Realizing Return on Investment from Computerized Maintenance Management Software

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Implementing a computerized maintenance management system (CMMS) will cause many water and wastewater professionals to ask the obvious question, “How much money will the system cost?” The real question is, “How many resources will I be able to redirect by using such a system?”

The objective of this paper is to provide an understanding for the Return on Investment (ROI) provided by implementing a CMMS. The return on a CMMS is not found in the traditional profit and loss parameters of Wall Street. Nor is it found in a pure application of benefit/cost analysis. The returns from a CMMS are subtle and better illustrated with case studies and interviews with practitioners.

Five entities nationwide share their results having implemented a computerized system. Daily activities include operation and maintenance management of a water and/or wastewater system. These entities share their experiences about the return they have received from implementing a CMMS. They rarely talk about dollars and cents. They speak more about improved effectiveness, better information, using facts to defend decisions and data to combat political influence on decision.

THE AGENCIES

Location, size and background are significant variables between agencies. Each of the five agencies in this article has implemented a CMMS with a Geographic Information System (GIS), yet the systems vary widely. Differences exist due to complexity, usage and availability of data. GIS usage is also a significant variable between the agencies.

1. City of Longview, Washington – Population served 32,000

   Longview is currently utilizing CMMS to track sanitary sewer inventory, water distribution inventory, customer requests, parts inventory, and maintenance. The city is also using the CMMS to update their existing GIS system. The integrated CMMS system was installed May 2000. Information in their existing GIS system was used to populate the sanitary sewer system and water inventory databases. The customer, work order and parts inventory databases of the CMMS were populated with imported information from other databases.

2. City of Greeley, Colorado – Population served 61,000

   Greeley is currently using CMMS to track sanitary sewer inventory and maintenance. The CMMS has been operational for two years. Sanitary sewer system data housed in an old computerized inventory system was used to populate the new inventory database. The City of Greeley is one of the few cities accredited by APWA.

3. City of Paris, Texas – Population served 25,000

   Paris is using CMMS to track the inventory and maintenance of water distribution, sanitary sewer, storm sewer, and street/pavement systems. The CMMS has been operational since August 2000. Information used to populate the CMMS included a combination of converting electronic data and the manual entry of new information.

4. City of Cedar Rapids, Iowa – Population served 110,000

   Cedar Rapids uses CMMS to track the inventory and maintenance of their sanitary sewer, storm sewer, and street/pavement systems. Operating for two years, the CMMS system has information from a combination of electronic data conversion and the manual entry of new information. The CMMS includes about 6,300 historical sanitary sewer work orders, which were manually entered.

5. Sanitation District No. 1 of Northern Kentucky – Population served 300,000

   The Sanitation District uses CMMS to track the inventory and maintenance of their sanitary sewer system. Their CMMS has been operational since 1999. Matching existing GIS data with electronic inventory data jumpstarted the data conversion. Over five years of historical work order information was also electronically imported into the new CMMS from the former legacy system.

Budget concerns were a factor in each of these implementations. Just as important were organizational issues and technology issues. When these agencies chose to implement a CMMS, their discussion focused on how the system could be used to meet their needs and how much money they could afford. Budgetary concerns, which impact the search and procurement process, were central to each discussion. Knowing all of the costs involved to implement a CMMS will enhance understanding the benefits derived from its use.

Implementation Costs

The cost of implementing a CMMS system continually declines. Today, even a town of 10,000 people can afford it. The costs can be broken into several categories.

Hardware Costs.
Currently, workstations cost as little as $1,000. Larger agencies requiring top of the line equipment can purchase a dedicated server to handle all database needs for less than $5,000. Many times, the hardware costs are a sunk cost because the workstations are already in place.

Software Costs.
Improved competition between CMMS vendors has resulted in price breaks. An agency can purchase off-the-shelf CMMS systems for less than $10,000. Previously, the cost might have been $100,000 to $250,000. Microsoft has also improved competition of relational database software with its introduction of Access and Microsoft SQL Server. Now, an agency can select a database platform to meet their needs while still complying with Open DataBase Connectivity (ODBC) standards.

Data Gathering Costs.
More and more agencies have available electronic information on their system. Many have their maps automated in AutoCAD, Microstation, Intergraph, or ESRI's ArcView. Unique identifiers for assets are part of these documents. Typically, this information can be easily imported into a CMMS system at a low cost.

For those agencies without electronic mapping, the cost of obtaining an accurate street centerline file for an entire county is now as low as $500. The file could be an excellent starting point for the development of a system map used for maintenance management.

BENEFITS

A list of potential benefits derived from implementing a computerized system is the most important element of this paper. These benefits can come in many tangible forms, but can also be intangible.

One benefit, efficiency in reporting, is both tangible and intangible. This paper will offer insight into reporting and documentation utilizing a CMMS. Utilizing a well-structured inventory database integrated with GIS enhances overall management, especially decision-making. Information can quickly be disseminated to service crews, contractors, consultants, and customers. Electronic tracking of complaints and service requests from beginning to end provides another benefit.

Improved Access to Facts

Implementing a CMMS will help tell the story of public works and water resources at the local level. One of the greatest obstacles facing public works professionals today has to do with the general public's unawareness or forgetfulness of how a sound operating infrastructure system affects them. More so, there is even less comprehension about the effort it takes to effectively manage a system. As a result, requesting more funds for an annual operating budget becomes political. From the outside, if your department cannot generate data necessary to support your request, you risk appearing as unorganized or superficial in your request for additional funding. Without providing complete documentation, your request could be viewed as inflated.

Politicians are hesitant to raise rates, or to suggest a bond issue to provide additional funding for your operations. Their hesitation resides in issues based on equity and affordability for their constituents. Increasing water rates impacts disposable income, which, in turn, could affect local commerce. Requests to increase an operating budget requires facts. If you're utilizing a paper-driven system, you might have a difficult time producing the necessary evidence your elected officials will need to effectively communicate to their constituents, the press, city mayor, city council, Chamber of Commerce and an array of other influential groups and individuals. In many instances, existing documentation will not account for all related costs associated with fleet management, equipment maintenance, system rehabilitation efforts, or the actual, real costs associated with responding to customer requests.

"Before implementing our system, we had no accountability," said Jim Shier, Water and Sewer Superintendent for the City of Longview, Washington. When he became director for the system two and one-half years ago, he implemented a basic work order tracking system, which improved productivity by

over 30 percent. This system was very difficult to retrieve useful data from, however, so it was not easily shared across other departments. By using the CMMS system he has recently installed, he is able to generate data for analytical projections of future rate increases based upon the data collected and organized in his CMMS. Data available from the software has already been used to justify more staff.

The ability to generate hydraulic models and view system performance provides objectivity. “We use aerial photos overlaid with our sewer layer to educate the public on system problems,” said Steve Hodges, Engineering Technician, City of Paris, Texas. The City of Paris has spent about $800,000 over the past 12 years developing their CMMS and GIS. Their mapping resources are impressive. In the late 80’s, the city utilized GeoDesk to digitize three-dimensional aerial photographs. The 8X8 photographs depict their city loop area. Once the digitization was complete, they contracted with another organization to provide line drawings of every element in the photos. In 1994, they incorporated satellite imagery from USGS maps. Later, they implemented a CMMS, which would integrate with their comprehensive GIS.

“The time, man hours, and equipment are compounded over and over,” said Hodges about the amount of savings his organization has been able to experience utilizing a CMMS integrated with GIS. “The GIS investment did not bring a real return until a CMMS was integrated to collect, store and track the various features and systems represented by the GIS.”

In 1995, Sanitation District No. 1 of Northern Kentucky became responsible for the maintenance of a collection system encompassing more than 1,100 miles of interceptor sewer and main trunk line. Previous to that time, the district, which is located in the Cincinnati, Ohio metropolitan area, owned and maintained only about 100 miles of sewer line. Today, the Sanitation District serves approximately 300,000 customers in a three-county area.

“The added responsibility meant we had to find a better way to manage our maintenance processes,” said Tom Braun, Information Systems Manager for the District. Previous to implementing an integrated CMMS, the district used a variety of paper processes, spreadsheet applications, and word processing documents to store system information, “we kept one person busy just looking up history,” he said.

“What we needed was an infrastructure management system that would tie all of this information together so it could be used by all of our departments,” added Braun. Once district personnel chose a software package, they began the process of data conversion and manually entering work history along with inventory data.

Today, Sanitation District No. 1 has input almost all the data from the last five years of operations, which includes about 30,000 work orders, into the software databases. Historical information is readily available simply by selecting or identifying an asset while using the software program.

Improved Data Consistency

Sanitation District No. 1 became aware of utilizing consistent standards while merging existing data sources. Their data sources included a legacy database, which was used to maintain the asset information, and ESRI’s ARC/INFO to create and maintain sanitary sewer maps.

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“We discovered a lot of manhole identifier discrepancies while merging our data,” explained Braun about identifying approximately 25,000 manholes in the system. Previously, crews were able to enter manhole identifiers using the legacy program to track asset information. Since the legacy system did not validate the manhole numbers, crews could easily enter inaccurate identifiers without knowing it. By using a CMMS instead of a spreadsheet and other unrelated programs, the District was able to reduce errors and consequently save time and resources. Having access to consistent and accurate information located in a database will lead to more effective decision-making for the District.

The synchronized data from the legacy database and ARC/INFO coverages were used to create the initial sewer network. Using the ARC/INFO coverages, their CMMS automatically populated their server databases. The CMMS also had tools they utilized to import the general asset information from the legacy database.

Having been through the software implementation and data conversion process, Braun says integration between maintenance management and GIS has been effective for the district. “We are able to create (electronic) pin maps of work requests quickly,” he said, data validation functionality of the CMMS provides a high degree of confidence of the data’s accuracy for analysis of future rehabilitation work.

“Right now, we are going through our system assets item by item,” said Shier from Longview, “I expect once our database is built, complete analysis of our geodatabase will help to further direct maintenance and rehabilitation efforts.” Software available on the market today is very comprehensive according to Shier. The amount of detail and fields available for populating information allows the user to chose the level of information they collect to make appropriate management decisions, he said.

The issue of consistency becomes more important when a city experiences significant growth spurts. For example, the City of Greeley, Colorado has been experiencing substantial growth for the last 10 years. The city expects a consistent growth over the next 10 years averaging an additional 15% in population every five years. Currently, on average, the city adds 12.8 linear miles of sanitary sewer line per year.

This year, the city completed a six-year effort to inventory all 5,800 manholes in the system. Before implementing an infrastructure management system, a consistent data management standard did not exist for the city. Now, the organization relies on integration between inventory, maintenance management and GIS software to enhance scheduling of routine maintenance and rehabilitation activities. They have developed standards for entering attribute information into the CMMS.

“Before, everything was on paper and was not tracked,” said Tony Braun, Information Analyst for the City of Greeley Water and Sewer Department, “now it’s much easier to retrieve infrastructure information.” Braun added he has recently utilized the CMMS to create a new root-cutting schedule. Having GIS integrated with a facility maintenance system gave him quick access to infrastructure attributes. It also enables his management team to view past rehabilitation projects and to plan future rehabilitation activities. “It’s easier to communicate work with crews because we can print a map and give it to them,” he said adding that the visual aid helps to eliminate confusion.

Improved Reporting and Analysis Capabilities

Reviewing cleaning logs will also become much easier for the Water and Sewer Department in Greeley. Prior to implementing an infrastructure maintenance program, their staff would regularly check two large three-ring binders to determine maintenance activities. If a claim were filed with the city, the department would have to research the logs to locate the last two or three cleaning dates for the sewer line. Searching through the notebooks to retrieve the dates was a time consuming activity. Next year, the city plans to utilize its CMMS to create a cleaning history for each segment, ultimately making the information available instantaneously.

Their current cleaning schedule is based on the number of backups per sub basin. Their system includes 10 sub basins. On an annual basis, they clean 1,853,280 feet of sanitary sewer line. “Our project next year will be to track our sub basins by the number of customer calls,” said Braun about utilizing the software functionality to determine maintenance procedures.

Greeley has been using CMMS to prioritize rehabilitation work resulting from television inspections. “Our selection is made easier because we can use TV inspection ratings to prioritize pipe rehab,” said Braun, “we spend less time reviewing video tapes.” On average, Greeley saves about 10 hours per report to summarize inspection results.

“We are saving money because we can query the system for pipes in the ground 50 or 60 years and fix them before they collapse,” said Hodges of system rehabilitation efforts in Paris, Texas. The Paris system includes 30 sub basins and 2,000 manholes. The City routinely performs TV and manhole inspections along with regular smoke testing.

“We used to wait for a line to break before any maintenance was done on it,” said Hodges about how rehabilitation efforts were prioritized in the past. Now, their procedures have changed becoming pro-active instead of reactive. They input results from the thorough inspections into the CMMS. Once all data has been populated, they generate hydraulic grids to indicate which segments need attention.

The City of Paris also uses the functionality of their CMMS to compile and generate year-end reports. Previous to implementing their computer system, they would spend 40 hours on average to generate the report. Hodges would have to dig through paper documents for each sub basin and make several calls to the Public Works department located 1.5 miles away to verify the records. Now, since his reporting is automated and networked, he spends only about two hours verifying information. In addition, the city engineering and public works departments have also taken an interest to the information housed in the database. Access to the databases along with the ability to automate reports has resulted in more frequent requests for various reports, he said.

“Our old system of doing the (year-end) report was archaic,” said Dave Elgin, City Engineer, City of Cedar Rapids, Iowa. The sanitary sewer infrastructure system in Cedar Rapids has 8,000 manholes, 13 major basins, four pump stations and 800 miles of sanitary sewer line. The system provides service to four cities: Hiawatha, Marian, Robins and Cedar Rapids.

“We kept stacks of thousands of work orders completed throughout the year. At the end of the year, we

would go through to categorize each one and produce the report." Completing the report the old way took about 150 man-hours. Utilizing a CMMS, his staff is able to produce the report electronically and have it ready for presentation in about 20 hours.

Improved Customer Requests and Work Order Tracking

The staff at Cedar Rapids has also changed the way it handles work order completion. "Our prior system was sorely lacking documentation. We would start with a paper note, which would not always get conveyed to field crews," said Elgin, "they would get busy doing something else and would lose track of the work request. A few days later, we would be talking about something else and would verbalize, 'Hey, what ever happened…' and then we would realize we forgot about the request."

Now, with the CMMS, the work order stays open until a supervisor closes it. Elgin further explained how generating a work order request using a CMMS actually takes one or two minutes longer to complete. "Now we are tracking everything. Tracking in more detail takes more time," he said.

"Data acquisition has increased geometrically," added Shier from Longview, "you have to understand it is no longer raw, it is all part of the geodatabase we're building every day." Shier predicts once his database is more fully populated, he will be able to generate work orders four times faster than he can today. Today, his staff can generate work orders in 15 minutes to one hour depending on the level of difficulty for the problem. In the future, generating work orders will be done in as little as two minutes for a routine request while difficult requests will require 30 minutes to document.

"Once our system is fully populated, we will be able to run queries almost instantaneously," Shier said. He added other benefits to having a work maintenance module include tracking all costs associated with the work orders, performing real-time status checks before contacting customers and developing a more complete budget, which would include all costs associated with completing requests.

These benefits are also evident in Paris, Texas. Hodges explained how their process became more efficient. Before implementing the work maintenance module of the CMMS, the Public Works department would send crew, equipment and fleet they thought would be able to handle the problem. Sometimes they were right, sometimes they were not. Now, each work request comes complete with a listing of required materials, equipment and fleet. A PW supervisor can schedule crew electronically based on their craft, trade or certification. Hodges said a part of the previous work order request process included making a phone call to the public works department to verify the request had been scheduled. "Now, we do a quick filter to check the status, there is no phone call," he said.

The ability to query the system to determine which work order requests are still active is another benefit of implementing a CMMS. Advanced filter functionality integrated with GIS can enhance understanding of how a system is operating and pinpoint areas requiring attention.

"We have worked really hard to input the data as quickly as possible," said Randy Moore, Collection Systems Foreman with Sanitation District No. 1 in Ft. Wright, Kentucky, about the huge project of converting details from thousands of work orders spanning the last five years of system operation. While searching for an appropriate software selection, Moore realized how integrating data between the work

management module and GIS could potentially bring cost savings to the district along with more efficient utilization of resources. “GIS is the foundation of our CMMS,” he said of the district’s final choice, “all features are created in GIS prior to access in the databases. The integration enables us to produce detailed maps of work requests.”

Improved Maintenance Productivity

After entering the initial data into the system, Moore recreated his routine maintenance work using the CMMS databases and software functionality called subsets. “Now we have the flexibility to schedule work by drainage areas,” explained Moore about using subsets, which help him to order the system’s work orders using integrated spatial analysis.

Maintenance supervisors can easily locate features requiring maintenance; view those features in GIS; and, then limit the selected set to a specific geographical area to create a work order for a crew’s daily work, said Moore. Scheduling work directly from a map allows more efficient resource utilization by centralizing the work performed. Once work is completed, this work history is available to CMMS users through ESRI’s ArcView and the rest of the CMMS database suite. The CMMS provides a complete history of each line, all the work performed on the line, and a list of all of the equipment used to complete each task, he said.

Moore says scheduling the work by flow basin has saved the district 40 to 60 labor hours per month.

“We are making better decisions and more efficiently scheduling work,” said Shier collaborating. He further explained how he was able to increase productivity 30 percent at his facility just by implementing an electronic work order system. Utilizing an electronic system provided the means to easily track and review crews’ work.

Utilizing advanced spatial analysis features provided by integrating GIS and a work order management system has provided more data to effectively evaluate solutions Shier said. He can more effectively manage the facility and increase the daily productivity with the same amount of staff, he added.

“Our TV inspections will take the same amount of time and our crews will drive just like they always have,” said Elgin from Cedar Rapids, “they have a timeline factor that remains constant no matter how efficiently a software package works.” Elgin’s long-term goal for his facility involves doubling his routine cleaning and TV inspection schedule. Currently, the City of Cedar Rapids Water and Sewer Department annually cleans 40 miles of sanitary sewer line. At the end of 20 years, or 800 miles, they start a new cleaning cycle. Elgin would like to start a new cycle every 10 years. Better record keeping combined with integrated asset data will validate a shift in priorities, said Elgin. Field activities will become more productive having employed data available from the software applications.

The CMMS can also help reduce routine work like cleaning and televising by showing to a supervisor the recently replaced or emergency cleaning activity. Those sections can be dropped from this year’s outine work because they were recently performed for some other reason.

Improved Response Times

“In the past, we have applied for disaster relief from FEMA because our area was flooded,” explained Braun from Sanitation District No. 1 in Ft. Wright, Kentucky. The procedure was tedious and took extraordinary effort to compile all the details necessary to complete the request. “Data was on paper and required searching through files,” Braun said, “if we had to do it again today, since the information is electronic and readily available, we could quickly access it and generate a report.”

Tragedies resulting from natural disasters such as floods and hurricanes require the compilation and distribution of large amounts of data. However, the occurrences of natural disasters are not the only events where large data acquisition becomes a necessity. Annexation of the city limits or situations resulting from negligence also require extensive documentation.

“A couple of years ago, we went through the process to annex the city limits,” said Hodges, “it was such a mess. Every time we turned around, attorneys were butting heads.” Hodges explained the battles kept recurring because asset information compiled from as builts, map books and various three-ring binders were not always accurate and up-to-date. The public works department did not have the extensive resources they have today. Today, if the City of Paris were to undergo another annexation process, Hodges predicts his department’s response would be quite different. The ability to quickly produce highly accurate and detailed thematic maps would result in much quicker resolution minimizing his contact with lawyers.

Producing documentation appropriate for settling insurance claims is another challenge. For example, consider a recent situation in Longview. Earlier this year, a contractor damaged 52 linear feet of water line. The damage resulted in a $13,000 expense and nine Public Works personnel working 26 hours overtime to fix the line. Shier had to produce a statement to bill the contractor. Knowing the bill would end up at an insurance agency he gave a high priority to thorough attention to detail.

As expected, once the insurance company received the bill from the contractor they had questions for Shier. Said Shier: “I emailed a report to them that included the pipe identification number along with its location on GIS. I used a digital camera to attach images to the report so there would be no questions about the amount of damage. I had the crews update the databases throughout the day in order to produce an outline of their efforts. At the end of the day I sent the report.” The ability to produce real time data provided significant cost savings, he said. He was able to reduce staff from several people to just one in order to produce the bill. Staff reduction and a quick turn-around time for the documentation resulted in cost savings for the ratepayers and the contractor.

The insurance company quickly reimbursed all requested funds as a result of the documentation procedures. Having utilized the tools available from the CMMS, Shier was able to divert the use of legal counsel and avoided utilizing additional staff time to compile informational responses to questions from both the insurance company and the contractor.

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Improved Communications Regarding System Needs

Shier has also employed data available from the CMMS to convince the public of the need to increase water and sewer maintenance rates a whopping 30 percent. The Water and Sewer Department sorely lacked the necessary funds to provide basic operations and maintenance activities.

“We added $4.8 million to our water and sewer operations budget,” said Shier. In order the gain public approval for the System Development Charge, or increased budget, the City of Longview presented the proposal as a coupon book. The presentation included the allocation of budget monies for various system activities. From the allotments, the City of Longview subtracted annual costs incurred for items current to the operating budget at that time.

He included a performance measure as a part of the presentation. To measure performance, he took the number of calls and jobs from the previous year of operations and produced dollar amounts based on quantity and activities based costing. He subtracted that figure from the operations budget to determine a deficit in funding. But it didn’t stop there.

By going through this process, the City of Longview was able to provide additional documentation indicating local developers were not paying for the impact they were creating on the existing infrastructure to tap into the system. “Before (implementing the new rate structure) the people paid for developers to make money . . . anyone could cash in on the system and drain it,” said Shier.

The presentation concluded with an outline allocating the usage of the new funds. The basic outline is as follows: 11 percent increase in capital improvement expenditures; nine percent increase in treatment plant upkeep and maintenance; eight percent debt service due to plant expansion; and, two percent increase in O&M.

Shier’s experience of relating his goals for the system in Longview provides the basic foundation for the final return on investment of implementing a CMMS. As more communities nationwide implement a CMMS in a single local agency, word will spread to other local agencies about how the CMMS has impacted daily operations. Discovery about the benefits of integrated GIS with work order management and customer complaint tracking systems will entice more PW professionals to learn more about such systems. Examples of more efficient asset management and facilities maintenance will provide a new standard for routine operating procedures.

Improved Coordination between Departments

“We are just now in the process of implementing a street program,” said Hodges of the CMMS in Paris, Texas, “once it is complete, we will be able to graphically display rehabilitation for all streets on the GIS. Say we have a proposed water line addition, for example. Having access to integrated data will tell us if the water line should go under the street because the street will soon need to be resurfaced, or if we should place the water line behind the curb because the street is in good condition.”

To further make the point, Shier points out that implementing a common CMMS between several departments is the most cost efficient method to implementing an infrastructure management system. It

saves money on networking and developing a server. Plus, the greatest advantage for everyone involved is access to the database information. Potentially, street crews will electronically check the water and sewer department's maintenance schedules to enhance coordination of activities.

Once citywide integration is established, it is only practical to suggest another return on investment centers on community planning and development. As more communication begins to take place between various local agencies, the city-planning department will become more involved. Their involvement will begin at first as requests for information on system capacity for proposed subdivision developments; or they will query the system to learn beforehand how providing service to a new large industrial customer will impact the system.

"Annexation areas will be planned more wisely," said Hodges of his experience. He added consultants would still need to be involved, but he felt their role would slightly change. The change would occur because the city would be able to provide precise, electronic information about the system and its assets to initiate projects. The new information format will serve to streamline consultants' efforts creating additional cost savings.

SUMMARY

Implementing a CMMS provides improved access to facts, data consistency and enhances reporting and analytical capabilities. These systems provide public works directors, superintendents and other water resource professionals with valuable knowledge and insight about their operations and performance levels.

Having these facts electronically integrated throughout all system modules provides even more opportunities to effectively manage a system and should become a catalyst for implementing a CMMS. Strategic value can be placed on improved tracking of customer requests and work orders, maintenance productivity and response times, which are real and measurable benefits.

As CMMS becomes more commonplace, even more value and benefit can be found as multiple area agencies utilize the system to communicate their needs and to coordinate their maintenance and rehabilitation activities. Data management will become the newfound methodology to infrastructure management practices.

ACKNOWLEDGEMENTS

The authors wish to extend their gratitude and appreciation to everyone who helped make the research and the writing of this paper a possibility. Special thanks to everyone who volunteered to participate in the survey used to research this paper. Very special thanks go to those individuals referenced in the paper for their willingness to share their stories about their particular agencies.

About GBA Master Series™ Infrastructure Management Software

The *GBA Master Series* is a suite of infrastructure management software programs designed for use by public works and water resources professionals. The *GBA Sewer Master*® program can utilize detailed inspection data to identify and prioritize needed manhole and pipe repairs. *GBA Water Master*® assists in rehabilitation, replacement, and expansion planning along with system trend analysis of water distribution systems. The *GBA Storm Master*® program can use inspection data to identify and prioritize needed conduit and structure repairs. *GBA Street Master*® is a highly detailed inventory database enabling accurate forecasting of future maintenance needs for pavement and roads along with analysis of accidents. *GBA Work Master*® can track customer complaints, track resources and costs of maintenance and rehabilitation activities, and schedule preventative maintenance work. The *GBA GIS Master*® program is an extension of ESRI's ArcView® GIS software, and can be used for intelligent mapping.

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