TARGETING LEAKS

A major manhole inspection and rehabilitation project in Lebanon, Mo., takes a big bite out of inflow and infiltration

By Mary Shafer

Jessie Couch and Vinson McCowan of the Lebanon crew use Miller confined-space safety equipment to work on a lift station.

When Richard Shockley looked at increasing inflow and infiltration during rain events in the city of Lebanon, Mo., he thought he knew exactly where the issues were. But Shockley, assistant public works director, was surprised by the results of a thorough, system-wide inspection.

Shockley and his team found that deteriorating manholes were contributing significantly to clear-water entry. As part of a comprehensive rehabilitation program, they repaired some 1,361 of the city's 2,100 manholes using a variety of methods, but relying mostly on pressure grouting with hydrophilic, liquid polyurethane resin.

During the four-year, system-wide inspection and rehabilitation program, the public works team substantially reduced I&I, improved their knowledge of the system, and completely revamped their service approach. They also installed permanent monitoring equipment that provides an accurate picture of system operation at any given time.

In the end, they implemented a sustainable strategy that keeps them ahead of the system's needs and eliminates future surprises.

System in trouble

In the spring of 2000, Lebanon was hit by the spotty but intense thunderstorms

PROFILE:
City of Lebanon, Mo., Department of Public Works

CUSTOMERS:
12,155 (water and sanitary sewer)

CITY AREA:
15 square miles

ANNUAL BUDGET:
$3.5 million

INFRASTRUCTURE:
2,100 manholes, 125 miles of gravity sewer, 4-5 miles of pressure main

WASTEWATER:
3.5 million gpd

WEB SITE:
www.lebanonmissouri.org

Common manhole problems: Above, roots growing in the pipe joint; below, roots growing in from the wall and pipe seal.

A technician pours concrete into forms inside an existing manhole.

> **"We really didn't have any idea how bad our system was. In the beginning, I believed we had more problems with our pipe, when in reality we had more manhole problems."**
>
> **Richard Shockley**

for which south-central Missouri is known. Several manholes were regularly surcharging, and more than a few lift stations repeatedly exceeded capacity. Residents complained of flooded basements and inadvertently flooded neighbors when pumping themselves out.

Shockley knew that Lebanon, county seat of Laclede County, was in trouble with its aging sewer system, some of it more than a century old. "A lot of our capacity issues were inflow-related," he says. "We really didn't have any idea how bad our system was. In the beginning, I believed we had more problems with our pipe, when in reality we had more manhole problems."

He knew a close look at the entire system was long overdue. The department had known that the city would soon have to invest in a system overhaul, and funds had been set aside for part of the cost. The city had won a U.S. EPA grant for just over $2 million toward the total $5.5 million project budget.

First things first

Shockley believed that preparation was critical. "Get a good plan, lay it out with a good schedule and realistic budget numbers," he says. "Then get the equipment you need, and train your field people in analysis and implementation."

The city developed a scope of work and created a request for bids from contractors for specialty rehabilitation work. Ads were run in newspapers and bid packages sent to contractors recommended by other municipalities and engineering firms.

City staff awarded contracts after screening contractors' past work. The staff also reviewed the experience and qualifications of contractor's technicians.

Engineer John Bergen of Wade & Associates of Lawrence, Kan., helped the city create a hydraulic model of the current system as a benchmark on which to measure progress. He also designed a Sanitary Sewer Evaluation Study and helped the city team draw up a complete project plan.

The plan called for installing capacity-measuring devices for initial data gathering and long-term monitoring. Then came a complete system inspection. From there, all data was fed into a database to generate a list of defects, and a repair program and schedule were established.

The project was plotted out in four phases, averaging just under a year. Phases I and II each covered field inspection and smoke and dye testing of half the watersheds served by the sewer system. Wade & Associates trained city personnel for the first phase, and city crews did the second-phase inspections on their own. Phases III and IV comprised rehabilitation work. The entire project extended from 2000 to 2004.

MEASURING FLOW

The City of Lebanon uses the Sigma 910 area velocity flow meter from Hach Company to measure wastewater flows. The device is designed for short-term flow studies, including sanitary sewer evaluation studies.

The unit measures average velocity directly without flow profiling, significantly reducing installation and operating cost. The meter is compact at 4.5 by 18 inches and weighs less than 8 pounds with battery. It logs level and velocity data for more than 30 days without a battery change, and is NEMA 6P sealed to withstand submergence and prolonged surcharge conditions.

The probe is detachable and interchangeable for flexibility. Advanced ultrasonic Doppler technology avoids signal dropouts and ensures high accuracy in low-flow, full-pipe or reversed-flow conditions. The meter automatically corrects for the effects of temperature on level measurement.

ELEGANT DESIGN

Scientists define an elegant theory as one that is both simple and powerful. The Lebanon Department of Public Works sewer rehabilitation project team found an elegant solution to a typical dilemma involving pre-repair inspections.

Whereas commercial buildings were readily open to building inspectors, households were another matter. The department knew that homeowners might be sensitive to inspection of their properties. To head off objections and unpleasant encounters for the staff, the team took a unique approach.

"We trained two crews of two women each to enter homes and analyze their water entry systems," explains Richard Shockley, assistant public works director. "Women are less intimidating, and with proper training they have better luck getting cooperation."

The forethought paid off in a timely inspection process. "We caught a lot of obvious defects during the building inspections," Shockley says.

Data collection

Work began with the installation of 11 Sigma Model 910 area velocity flow meters from Hach Company in Loveland, Colo. One meter was installed on each watershed to document dry- and wet-weather flows. Next, five data loggers with Kellogg rain gauges were installed on public building rooftops to test storm intensity at various locations.

The complete system inspection meant not just looking for infiltration in sewers, manholes and lift stations but checking for inflow from homes and commercial buildings with improper connections or leaking laterals. Team members looked in basements and crawl spaces at drain lines and sump pumps, and checked exteriors at downspouts, stairwells and area drains. Questionable connections were followed up by crews equipped to dye test for connection integrity.

Eric Mork, assistant superintendent of the I&I department, oversaw the inspection. Field technicians, a four-man crew, received classroom training in inspection and reporting procedures. "I think the data collection in the field is the most important thing," says Shockley. "Accurate measurement, good photos, detailed documentation — it's all key to quantifying the entire project."

"I think the data collection in the field is the most important thing. Accurate measurement, good photos, detailed documentation — it's all key to quantifying the entire project."

Richard Shockley

Members of the Lebanon Water and Wastewater Department: From left, Cecil Tanehill, treatment plant operator; Richard Shockley, utilities operations manager; Michael Ogle, water and wastewater superintendent; Jimmy Coleman, I&I technician; Jared Day, I&I technician; Ronnie Johnson, I&I technician; Dustin Perry, lab technician; Gary Bryant treatment plant operator; Jessie Couch, maintenance mechanic; Michael Shockley, water technician; Paul Stewart, water technician; and Eric Mork, assistant water and wastewater superintendent. Not pictured is Vinson McCowan, I&I technician.

Manhole inspection

Workers visually inspected all of the city's manholes, entering each one using Protecta RDI 100 confined space entry equipment from Miller Fall Protection of Franklin, Pa. Some manholes had been buried over the years with asphalt and dirt or were covered by portable containers or gardens, but they dug them out and crawled in.

"You have to make every effort to inspect every manhole, because tight manholes make the system more reliable," says Mork. Shockley adds, "We are now able to access our manholes better, because as part of the rehab process, even the difficult-to-enter ones were made easier to get to. It's just easier to manage now."

Repairs on isolated manholes (except those with obvious and severe defects) were given secondary priority, in favor of line segments needing replacement. Simple manhole repairs, such as replacement of bent lids, were executed immediately.

More severely deteriorated manholes required structural rehabilitation using pour-in-place or sprayed cementitious relining. Where restoration wasn't possible, cured-in-place pipe (CIPP) replacement and other specialized work was contracted. This decision was based on cost effectiveness, as training and equipment expenses would have been greater for traditional dig-and-replace operations.

Smoke testing reveals a manhole defect in need of attention.

Repair work begins

The city contracted much of the rehabilitation work because it required specialized equipment and expertise. "We weighed out the positives and negatives according to the needs of our system, then bid out all the contract work early in the process to find the most cost-effective vendors and products," says Mork.

Much of the manhole work required cured-in-place solutions, for which the Lebanon team chose pressure grouting with hydrophilic, liquid polyurethane products from Prime Resins Inc. of Conyers, Ga.

They used Prime-Flex 900 LVSF injectable resin extensively on the lower 18 inches of manholes, where the pipes enter. Expanding up to 600 percent when activated by contact with water, the resin forms a tough, flexible foam seal that is impervious to water. Crews used it to fix failing pipe seals and cracks.

They used less viscous 600 percent expansion Prime-Flex 900 XLV to seal smaller cracks and leaks in concrete and to stabilize older, crumbling masonry structures. They used moisture-curing Prime-Flex HydroGel SX to stop leaks in below-grade structures. This material reacts with water to form a watertight foam or impermeable gel, depending on the water-to-gel mix ratio.

Drilling deep

The repair process started with 3/8-inch holes drilled in the leaking concrete or masonry wall. Water poured in through the hole, relieving the water pressure on the structure. Technicians then injected the liquid or gel, which expanded to form a "curtain" along the back side of the surface being sealed.

Material backing through cracks and other leak areas provided visual confirmation that the voids had been filled. "It's a pretty easy product to work with, if you have personnel who can handle a hammer drill," reports Shockley.

"There's a little bit of technique involved in the injection process. An operator has to inject just a little product, then allow it time to travel and expand through the fissures. It takes three or four minutes. You can waste a lot of product if your operator doesn't allow enough time for expansion."

The Lebanon crews used a Graco 495 ST Pro pump and a commercial grade airless paint sprayer to force the product into the leaks. "There are pumps that will mix the product and water, but we saved a little money by doing repairs during already wet conditions, or by putting a probe nozzle (like a 3/4-inch steel pipe) on the end of a 2110 Vactor jetter, pushing it down into the ground, and forcing water through the leaks to activate the expansion foam or gel," Shockley says.

Ahead of schedule

The entire project proceeded without major delays. The city had targeted Jan. 1, 2005, for completion, but actually finished in June 2004. Shockley attributes the early completion to "the really good personnel here who were willing to learn new processes to make these repairs.

"We also had cooperative weather. A lot of the work we were doing involved newer technology, and a lot of it was a 'make-it-up-as-you-go-along' process.

Jared Day and Vinson McCowan vacuum-test a manhole using Cherne vacuum testing equipment.

> **"We cut our inflow down by more than 30 percent. That reduced our costs because we were able to eliminate the need for upsizing sewers, trunk lines and lift stations."**
>
> **Richard Shockley**

There wasn't a cut-and-dried method for making some of the repairs, so it was a matter of being able to think on your feet."

Shockley is pleased with the program's results. "We cut our inflow down by more than 30 percent," he says. "That reduced our costs because we were able to eliminate the need for upsizing sewers, trunk lines and lift stations. It's really an ongoing project, because your system can continually deteriorate. We schedule 20 percent of our system for service annually, so everything gets done every five years."

As part of a monitoring study according to federal Capacity Management Operation and Maintenance (CMOM) guidelines, the city replaced flow meters after rehabilitation. The new monitors will catch any new failures so that the staff can select the most cost-effective repair.

"I think things went pretty smoothly," Shockley says. "We have a much better system now than we did in 2000, and we have people on staff who know the system a great deal better than they did before. For any city that's going to undertake a project like this, I would encourage their employees to get involved in the process. They just get more familiar with the system." ✦

MORE INFO:

155 **Hach Company**
800/227-4224
www.hach.com

175 **Miller Fall Protection**
800/430-5490
www.millerfallprotection.com

176 **Prime Resins**
800/321-7212
www.primeresins.com

MUNICIPAL SEWER & WATER

May 2006
COLE Publishing Inc., P.O. Box 220, Three Lakes, WI 54562 / 800-257-7222 / www.mswmag.com