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learns stronger I&I
mitigation strategy

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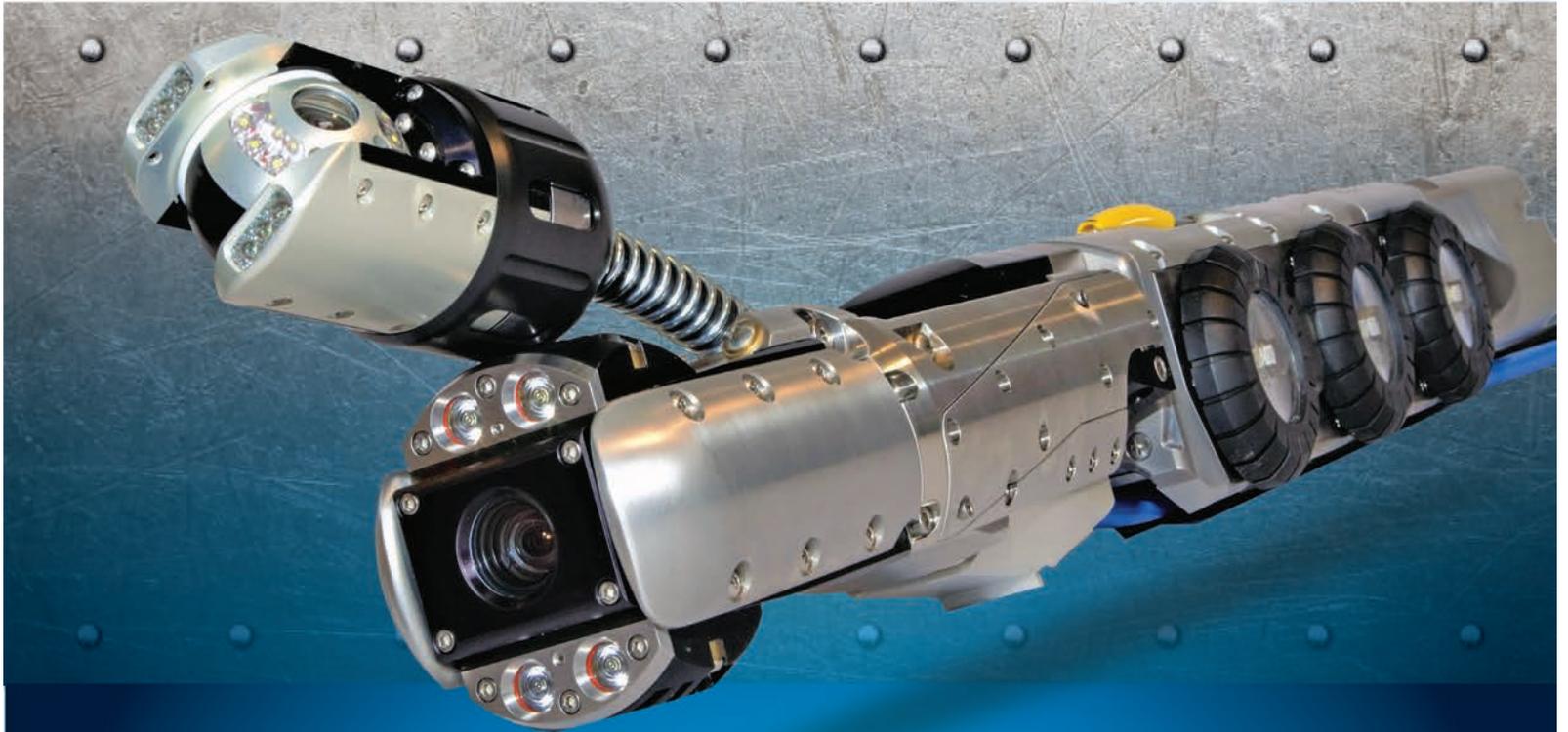


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INFLOW & INFILTRATION
SOLUTIONS AND EQUIPMENT



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By Suzan Chin-Taylor

COVER PHOTO: Supervisor Kreg Butler of BLD Services prepares for a CIPP lining project on a residential sewer lateral as part of Jefferson County, Alabama's robust I&I mitigation program. (Photography by Jeff and Meggan Haller)

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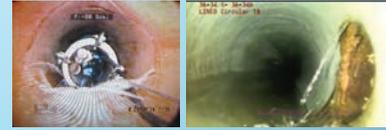
By Anthony Drew

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Workers use a Mud Dog vacuum excavator by Super Products during a lateral CIPP repair job in one of Milwaukee Metropolitan Sewerage District's residential areas.

A DISTRICT STRIKES BACK

Milwaukee's private property I&I pilot project will be a permanent fixture

By Traci Browne

On a Saturday afternoon in July of 2010, while watching his son's tennis lesson, Kevin Shafer, executive director of the Milwaukee Metropolitan Sewerage District, had an epiphany.

Mother Nature had been hitting his city hard with three years of heavy rainfall. During that July alone, the area had two back-to-back storms that exceeded a 100-year rain event. According to the National Weather Service, 8.98 inches of rain fell across the 411 square miles of the district's service area between July 22-24 alone — an estimated 63 billion gallons of water.

As the on-court volley intensified, Shafer says the thought suddenly occurred to him: "We're getting hit at, but we're not hitting back."

To understand this story, you must go back to the 1970s and '80s when the district, Milwaukee County communities and the outlying suburbs were involved in a heated political battle, dubbed the "Sewer Wars." The conflict centered around who would pay for a deep tunnel project to help reduce the frequency and volume of sanitary sewer overflows and combined sewer overflows.

The district doesn't just manage the wastewater for Milwaukee County. It captures rain and wastewater, cleaning it for 28 communities, totaling about 1.1 million people. However, each of the 28 municipalities owns and operates its sanitary sewer system. As a result of the distrust created by those Sewer Wars, the municipalities complained to their state representatives, and legislation was passed that basically said the district must keep its hands off the local systems.

That environment of mistrust still existed decades later when Shafer — who at the time was head engineer for the district — felt there were far too many overflows and basement backups. He wondered where all that water could be coming from, and that's when he began his on-the-job education on inflow and infiltration.



A sewer worker uses a RIDGID SeeSnake to inspect a residential sewer lateral as part of a CIPP repair job.

AN INVISIBLE ENEMY

Shafer conducted sanitary sewer evaluation studies, looking for leaks and bad pipes; and in 1999, Shafer started talking to the municipalities about the I&I problem. That's when they reminded him that, per the law, the district couldn't touch the local systems. Not even to improve them.

The district decided to work on what they could fix and began upgrading its own sewers, treatment plants and pump stations. A few years later, Shafer became the district's executive director, and that brings us back around to that fateful tennis lesson and his decision to start hitting back.

Shafer called his legal counsel and his head engineer into the office the next day, a Sunday, and said, “We’re going to do something about this I&I.” Together they reviewed the law and discovered their loophole. The law only prevented them from having any involvement with the municipality’s sewer system. It said nothing about private property. Shafer says this meant they could simply leapfrog over the towns and address private property infiltration. They did not waste any time before putting together a plan.

“In 2010, we announced the 10-year Private Property Inflow and Infiltration (PPII) Program and kicked it off with a \$50 million investment, broken down to \$5 million per year over 10 years,” Shafer says.

“It’s going to be a continuous program. We’ll get to the end, and then we’ll start over again. And then we’ll just keep going.”

Kevin Shafer

That 10-year pilot program is now a decade old, but Shafer says he has no intention of ending it this year.

That annual \$5 million comes out of the district’s capital budget, which is based on equalized value property tax. Of course, just like during the Sewer Wars, each suburb didn’t want its money to go to another suburb. They wanted their dollars spent on their municipalities. So, the district decided on a structure that would return each town’s equalized value percentage back to them.

For example, if a municipality contributes 10% of the overall district capital budget, that municipality would receive 10% of the annual district \$5 million PPII program budget.

“It’s kind of like smearing peanut butter over the entire region. It’s a constant depth, but you’re not always hitting the areas that need it the most. That’s where we’re at now, but we got the program going, which at the time was important.”

There was much discussion on the roles and responsibilities of each entity, especially to determine how those responsibilities would be split between the district and the municipalities. Ultimately, significant autonomy and decision-making responsibility were placed with the towns since the homeowners are technically their customers.

One example is that the district felt strongly that a resident cost share should be included to stretch the limited budget and give the homeowner responsibility for the work. Many municipalities were opposed to having any such cost implications for homeowners. The district conceded, and the program currently has no cost share requirement.

DOING THE WORK

Once Shafer’s plan was approved, the district started gearing up to help the neighborhoods where private property was the suspected source of high flow rates. While municipalities had autonomy and decision-making responsibility, the district had control over what projects got funding. Therefore, municipalities were required to submit a work plan to the district.

Those work plans included solutions such as sump pump installations and rainspout work, but the most prominent issues were much-needed lateral repairs and replacements, as well as foundation drain disconnects.

Sump pumps turned out to be a problem at times. There were instances in which the property owner’s electrical system couldn’t handle the pump, but that was often determined after digging the pit and installing the pump. That required electricians to make updates and caused the price to go way up. In those cases, the district talked with the property owner about sharing the costs.

Lateral issues turned out to be easier to resolve than foundation repairs, if only because they didn’t require access to the interior of the property. For the lateral repairs, trenchless solutions were the most popular, and in the last 10 years, 8,000 laterals were rehabbed. Only about 100 lines were entirely replaced.

Jerome Flogel, senior project manager of the PPII Program, says that one important lesson learned during the last 10 years is that municipalities need a better understanding of the situation before getting into these projects.

CIPP lining was the overwhelming choice of all the municipalities, but in many cases, it turned out to be the wrong choice due to the level of damage and disrepair in the laterals. They are now exploring more invasive techniques such as pipe bursting and doing more replacements.

“One municipality did a lot of pressure grouting and pushed the limits of how far up the lateral they could get, but the overall I&I reduction and longevity of the benefit is yet to be determined,” Flogel says.

The program is still young, and both Flogel and Shafer admitted going through a steep learning curve. “We’ve learned enough from working on private property to know that problems could be worse than what we had. There have been some close calls,” Flogel says. *(continued)*

POSITIVE EFFECT ON THE NATURAL HABITAT

You’ve probably heard of the Milwaukee Metropolitan Sewerage District and its executive director, Kevin Shafer. According to *Bloomberg CityLab*, Joel Brammier, the executive director of the Alliance for the Great Lakes, has hailed the “astounding” performance of the district at stopping overflows. In that same report, Adam Krantz, CEO of the National Association of Clean Water Agencies, describes the leadership of Shafer as “the gold standard.”

Shafer and the district have also won numerous awards including the US Water Prize from the US Water Alliance, the National Association of Clean Water Agencies public service award, and the Kodak American Greenways Award for the district’s Greenseams program.

Shafer and the district credit their reduction of combined sewage overflows — from more than 50 a year to just fewer than three — to the Greenseams program (set to acquire 3,000 acres of open land) and the creation of public-private projects that expand the use of green infrastructure.

While so many metropolitan areas struggle to meet the national goal of capturing and cleaning 85% of all rain and wastewater, the district has been achieving 98.4% since 1994. But it’s not settling there. The district’s plans for the future, proposed in its 2035 Vision, include zero overflows and 100% renewable energy usage.

In addition to the Private Property Inflow and Infiltration Program, the district started an initiative in 2002 to fund green infrastructure on public property and private property. That initiative is made up of three separate programs, including a Green Infrastructure for Partnership Program, which is targeted at residential, industrial and commercial projects. The second program, Green Solutions, is set up for the municipalities. The third program is its Community-Based Green Infrastructure public-private partnership with Corvias, a consulting firm specializing in infrastructure needs through design, financing, construction, maintenance and community services.

Total funding for all three programs ranges from \$5 million per year in 2020 up to almost \$20 million per year over the next six years.

Shafer says these programs are not just reducing flow into the system, but they have a positive impact on all parts of the natural habitat.

“We should try to mimic nature as much as we can in an urban setting. So, waterways should be as natural as possible: Still provide a 100-year protection for the homes around them, but naturalize the waterways, allow habitat and provide connectivity.”

If the number of sailors on Lake Michigan and kayakers paddling on the Milwaukee River that winds through the city are any indication, it looks like Shafer, the district and the surrounding communities have had a positive impact on the natural habitat.

A PERMANENT FIXTURE

As they move from the pilot stage to an ongoing program, they intend to be more proactive in preventing significant problems. Moving forward, the district will be providing more consulting assistance and instruction to the municipalities, as well as conducting a closer review of work plans before any contracts are signed.

“We have a lot of flowmeters so that we, as a district, know where the water is coming from and have rules in place for goals regarding peak flow,” Fogel says. “We look at where they are proposing to do the work, and we make sure they prioritize areas with problems.”

While some municipalities were surprised they had significant flow problems, Fogel says it wasn’t a shock to him. “No one hasn’t needed the money,” Fogel says. “Anyone who has looked for it found work.”

The district is also now recommending more dye testing and CCTV to get a good picture of the core problems. That information will help avoid situations where a municipality puts out a contract before understanding the state of deterioration or conditions, which complicates matters and results in costly change orders.

While the municipalities will continue to be responsible for putting out the contracts to do the work, the district will now have a preapproval process for contractors and products. To receive reimbursement, municipalities will have to use contractors and methods on an approved list. There will also be terms in place for contractors who want to remain on the list.

“Standard warranties for completed rehab work will have to be established as one strategy to reduce issues down the road,” Fogel says.

The district recognizes there is quite a bit of emerging technology, and those products and methods are not being used in their market. They hope the contractor approval process will help them attract those contractors specializing in these cutting-edge, but proven methods.

THE POWER OF PLANNING

Fogel’s advice to other organizations looking to undertake a significant new project of the district’s PPII Program’s size and scope is to define your objectives clearly. That is a challenge when you’re trying to get 28 different municipalities and elected officials on the same page. However, without those objectives in place, you have no way of knowing what exactly you are accomplishing.

“You can spend a lot of money and then look at your flowmeters and say, ‘We’re not getting anywhere.’ You want to have metrics in place to measure your success. You need to be able to show what you did 10 years down the road,” Fogel says.

However, the district’s metrics are not just there to prove a success. Parameters are there to guide them through every project and every step forward. Once they have the data in front of them, they will know what they must do better the next time.

Despite a few setbacks, Shafer is pleased with the outcome so far. Individual neighborhoods are seeing results immediately downstream from where the work has been done. But for him, success is measured by improvements in flow reductions at the plant and overflow reductions. He says it is still hard to judge the overall impact.

“It’s going to be a continuous program,” he says. “We’ll get to the end, and then we’ll start over again. And then we’ll just keep going.”



The district is exploring the use of more invasive lateral repair techniques in some cases, including pipe bursting.

“We have a lot of flowmeters so that we, as a district, know where the water is coming from and have rules in place for goals regarding peak flow. We look at where they [the municipalities] are proposing to do the work, and we make sure they prioritize areas with problems.”

Jerome Fogel



Crews employ a RIDGID SeeSnake as part of a residential lateral pipe repair project in Whitefish Bay.

While Shafer may not have the results he’s looking for to declare the program a success just yet, others feel differently.

Shafer was able to convince his adversaries of the political capital they would gain by helping their residents without raising taxes to pay for it while also doing their part to improve the environment. That was enticing enough to get just about everyone behind the program. Shafer says even his most vocal opponent is now his biggest supporter. **I&I**



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“We needed to make sure that every dollar we spent was going to produce a good result. ... So we took our time and focused on planning efforts to develop a good asset management plan before we kicked off the next phase of projects and investments.”

Daniel White

Supervisor Kreg Butler (left) and downstream technician Brandin Burton of BLD Services prepare a lateral liner as part of Jefferson County, Alabama’s robust I&I program.



The Whole Picture

Huge investments into sewer capacity left Southern community looking for answers when SSOs continued

STORY Suzan Chin-Taylor | PHOTOS Jeff and Meggan Haller

You often hear from municipal sewer officials how important it is to have a comprehensive plan to address I&I, but few utilities better exemplify the concept better than Jefferson County, Alabama.

When the county received a consent decree in 1996 to reduce its release of untreated water, it invested roughly \$2.4 billion in collections system and treatment improvements. But it learned that this investment would not be enough to combat ongoing sanitary sewer overflows and capacity issues during peak flows.

Embarking on a comprehensive approach to mitigate inflow and infiltration by using modeling and viewing its system as a whole versus the traditional practice of single components has enabled the county to significantly reduce its I&I without the need to upsize assets — all while removing issues during peak flow events.

THE CONFRONTATION BEGINS

From 1996 to 2006, Jefferson County embarked on an aggressive program to meet the mandates of a consent decree from the U.S. Environmental Protection Agency. During this period, roughly 20% of its collections system was renewed either through capacity improvements, replacements or trenchless rehabilitation. In total, approximately 3 million feet of pipe were addressed and a high degree of success was achieved, as the volume of its releases saw more than a 98% reduction. Unfortunately, even with its large investment, the county still struggled with SSOs in some of its smaller-diameter sewer mains and experienced capacity issues during peak flows.

Later, in 2011 as the consent decree work was winding down, Jefferson County decided to begin a program with the help of consulting engineers Hazen and Sawyer to meet the remaining requirements of the consent decree in all of the basins previously identified.

Because of all of the funds that had been spent to improve the system and the disruptions to the financial markets following 2008, the county found itself in bankruptcy in 2011 and with some of the highest sewer rates in the country. Local government



Daniel White, left, deputy director of engineering and construction for the Environmental Services Department of Jefferson County, discusses a work project with Tad Powell, a consulting engineer with Hazen and Sawyer.

engineering and construction for Jefferson County Environmental Services. “The system was too large for us to just approximate where we had the largest need and where the priorities should be placed. So we took our time and focused on planning efforts to develop a good asset management plan before we kicked off the next phase of projects and investments.”

ENLISTING HELP

In 2011, Jefferson County had enlisted Hazen and Sawyer to assist with a project at its Village Creek treatment plant. The project was successful and fostered a great working relationship, so the county didn’t hesitate to reach out to Hazen and Sawyer for assistance with developing a strong collections system asset management and maintenance program to continue I&I mitigation efforts. Hazen and Sawyer also had extensive experience creating a similar program for another client that was experiencing many of the same issues, making it an excellent match.

The county and Hazen and Sawyer worked together, developing a plan that was driven by modeling

and asset condition assessment to determine where the county should focus its priorities and limited funds. Luckily, through the consent decree work, the county had already established a robust and extensive flow monitoring network with approximately 150 flow monitors spread throughout the system’s nine sewer basins and 176 pump stations. This allowed them to see what was happening and where the largest peak flows were occurring.

Although CCTV inspection data had been collected under the consent decree program, it was captured in a format that did not allow the ability to store or record asset condition. The county needed to begin from scratch and inspect the lines to collect new data for incorporation into its CityWorks asset management software.

TAKING IT IN SMALL CHUNKS

How do you eat an elephant? One small bite at a time. This is the approach Jefferson County decided upon. One basin area known as the Chapel project was determined to be an excellent starting point for this new approach.

The Chapel project included a pump station with a flow capacity of 84 gpm. Peak flows from a two-year average of 24-hour storms were measured at 390 gpm — impossible for the pump station to handle. The county was initially considering upsizing the pump station, which would also require upsizing all of the downstream sewer, but county officials and Hazen and Sawyer associates felt that didn’t make sense.

“And this is where a change of approach all started,” says Stephen King, associate vice president of Hazen and Sawyer and program manager for the

“Traditional engineering says build a bigger pipe, move the water downstream or build storage, but we found we can get enough water out of the system through these new I&I-reduction methods to reclaim capacity, move the water and experience success at a lower cost.”

Daniel White

JEFFERSON COUNTY (ALABAMA) ENVIRONMENTAL SERVICES

SERVICE AREA:

536 square miles

CONNECTIONS:

128,000 residential, 14,000 nonresidential

SEWER INFRASTRUCTURE:

3,203 miles of sewer, 176 pump stations, 84,391 manholes, nine water reclamation facilities, one pretreatment facility

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and politicians were pushing back against rate increases to fund the additional work that would be needed — above and beyond what had already been spent — to bring the system into compliance. There was a small amount of cash on hand for capital improvements, but it needed to be spent wisely.

“We needed to make sure every dollar we spent was going to produce a good result. But how do we do that?” asks Daniel White, deputy director of



Preparing a CIPP liner with resin on a wet-out table.

Jefferson County Asset Management Program. “Our approach for rehabilitation and drying up the I&I shifted to attack service connections — something that had never been done before in Jefferson County because the county doesn’t own the service connections. However, we made the decision to address the laterals anyway because it appeared to be in the best interest for the county to try and see if this solution would work.”

This would be the first project where the use of rehabilitation technology would allow the county to forgo other capacity improvements. It had performed much CIPP in mainlines in the past, and that had proven itself a solution for reducing I&I, but lining the mains alone wasn’t the silver bullet the county needed to resolve the ongoing issues.

Lateral CIPP lining was determined as the best option for the county since the materials have a long life span and the ability to truly eliminate I&I and seal the system. “We researched and considered products that could be tested and would be installed by prequalified contractors who had extensive experience with the installation. We wanted to build a long relationship with an installer and the products they would provide and recommend,” says Tad Powell, senior associate of Hazen and Sawyer and construction manager for the Jefferson County Asset Management Program.

They selected BLD Services of Kenner, Louisiana, as the primary contractor for the Chapel project. The choice was based primarily on BLD’s products for lateral rehab and its extensive experience with installations. Any remaining mainline CIPP, manhole rehabilitation or excavations were set to be handled by BLD’s chosen subcontractors.

To reline the laterals in the Chapel basin, BLD used its proprietary product, Service Connection Seal + Lateral (SCS+L). It’s a full-wrap liner with hydrophilic material in the main that expands in the presence of water to eliminate infiltration at the connection point. The BLD SCS+L is an

Lee Martin, CCTV operator, inspects the mains and laterals.



MODELING AND OPTIMIZING

Sewer modeling is the key to Jefferson County, Alabama’s successful rehabilitation and I&I elimination program. “Without a plan, an asset manager is just floating out there, guessing what should be done next. Modeling is the foundation for creating a solid plan,” says Stephen King, associate vice president of Hazen and Sawyer and program manager of the Jefferson County Asset Management Program.

Hazen and Sawyer performed the modeling using InfoWorks software (Innovyze), while WCS Engineering completed the optimization using Optimatics Optimizer software, which evaluates tens of thousands of solution combinations and evaluates each against total life-cycle cost, hydraulic performance and stakeholder objectives.

The most favorable solutions are developed into summary reports and geodatabases for mapping. This information gives Jefferson County and the Hazen and Sawyer team the ability to make highly informed decisions and come up with cost-effective plans to achieve their goals. The planning, modeling and prioritization process also helps the county improve its system performance and prioritize its tasks based on need, budgets and timelines.

Jefferson County has a willingness to try new things and is open to pilots. If they work, great; if they don’t, the county moves on, having gained knowledge to help make its program better the next time. Jefferson County has an attitude of never being satisfied with the status quo — a mindset that is serving it well.

All of the learning and data collected through modeling, optimization and pilots is also providing Jefferson County the ability to get out in front of future issues, moving away from reactive maintenance into a proactive and predictive maintenance mode.

ambient cure product, and installations were performed from the main without the need for crews to have access to a clean-out or create a secondary access point.

This combination-style trenchless CIPP lining product provided a watertight seal at the lateral interface with the mainline to mitigate infiltration at the connection and become a jointless CIPP liner to structurally replace the lateral host pipe if needed.

AN EYE-OPENING EXPERIENCE

The Chapel project demonstrates the advantages of an all-inclusive approach instead of the methods used in the county's early program from 1996 to 2006. During that time, the county performed large amounts of lining but continued to experience unexpected I&I from its laterals.

There was a lack of focus on removing abandoned service connections during that period as well, and technology like lateral-launch cameras weren't yet available. The county didn't have the manpower to track down abandoned service connections or perform smoke and/or dye tests to determine which laterals were active.

"As we were performing CIPP lining on the mains, we were addressing structural issues; but when they were reinstated, we were simply connecting infiltration points back into the system in the rehabilitated mainline," Powell says.

During the Chapel project, it was discovered that a high percentage of the service connections were actually inactive, so these were plugged off and patched. Active service lines were rehabilitated by BLD with the SCS+L lining, and manholes were also rehabilitated.

"Our goal with the Chapel project was to make the whole area and all of the elements in the system watertight, eliminating all I&I possible," Powell says.

But performing the work and remaining hopeful is not enough for the county or Hazen and Sawyer. They need to know for certain that the efforts they make are in fact successful. Using the information from their modeling, once an area is completely rehabilitated, flowmeters are set up as control meters to measure the actual flow. Following this is a small regression analysis to determine what the volume reduction is and what the peak flow reduction level has reached.

"Because we are using similar rainfall before the rehab was performed and comparing it to after the rehab is complete, we are able to compare apples to apples, pre- and post-flow monitoring accurately," King says.

If a remediation is not performing as well as expected, the county may opt to not wait for rain events to determine model flows and instead will perform quick field evaluations. For example, the county would choose 10 manholes in an isolated area for manual examination and, if necessary, make needed repairs to an area where I&I has migrated.

The county quickly acknowledged that approaching I&I mitigation projects as it did with the Chapel project demonstrated just how effective a comprehensive rehab is versus looking at capacity improvement projects as the only alternative.

PEAK FLOW CHALLENGES

Jefferson County's largest challenge is peak flows induced by weather. These wet-weather events continue to create stress at the county's treatment plant, pump stations and even as far along as customers' homes.

During heavy wet-weather events, customers were affected so severely that they would not be able to operate washing machines unless they removed the clean-out cap on their property. This is where sewer modeling assisted the county in addressing its entire system. Jefferson County modeled its entire system (pipes greater than 8 inches in diameter and critical 8-inch pipes), basing its design on a two-year, 24-hour storm. This allowed the county to accurately pinpoint where its most severe problem areas were located.

"We found that we could have great success, and the modeling and optimizing changed the way we began to look at future work," White says. "Traditional engineering says build a bigger pipe, move the water downstream



Technicians Anthony Smith (left) and Brandin Burton feed a lateral liner into a manhole.

"It's rewarding to know we're making good investments and the community now will have a sewer system that's reliable and effective."

Daniel White

or build storage, but we found we can get enough water out of the system through these new I&I-reduction methods to reclaim capacity, move the water and experience success at a lower cost."

Between the modeling, post-project quality control, optimizing analysis and comprehensive approach, the county has a solid road map for maintaining its system cost-effectively and long into the future. "I believe, for the first time, we as system owners know where our problems are," White says. "We have the planning tools to forecast what it's going to take in terms of work and cost to eliminate the problems and truly achieve success.

"With Hazen and Sawyer's tested design approaches and solid, reliable technology products from contractors like BLD, we can achieve our I&I reduction goals and get the extra capacity we need, all at a lower cost, making us good stewards of public money. It's rewarding to know we're making good investments and the community now will have a sewer system that's reliable and effective." **I&I**

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GETTING THE PICTURE

Learning basic troubleshooting for common inspection system problems reduces downtime on the job

By Ken Wysocky

Inspection cameras are a critical tool on sewer cleaning and pipe rehab projects. So when a camera breaks down on a job, productivity, profitability and customer relations suffer.

But it doesn't have to be that way. Equipped with some basic know-how, savvy contractors can save the day by troubleshooting camera issues.

Of course, inspection cameras are complex machines and many repairs must be performed at service centers. But industry experts say there are certain problems contractors can troubleshoot themselves — to keep jobs moving on schedule.

To learn more, *I&I* spoke with Julie James, customer service manager in the Western office of CUES, and Adam White, a technical specialist at RIDGID.

James and White point out that most manufacturers' camera systems are different, which makes troubleshooting generalizations difficult. Nonetheless, the key to resolving many camera problems lies in determining which of the system's basic components are malfunctioning: the monitor, reel, camera head or cable.

Doing so requires isolating and testing each of these components. And isolating the problem component provides a side benefit — operators only need to send in the broken component, as opposed to sending in the entire system, leaving them without a camera, they say.

On CUES camera trucks (most of the company's camera systems are truck-mounted), contractors can use a test cable to evaluate the state of various



Inspection cameras are complex machines and many repairs must be performed at service centers, but there are certain problems contractors can troubleshoot themselves to avoid downtime.

“It’s always a good idea to have a spare of anything that can be easily changed out. Some guys don’t like to spend the money upfront on spare components, but that can be the difference between uptime and downtime.”

Adam White

components; a test cable is included with cameras. For example, an operator can bypass the cable reel by plugging one end of the test cable into a test port on the truck and the other end into a camera head; if the camera works, it's not the source of the problem, James explains.

“If you use the test cable and the camera comes up and running, then you know the issue is in the cable,” she says. “If the camera doesn't work, then the cable isn't the problem.”

Here are some other common problems and how to troubleshoot them:

NO IMAGE ON THE MONITOR

With RIDGID cameras, this could indicate a problem with the monitor, reel, camera head or interconnect cable, which is a short cable that connects the reel and the monitor. To make a determination, White says operators should disconnect the reel from the monitor, then use the monitor to watch a prerecorded videotape (if it's an older camera) or a video that's been downloaded onto a thumb drive.

“If you can watch a video, you know the monitor is working properly,” he says.

To eliminate the camera head as a problem, operators using RIDGID equipment can use a spanner wrench (it comes with the camera) to remove the head from the cable. Then plug the camera head directly into the interconnect-cable port on the monitor.

“If you get an image on the monitor, then you know the camera is good, too,” he explains. “So now you know the problem is not in the monitor or the

camera head so it must be in either the reel, the push cable or the interconnect cable.”

To test the interconnect cable, attach the camera head to one end and plug the other end into the interconnect port on the monitor. If an image appears, then the interconnect cord also works, he says.

“The good news is you can replace the interconnect cord in the field,” White says. “It’s always a good idea to have a spare of anything that can be easily changed out. Some guys don’t like to spend the money upfront on spare components, but that can be the difference between uptime and downtime.”

If you still don’t get an image on the monitor, the problem most likely is in the push cable or the reel. “At that point, there’s not much you can do in the field,” he says. “Further diagnosis would require more in-depth disassembly that isn’t feasible to do in the field.”

WATER OR SEWAGE IN THE LIGHT HEADS

This problem typically is caused by failed O-rings. To fix this problem, remove the light heads, let them dry off for a few hours (or use a hair dryer to save time) and then replace the O-rings, James advises.

“We encourage people to maintain their light heads, too,” she adds. “Just remove a few screws and the heads come out. You can replace lenses, reflectors, O-rings and bulbs. It’s simple to do, and parts are readily available. And it doesn’t hurt to carry extra parts out in the field.”

BROKEN CABLE

If a cable breaks, operators sometimes can “reterminate” it in the field. To do this on a CUES camera, cut off the bad part of the cable, then use the metal splice chamber to reconnect to the cable; the splice chamber protects the connection between the cable and the “pigtail,” which has pins on the end that plug into the mainline equipment, James explains.

“We recommend that if operators are going to go through all that work, they might as well replace the pigtail, too, because they get pretty beat up,” she says. “It’s a judgement call.”

Proper operation can help minimize the chances for broken cables. For instance, it’s recommended that operators keep their hands as close as possible to the drain they’re cleaning, which reduces pressure on the cable, says Adam Teets, a service manager at RIDGID.

“I’d say that 80% to 90% of camera failures stem from push-cable breakage,” he says. “So the best preventive measure is to push the cable down the line without too much pressure.”

PREPARE WITH SPARES

Carrying spare parts is critical to minimizing downtime. Even something as seemingly simple as a lifting strap for a transporter can cause profit-



Operators also need to remember that camera systems are electronic devices that need to be treated with care.



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killing job stoppages because without it, the camera can’t be lowered into or removed from the pipeline, James notes.

“Little things failing will shut you down just as quickly as big things,” she says. “If you’re ordering a motor cable (which connects a camera transporter and the cable), order two. Sometimes you just don’t want to incur the expense, but don’t be penny-wise and pound-foolish. ... It’s not a lot of money compared to the cost of shutting down a truck.”

Proper maintenance is also crucial. Because of the environments in which they work, cameras are constantly confronting water and debris. That means it’s important to disconnect electrical connections to let them dry out to avoid corrosion, and remove debris that can slowly degrade seals and other parts, James says.

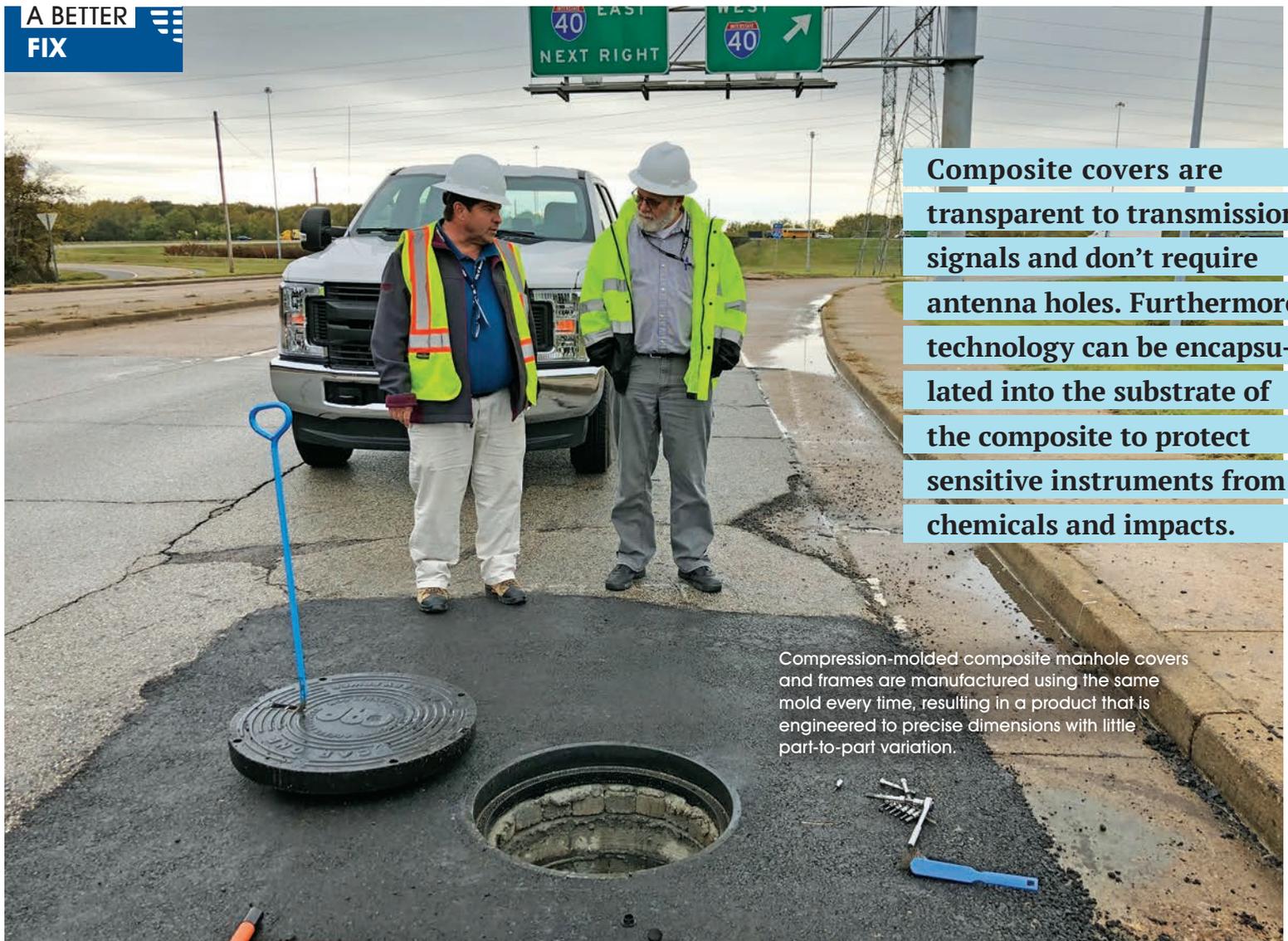
On pan-and-tilt cameras, for example, minute bits of grit can compromise the pivot mechanism. “And when you’re going up a sewer pipe, the wheels will pick up everything from hair to dental floss,” she adds. “Hair actually acts like wire and digs into the seals until they fail.”

As such, it’s important to do things like remove wheels and clean the axles. If a camera lens cracks, replace it right away so moisture doesn’t enter, she says.

Operators also need to remember that as electronic devices, camera systems need to be treated with care. “Our field reps often see users treating monitor-control units like anything but a complex electronic device,” White says. “They need to be properly stored: Don’t let them rattle around your truck every time you make a turn or a hard stop.”

Operators in cold climates also need to remember that electronic devices have a harder time working in bitter cold weather and battery life diminishes rapidly. So if temperatures are below zero, it’s a good idea to move the monitor into a garage or a utility room overnight, he suggests.

Taking care of your inspection camera will help prevent downtime when problem pop up on a job. **I&I**



Composite covers are transparent to transmission signals and don't require antenna holes. Furthermore, technology can be encapsulated into the substrate of the composite to protect sensitive instruments from chemicals and impacts.

Compression-molded composite manhole covers and frames are manufactured using the same mold every time, resulting in a product that is engineered to precise dimensions with little part-to-part variation.

THE CASE FOR COMPOSITES

How composite manhole covers can alleviate I&I and help the environment

By Chad Nunnery

Over the years, a number of accessories have been designed to alleviate issues with cast iron manhole covers — issues like corrosion, theft, heavy weight, stormwater infiltration or their significant carbon footprint. Today, there's a comprehensive option in the form of composite manhole covers.

Composite manhole covers were originally developed to prevent theft of iron manhole covers for scrap metal content, which cost cities millions and left gaping holes in streets for people, vehicles and wildlife to fall into. But municipalities found they'd also gained another benefit: not having to deal with the corrosion of iron covers and frames.

A variety of bacteria in sanitary sewers emit hydrogen sulfide gas, which gets converted by a second bacteria, *Thiobacillus*, into sulfuric acid. The acid corrodes iron covers and rings, degrading the mechanical strength and sometimes fusing the cover to the frames. Covers can become nearly impossible to open without slamming the cover with a sledgehammer, further damaging the unit.

Composite covers solved those issues. They're not recycled in the same manner and there's no market for the scrap, which eliminates the root cause of cover theft. Also, they're resistant to corrosion and don't fuse, allowing inspectors critical access for reviews and preventive system maintenance.

STORMWATER ISSUES

Some 32 trillion gallons of floodwaters are polluted annually by sewage, chemicals and waste, according to the Summer 2019 issue of Nature Conservancy. When stormwater enters sanitary sewer lines through water pathways at the junction of the manhole cover and frame, it results in inflow and infiltration as pumps are overworked, sewer systems are overburdened and municipalities have to pay for unnecessary wastewater treatment costs.

When systems overflow, hazardous waste finds its exit into streets, creeks, rivers, lakes, ponds and oceans. Recent increases in flooding have only exacerbated the issue of sanitary sewer overflows.

Iron covers and frames are molded in individual sand casts, and a different cast is used for each cover and frame, which can lead to part variation. Iron covers are also designed with larger gaps between cover and frame than composites, and utility workers sometimes replace damaged iron covers without properly mating them to the frame. All of this can lead to stormwater infiltration.

Corroded covers are even worse, as sections of the cover or frame can break over time. And using a sledgehammer to combat cover fusion also chips away at the seal.

Composite covers and frames are a watertight solution. For instance, Composite Access Products (CAP) covers and frames have been shown to be 100% watertight in 20 inches of water, as 0.00 gpm infiltration was measured and verified by a third party.

Unlike iron castings, compression-molded composite covers and frames are formed by the same mold every time. The molds are highly engineered to precise dimensions (ten thousandths of an inch tolerances), and the part-to-part variation is greatly reduced with single molds.

Furthermore, because of the properties of polyester/vinyl ester thermosetting resins, which make up the composite resin matrix, the resulting parts maintain a tight dimensional precision and stability over a range of conditions. This includes dimension stability from 60 degrees below zero to 360 degrees F.

In an effort to monitor and prevent SSOs, smart city technologies are being developed to detect irregularities inside the manhole, transmitting data to utility operators for a quick response. Iron covers block the transmission signals, and it is necessary to drill holes in the cover for antennae, thus creating an additional water pathway.

Meanwhile, composite covers are transparent to transmission signals and don't require antenna holes. Furthermore, technology can be encapsulated into the substrate of the composite to protect sensitive instruments from chemicals and impacts.

ENVIRONMENTAL IMPACTS

The iron forging process is performed at a significantly higher temperature than that which is used for composite molding, which is approximately 275 to 300 degrees F. The much higher temperature of iron forging incurs higher energy consumption and a larger carbon footprint for the production of parts. Also, in iron forging, dust and fumes can be exhausted into the air, and slag must be disposed of.



A finished composite manhole cover offers a watertight solution in the fight against stormwater infiltration.



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To slow the corrosion process on iron manhole covers, some municipalities require them to be dipped in chemical coatings, which can eventually wear off. Some use a coal tar sealant, which the U.S. Geological Survey found is linked to several forms of cancer and is toxic to aquatic life when runoff occurs. While coal tar coatings are banned in several states and cities, they're still in use.

Meanwhile, the compression molding of thermoset composites produces little waste and emissions. Less than 5 ppm of styrene is released during the process, and the Occupational Safety and Health Administration sets human exposure limits for styrene at 100 ppm for an eight-hour time-weighted average.

No runners or sprues are produced for scrap, and only about 200 grams of excess molded fiberglass is produced per part in composite manhole manufacturing. The molds used are steel and are used for millions of cycles.

For years, industry outsiders have claimed that thermosets can't be recycled. Though not recycled in the usual method like plastics (melting and reforming), thermosets have been recycled and blended back into compounds starting with applications in the '90s. There is no "market" for recycled thermosets, so thieves will not have an incentive for stealing these manhole covers. At the end of a composite cover's useful life, however, it will be possible to grind and reuse this material back into the raw material mix.

Finally, many technologies are being developed that use biodegradable resins and reinforcements, but research is required to see how this would work in a manhole cover application.

Environmental awareness and gauging how products impact the environment will continue to grow in importance to society. While the fast-growing composite manhole cover technology presents significant benefits to infrastructure, those benefits also extend to the environment.

ABOUT THE AUTHOR

Chad Nunnery is the president of Composite Access Products (CAP). **I&I**

By Craig Mandli

CHEMICAL TREATMENT HELPS REMOVE ROOT INFILTRATIONS

PROBLEM:

Sanitary sewer overflows are one of the largest costs to municipalities, and the majority are root related. In one case, the town of Meno, Oklahoma, was experiencing stoppages and overflows throughout the city. In January 2019, Mayor Rick Goodman and the board of directors for the city of Meno decided to move forward.



SOLUTION:

In order to provide a comprehensive risk management program for its 500 municipalities, Oklahoma Municipal Assurance Group partnered with **Duke's Root Control** to provide sewer **root control treatments** to participating municipalities via a \$5,000 matching funds grant program. OMAG begins with providing a Sewer Line Rapid Assessment, or SL-RAT, tool from InfoSense to the participating municipality. The SL-RAT is a portable on-site assessment tool that identifies capacity issues in gravity-fed sewers within minutes, without the need for traditional CCTV and at a fraction of the cost. OMAG trained the team on its use and loaned them the instrumentation for two to three weeks. In Meno, 14,000 linear feet were inspected, and the SL-RAT identified significant blockages and poor scores. The lines were treated using Duke's RazoRooter II, an herbicide-laden, thick foam that kills roots on contact, penetrating through wye connections and killing roots in laterals as well.

Result: Upon inspection of manholes after treatment, there were no stoppages and no overflows in the city. RazoRooter II allows roots to decay naturally and slough away, with regrowth delayed for two to three years.

800-447-6687; www.dukes.com



MANHOLE RISERS A FIT FOR COASTAL COMMUNITY

PROBLEM:

Ocean Springs, population 17,500, is a town on Mississippi's Gulf Coast. The 42 members of Ocean Springs' Public Works Department maintain 186 miles of roadway along with 7,200 manholes. They sought a reliable way to bring manholes to grade easily during repaving projects.

SOLUTION:

For about 30 years, the department has relied on adjustable manhole risers to raise manholes to grade after new paving. The **American Highway Products Pivoted Turnbuckle Manhole Riser** is a ring of galvanized steel featuring a turnbuckle link used to expand or contract the riser as needed for insertion into manhole rims. The adjustable risers are available in fine size gradations to match manhole diameter and paving lifts precisely.

Result: The risers save money and many hours of labor. At-grade risers are gentle on roads in many ways, compared to concrete ring replacement. They don't set low, so water doesn't collect around the manhole lid causing excessive infiltration; and they don't set high, so vehicle tires don't jar the lid and rim continually. Ocean Springs has been ordering and installing about 60 adjustable risers annually for a few decades, and it plans to continue indefinitely.

888-272-2397; www.ahp1.com

TWO-COAT SYSTEM USED TO REHABILITATE MANHOLES

PROBLEM:

In Santa Barbara, California, four brick and concrete manholes needed rehabilitation due to root intrusions and mild body deterioration caused by gas exposure.

SOLUTION:

Having no outside water intrusion made for an easy rehab project for contractor V. Lopez Jr. & Sons G.E.C. Using Mortartec Ceramico for rehabilitation combined with Epoxytec's CPP liner for protection created a suitable system for manhole rehabilitation. Mortartec Ceramico provided a quality rehabilitation mortar, and a topcoat of CPP provided the protection necessary for the harshest environments. V. Lopez Jr. & Sons applied this two-coat system. Mortartec Ceramico was installed over deteriorated areas, and CPP was applied at 250 mills over the manholes. The crew constantly checked the mill gauge to ensure 250 mills were reached consistently.

Result: The entire project lasted five working days. Since there was an experienced contractor on the job, no major obstacles to contend with and proven products were used, the rehab project was a slam-dunk. "The Epoxytec products are easy to use and extremely durable," says Butch Lopez, project manager and treasurer for V. Lopez Jr. & Sons. "Customers are pleased with the product and the overall look." 877-463-7699; www.epoxytec.com



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tested using Superior Smoke products, eliminating countless faults and the costly sanitary sewer overflows that would result. Smoke testing is the fastest and most cost-effective method to find all sources of surface inflow to sanitary sewers: Anywhere that surface water can flow in, the smoke

will come out. Finding problems quickly and cost-effectively is the key to reducing peak flows, stopping sanitary sewer overflows and saving money. Superior Classic Smoke Candles provide a highly visible smoke to find more faults at a longer distance. Superior Smoke Fluid Systems feature a stainless steel injector to maximize dry-smoke output, producing a higher-quality, liquid-based smoke.

800-945-8378; www.superiorsignal.com/ll



CITY ADDRESSES INFLOW AND INFILTRATION WITH REFORMED INSPECTION PROCESS

PROBLEM:

Roughly 10 years ago, the city of Bedford, Indiana, was facing criticism from the Indiana Department of Environmental Management regarding its sewer and stormwater systems. Many of the city's pipes were cracked and filled with debris. The department threatened a ban on Bedford's ability to add pipes if action wasn't taken. Bedford's biggest challenges were addressing overflows and I&I.

SOLUTION:

The city purchased a ROVER X sewer inspection crawler from Envirosight, but it also needed an organized way to report the problems to the Indiana Department of Environmental Management. To tackle the issues

head-on, the city set up a monitoring system and invested in additional equipment, including the QuickView airHD zoom camera, Quick-Lock point repair sleeves, a second ROVER X crawler and a ROVER X SAT lateral launch. It even custom-designed a mobile unit to take its inspection equipment on the road. The crew has divided the 79 miles of pipe it manages into two sections. Each day it picks up where it left off, documenting defects, damage and other issues.

Result: In this way, Bedford has discovered many roots and broken pipes and can now identify needed repairs. "In these last few years, they have basically been going line by line tele-vising, doing reports, repairs and just getting



everything lined out," says Charles Parsley with Best Equipment, Envirosight's regional sales partner. "Bedford is a small community, yet they bought this box truck with everything. It's Middle America and everyone has the same problems they do, but they are acting on it and getting the work done."

866-936-8476; www.envirosight.com

(continued)



EXPANSION PLUGS PROVIDE A LEAKPROOF SEAL ON CLEAN-OUTS

PROBLEM:

The Camera Inspection Division for Q3 Contracting, a subsidiary of Primoris Services Corp., a large energy contractor located in Minneapolis, inspects municipal pipe and sewer laterals, looking for breaks and breaches. The crew frequently encounters leaky clean-outs or broken pipe openings when doing premise-out inspections. The inspection crews needed a replacement expansion clean-out plug that seals even when encountering fouled threads or damaged clean-out openings.

SOLUTION:

The video inspection crews switched from installing a clean-out plug that ineffectively sealed behind the clean-out threads, allowing leakage, to using **Counter Sunk Expansion Plugs** from **Real-Tite Plugs** that incorporate a large gasket that seals three ways: behind the threads of pipe openings, over the fouled threads and at the mouth of the opening with a shoulder seal.

Result: The expansion plugs effectively provided a leakproof seal, even when installing in a damaged clean-out opening with a broken lip or fouled threads.

800-877-0610; www.real-titeplugs.com

SMART PUMPING SOLUTIONS ALLEVIATE STORMWATER FLOODING

PROBLEM:

The city of Hoboken, New Jersey, has a long history of flooding. Two-thirds of the populous city lies in the Federal Emergency Management Agency's flood zone, and most of Hoboken's water infrastructure dates back a century or more.

SOLUTION:

To help mitigate stormwater flooding, the North Hudson Sewerage Authority installed two wet-weather pumping stations. The H1 pumping station, completed in 2011, has alleviated flooding on Hoboken's southwest side. The station can expel approximately 84 mgd. Pumps activate automatically when water in the system reaches a certain level, and excess stormwater is pumped into the Hudson River. The H5 station, which went online in 2015, has provided Hoboken's northwest region with major relief. **Pumps and controls** from **Flygt - a Xylem Brand** contributed to a pump station design that helped reduce costs, increase efficiencies and alleviate stormwater flooding. The station has two high-performance submersible pumps, each with a capacity of 40 mgd, for a total pumping capacity of 80 mgd. During intense rain events at high tide, the pumps will work against the tide, preventing the combined sewers from filling to capacity and overflowing.

Result: Based on data collected and analyzed over a six-month period, a 2013 report concluded that the H1 pump station kept city streets and basements free of an unhealthy mix of sewage and stormwater runoff that otherwise would have overwhelmed the combined sewer system. The authority realized similar results with the H5 pumping station: Between November 2016 and April 2017, the station handled four rain events that previously would have caused flooding. 855-995-4261; www.xylem.com/pumping



DEPARTMENT OF TRANSPORTATION REPLACES REMOTE TELEMETRY UNITS TO HELP KEEP DRIVERS SAFE

PROBLEM:

One key priority for the Michigan Department of Transportation is to enhance the safety of all drivers by preventing freeways from flooding during rainstorms and snowstorms. As part of this project, MDOT decided that 98 stations needed to have their remote telemetry unit (RTU) replaced to better measure and report the amounts of water being pumped and to keep the roads safe.

SOLUTION:

PRIMEX built the **RTUs** and delivered them based on the timing the general contractor specified, which included shipping five panels per week for a period of 18 weeks. Included in the build-out was integration of the MultiSmart controller, cell modem, all wiring, relays and time-delay relays to manage the backup float control, phase monitor and emergency stop. As part of its standard testing procedures, PRIMEX configured all the programmable devices per customer preferences so a complete operational panel test could be completed prior to shipment.



Result: PRIMEX updated the pump stations with new technology to ensure the pumps not only work 24/7, but also continuously monitor all the critical station information to ensure the pumps are working properly. If they are not, the system will immediately notify work crews. PRIMEX was able to adapt to requests from MDOT and the general contractor as the project continued and meet key deadlines.

844-477-4639; www.primexcontrols.com

COATING SYSTEM USED TO RELINE PVC PIPE

PROBLEM:

NTX Plumbing of Richardson, Texas, got a call for a residential home that had pipes leaking in both the front yard and backyard. The PVC pipe had root intrusion along with cracks and leaking at the joints.

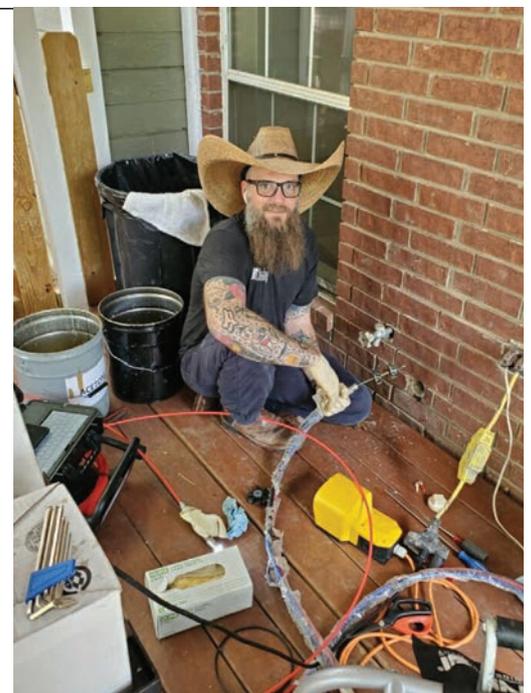
SOLUTION:

Since the new homeowner wanted it fixed before move-in, Scott Hooper, owner of NTX Plumbing, came to the rescue. On the first day, he inspected the pipe with **Pipe Lining Supply's** 100-foot sewer inspection camera, then cleaned and jetted the pipe. On day two when the pipe was prepped, he accessed the front leak via a clean-out that had 12 feet of pipe total — 5 feet of 3-inch pipe that then tran-

sitioned to 4-inch pipe for the rest of the run. With the **Quik-Coating System** and Renssi 50-foot high-speed cable machine, he repaired the pipe with five passes to build a 3 mm finish. He then moved to the back clean-out that consisted of 8 feet of pipe — 3 feet of 2-inch that transitioned to 3-inch pipe. He did four passes in the smaller-diameter pipe with five-minute quick-dry polyurea resin. The transitions are simple with the brushes, which fill in the cracks, coat the pipe and return it to new condition.

Result: The second day took a total of three hours, and it was 98 degrees F with 90% humidity. The leaks and root intrusion were repaired in a short time, and it was a one-person job.

888-354-6464; www.pipeliningssupply.com I&I





By choosing the appropriate technology, location and siting conditions to measure rainfall, you're giving yourself the best chance at accurate data for expensive sewer system rehabilitation decisions.

TAKING A RAIN CHECK

When critical upgrades depend on rainfall data, it's important to get it right

By Anthony Drew

When a city is facing inflow and infiltration issues, expensive sewer system rehabilitation decisions often involve the use of rainfall data. In those cases, it's important you're doing everything you can to ensure the accuracy of that data.

Rainfall-derived I&I prediction can be greatly obstructed by imprecise precipitation data, often due to improper rain gauge density, inadequate gauge siting, equipment malfunction or data collection errors. By choosing the right rain gauge equipment, maintaining it per manufacturer standards, spacing gauges appropriately and establishing proper siting, you're giving yourself the best possible chance of precise data.

TIPPING-BUCKET ACCURACY

The most commonly used technology to measure rainfall in municipal sewer system studies is the standard tipping bucket, due to the simplicity of its installation, operation and maintenance.

It works by funneling rain into one of two carefully calibrated compartments on a seesaw pivot. When one compartment collects the calibrated amount of rainfall, the bucket tips to drain and the second compartment rises to catch water. When a bucket tips, a reed switch is triggered and that data is sent to a rainfall monitor.

However, the standard tipping bucket has a drawback. During the brief tipping motion, as one bucket drops and the other moves into position, rain falling into the funnel is not recorded. The heavier the storm, the more pronounced this drawback becomes.

Alternatives to the tipping-bucket gauge typically include weighing rain gauges and manual water-level rain gauges. The weighing gauges are the most accurate technology available but can be prohibitively expensive and also require the most maintenance, while water-level gauges can be less accurate. A third option is a variation of the standard tipping bucket that uses a siphon at the base of the funnel to control the rate of flow, allowing the system to account for rainfall that occurs during the bucket tip.

Because wind can cause the gauge to underreport actual rainfall, ideal conditions are found in clearings where there's a windbreak nearby.

Deciding on the right technology for your application is largely a determination of how much rain you're expecting. The World Meteorological Organization recommends a measurement uncertainty within plus or minus 5% for rainfall intensity. According to a 2020 white paper by ADS Environmental Services titled *Rain Gauge Equipment Selection for the Urban Sewer Environment*, the standard tipping bucket meets WMO guidelines for rainfall intensities up to 6 inches per hour. Meanwhile, the siphoning tipping bucket can operate within plus or minus 5% uncertainty up to 20 inches per hour.

By using the National Oceanic and Atmospheric Administration's Precipitation Frequency Data Server at hdsc.nws.noaa.gov/hdsc/pfds, you can calculate the best tipping bucket for your needs.

“Like we say in the sewer,
‘time and tide wait
for no man.’”

— Ed Norton, *The Honeymooners*

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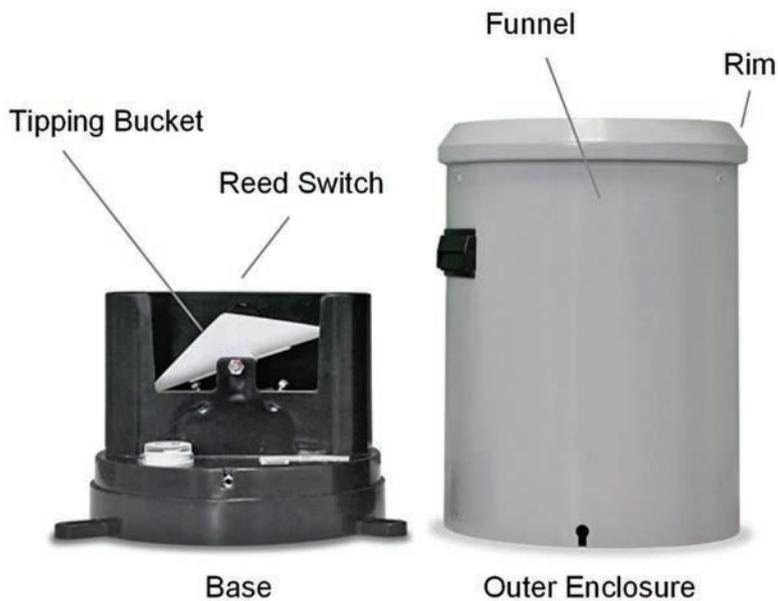


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The standard tipping bucket used for rainfall measurement works by funneling rain alternately into one of two carefully calibrated compartments on a seesaw pivot. When a compartment fills, the bucket tips to drain water and a reed switch is triggered, sending data to a rainfall monitor.

GAUGE LOCATION AND SITING

Choosing the proper siting for a rain gauge is a balance between good connectivity to wireless networks (if needed), limiting easy public access to prevent tampering, maintenance accessibility, and consideration of local weather patterns or physical obstructions. For these reasons, pump stations,

wastewater treatment plants or other municipal buildings are good locations for rain gauges.

Next, you'll want to select a location for the gauge to receive rainfall unobstructed, as poor siting conditions can diminish the accuracy of the equipment. Because wind can cause the gauge to underreport actual rainfall (the WMO estimates between 2% and 10% undercatch in direct wind), ideal conditions are found in clearings where there's a windbreak nearby.

“Although surrounding trees provide shelter from the wind, a rain gauge must not be too sheltered and should also be situated in an area free from rain interference, such as overhanging trees, nearby buildings or other obstructions,” states a second 2020 white paper by ADS titled *Rain Gauge Siting Principles for the Urban Sewer Environment*.

Guidance from WMO on this matter states that nearby obstacles or obstructions should be no closer than twice their height from the rain gauge. If you can't find the perfect location, the ADS white paper recommends documenting the site conditions and accounting for any potential impacts. The white paper — available online at www.adsenv.com/white-papers — also includes instructions for a do-it-yourself siting device to estimate distances from windbreaks.

Finally, it's also important to consider the height above grade at which you're installing the rain gauge, as wind speeds increase higher up. While the rooftop of a municipal building might seem appealing, if there's another secure or fenced location closer to the ground with a windbreak, the gauge would be better off there. If you have to install it on a roof, install it as close to the center as possible to avoid eddies of wind.

ADS recommends installing a rain gauge about 3 feet above grade, ideally. However, WMO offers an acceptable range between 1.5 and 5 feet. **I&I**



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- Dealer/Distributor/Manufacturer
- Rehabilitation/Relining/Bursting
- TV/Video Inspection
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Which types of sewer, storm & water repair, maintenance & inspection do you perform monthly?

- Jetting
- TV Inspection
- Repair/Replace Excavating
- Vacuum Truck Service
- Manhole Rehabilitation
- Treatment
- Pipeline Rehabilitation & Relining

What is the approximate population of the area in which you provide service?

- 0-10,000
- 10,001-50,000
- 50,001-100,000
- 100,001-200,000
- 200,001-500,000
- 500,001+

How many vehicles do you currently have in service?

- 1-5
- 6-10
- 11-15
- 16-20
- 21+

What is your annual equipment budget?

- \$0-\$50K
- \$50K-\$100K
- \$100K-\$200K
- \$200K-\$300K
- \$300K-\$400K
- \$400K-\$500K
- \$500K +

If municipal, what percentage of your sewer and/or water work is done by private contractor?

- None
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 80%+

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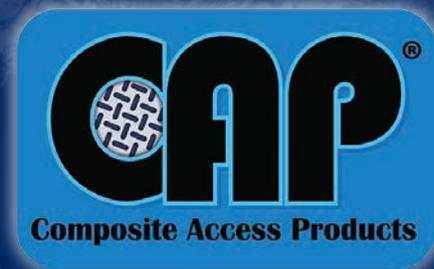
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