity issues is important as it relates to development. Does the system have the capacity to handle new development in certain areas? Which ones? Are lines large enough? Are new lines needed? Which areas present limitations? By understanding capacity in all areas of the wastewater system, a utility immediately will be able to determine what impact a new development will have on existing infrastructure and respond appropriately. If impacts will be significant, the developer could be asked to provide improvements to existing infrastructure as a condition of approving the development.

Municipalities can address capacity issues by collecting data and creating a detailed system-wide hydraulic model to determine capacity limitations. However, this requires a major investment in time and money.

Concord's solution was to perform a second level of flow monitoring that examined the collection lines immediately upstream to determine if capacities were sufficient. "An organization can smoke test an entire collection system, but if it fails to collect capacity data on pipes using flow monitoring, it's missing the boat on an issue that CMOM is definitely going to address," Fowler said.

Management

In order to zero in on potential major problems, managers can begin by listening to and asking questions of maintenance staff to understand today's problems such as cleaning issues or chronic blockages and overflows. Managers and maintenance staff can participate in a series of roundtable discussions to begin learning what needs to be done to reduce I/I. What chronic problems do maintenance staff deal with daily? Where do these problems routinely occur? Staff should pinpoint problem areas on a map so managers can begin determining where to focus efforts. These discussions will be a good starting point to target all other efforts for investigating the source of system deficiencies.

Operations

One way to begin understanding operations issues is to focus immediately on I/I reduction through a comprehensive flow monitoring, smoke testing and dye testing program, the approach that Concord used. This program can be performed at lesser or greater levels of detail based on an organization's needs or budget and lets managers and staff get a snapshot of how the system responds during wet and dry weather conditions.

Another method is to rethink and reallocate maintenance activities for better operations results. What additional preventive maintenance activities could staff assume? Is staff conducting periodic inspections to locate problems? Are line cleaning operations tracked based on location and date? Is the number of staff efficient? Is the right equipment available for cleaning and inspection efforts? These questions and others can help define new proactive measures.

Maintenance

Preventing problems before they occur is the goal of maintenance. These efforts include processes such as routine cleaning and CCTV inspections. Like Concord, many wastewater utilities perform an extensive amount of preventive maintenance work already. Concord has begun a simple tracking effort to monitor proactive maintenance monthly. Concord also is implementing a GIS-based Computerized Maintenance Management System (CMMS) that "will ensure the repair work we do in the field doesn't get lost in the paper shuffle," Fowler said. Preventive maintenance and CMMS implementation will allow the city to meet collection permit requirements and use data to improve decision making and support policies in the future.

Future

Concord is moving ahead with other proactive CMOM-type measures. These measures include

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- **Performing capacity analysis.** By accessing population data, using state criteria to project future flows, and using the GIS to calculate acreage, Concord can determine if current pipe capacities are sufficient based on projected future capacities in defined areas. If additional capacities are required, new customers will be expected to pay for improvements needed to increase capacities.
- **Deciding how to handle costs for fixing I/I problems caused by individual property owners.** The average property owner may not be able to pay $1,000 or more to repair lateral lines causing I/I problems downstream. Concord is considering several options for working with property owners to make repairs, including allowing customers to finance improvements over several years.
- **Giving input on a potential I/I policy being developed by the WSACC.** Fowler said the Water and Sewer Authority of Cabarras County is considering an I/I policy that would cover all jurisdictions governed by the authority and result in better asset management. "The goal is to have each jurisdiction make sure its system is performing properly so it does not negatively impact the systems in other jurisdictions," Fowler said. "If one jurisdiction has excess I/I, there may have to be surcharges penalizing that jurisdiction. After all, no jurisdiction wants to pay for treatment plant capacity from someone else's jurisdiction."

Conclusion

CMOM is coming, and municipalities and utilities will have to start doing something soon. If a wastewater system is more than 30 years old, it is bound to have some problem with I/I. Materials have changed; joints have deteriorated over time. Communities unsure about the extent of their I/I problem can begin by analyzing large areas within the system. For example, dry weather treatment plant effluent can be compared to wet weather effluent. The next step is performing flow monitoring to validate I/I assumptions and collecting enough data to draw valid conclusions.

There is no wrong way to proceed with CMOM; each systematic approach is unique based on system needs, age and budget. A fairly new system may not have significant structural issues; instead, capacity may be a bigger issue, especially in a developing community that needs to satisfy infrastructure requirements.

There's no reason to wait on the federal mandate. Communities with sufficient staff, resources and funds should proceed. Those that believe they do not have sufficient staff, resources and funds may need to consider reallocating existing resources.

"CMOM is a 'pay me now or pay me later' situation," Fowler said. "Right now, we can't get lines in fast enough to accommodate all the people involved in development. If there's a major development coming in, I don't want to go before Council and say we can't allow the developer to build here because we don't have enough capacity in the lines. I'm not going to get myself in that boat."

"If you are the manager of a wastewater system and you don't think you have problems, then you've got a problem. If you don't know your problems, you just haven't identified them. If you don't start getting your hands around the problems, they will perpetuate and be twice as bad later," Fowler said.

Communities that choose to remain in a reactive mode and take no steps to reduce I/I will likely face premature expansion of their treatment plants. However, a good CMOM-type program will provide a healthy return on investment with annual savings because of less inflow, increase the life of the community's current treatment plant and minimize or eliminate treatment surcharges.

About the Authors:
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Todd Schuster has 10 years of experience in the engineering field. Currently, he is extensively involved in sanitary sewer evaluation surveys. His responsibilities consist of coordinating and implementing all flow monitoring and various field activities including project planning, data analysis and reporting.