METROPOLITAN SEWER DISTRICT of greater CINCINNATI

Necessity is the Mother of Invention: MSD of Greater Cincinnati's Use of Technological Innovation to Lower Costs for Customers

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"A crow perishing with thirst saw a pitcher, and hoping to find water, flew to it with delight. When he reached it, he discovered to his grief that it contained so little water that he could not possibly get at it. He tried everything he could think of to reach the water, but all his efforts were in vain. At last he collected as many stones as he could carry and dropped them one by one with his beak into the pitcher, until he brought the water within his reach and thus saved his life."[1] Moral of the story? Necessity is the mother of invention.

Like the crow in this Aesop fable, the Metropolitan Sewer District of Greater Cincinnati (MSD) was pressed to find a solution to a knotty issue: how to make a $3.2 billion Consent Decree to reduce combined sewer overflows (CSOs) more affordable to its customers in an urban area with high rates of poverty.

As a Midwestern utility serving more than 200,000 households and commercial users, MSD turned to a technological innovation as practical as adding pebbles to a pitcher of water: using the existing collection and treatment system to reduce CSOs instead of building expensive new infrastructure.

Historical Background

Like other "legacy city"[2] sewer utilities across the United States, MSD negotiated a settlement agreement (Consent Decree) with the U.S. EPA, Ohio EPA, and ORSANCO[3] to reduce combined sewer overflows (CSOs) and eliminate sanitary sewer overflows (SSOs) by making wet-weather capacity improvements to its sewage collection and treatment system. This unfunded federal mandate was put into effect in 2002 and 2004. During a typical year, about 11 billion gallons discharge from more than 200 CSO outfalls along local rivers and streams in Cincinnati and Hamilton County. One of these waterways is the Mill Creek, an industrialized and channelized urban waterway running through the central City that was once critical to the city's and county's early residential and commercial development. In 1997, it was designated by American Rivers as the "most endangered urban river in North America."[1]

MSD's $3.2 billion Consent Decree is structured to eliminate specified SSOs, to reduce the volume of CSO discharges, and to adjust the utility's ability to treat wet weather flows in the system, approximately 40% of which is a combined system. Improvement in water quality is an optimal by-product of this effort. MSD's Phase 1 series of Consent Decree projects are designed to provide sufficient volumetric capacity where needed, to provide variable stormwater source control to reduce the CSOs when and where possible, and to improve the ability to treat wet weather flows that reach the end-points of the system. These end-points are comprised of three river-based wastewater treatment facilities that were initially constructed between 1953-1961 during one of the first phases of sewage treatment in the middle Ohio River Valley. Phase 2 of the Consent Decree will be developed in 2017 and implemented after 2018.

The MSD Consent Decree enforces criteria for getting to "clean," with the specifics outlined by a U.S. District Court-approved wet weather improvement plan (WWIP). Re-inventing and re-invigorating Hamilton County's 188-year-old sewer system to comply with modern pollution control requirements is not only technically challenging – as most sewer assets are complex networks of buried pipes – but fiscally exasperating as well. The improvements delivered as a result of MSD's Consent

Decree WWIP are publicly financed expenditures, paid for by sewerage services costs (rates), that create questions of equity for all rate-payers.[2] The Cincinnati Standard Metropolitan Statistical Area has a 14% rate of urban poverty among its residents (30% within the center city of Cincinnati), including crisis levels of childhood poverty in its center city. Consent Decree costs have spawned a need to innovate technologically.

The Innovation

Sewers and wastewater management and the civil engineering behind its processes are nothing new in a historical context. So, use of the term "innovation" in this industry is rather odd for what is basically a 2,000+ year old technology. After all, there are only so many ways that humans can transport and treat their waste products in an urban setting in ways that have not been used before throughout history: pits and channels, chemical and biological treatment, membrane filtration, aeration, flocculation, and incineration, UV disinfection, interceptor sewers, flow monitors, combined sewer overflow controls, SCADA monitoring and controls and deep-tunnel storage. The historical goal of sewage control in American cities is to find the "ultimate sink" (or way to deal with urban wastes), the perfect confluence of technology and ability to modify and control the environment to suit human ends and protect human health.[3] But what if the innovation is not in new devices, but a combination of existing technologies in ways that have not yet been used? What if the outcome, the "invention," is to make the sewer system more useful and able to respond to rapid changes in flow through its pipes without taking away human control and accountability?

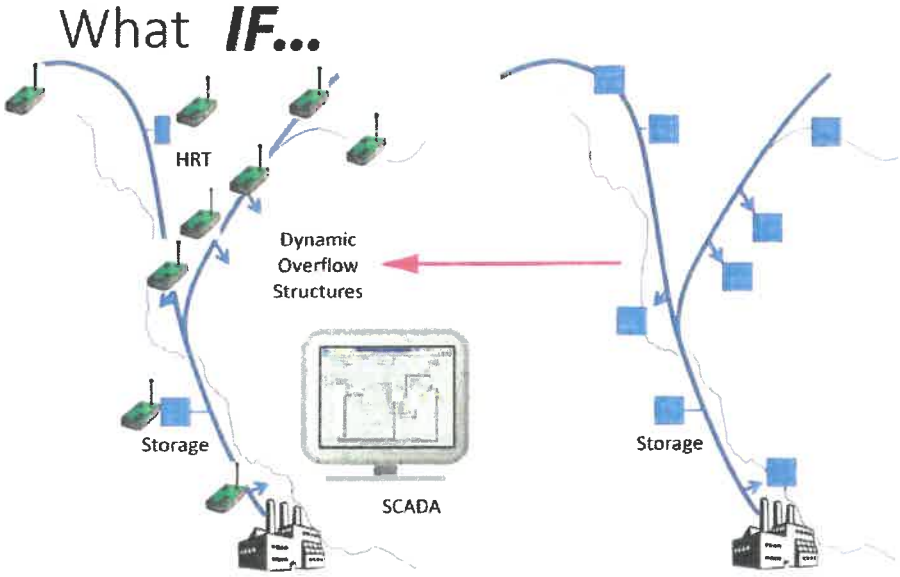
To that end, MSD is developing a smart sewer system that uses existing infrastructure combined with "real-time" controls, including sensors, gates and a computer-controlled monitoring system (Wet Weather SCADA). These "real time controls" are a paradigm shift in wastewater management: instead of only building bigger pipes, deeper storage tunnels, or new treatment plants, the utility can use, store, or divert excess flows to existing sewer lines, storage tanks or treatment facilities that have available capacity, thus reducing CSOs into local streams and rivers. South Bend, Ind. recently invested in a similar technology, which is projected to reduce its Consent Decree spending by 27%. MSD's new system is anticipated to save tens of millions of dollars in capital investments in Consent Decree projects.

How it Works

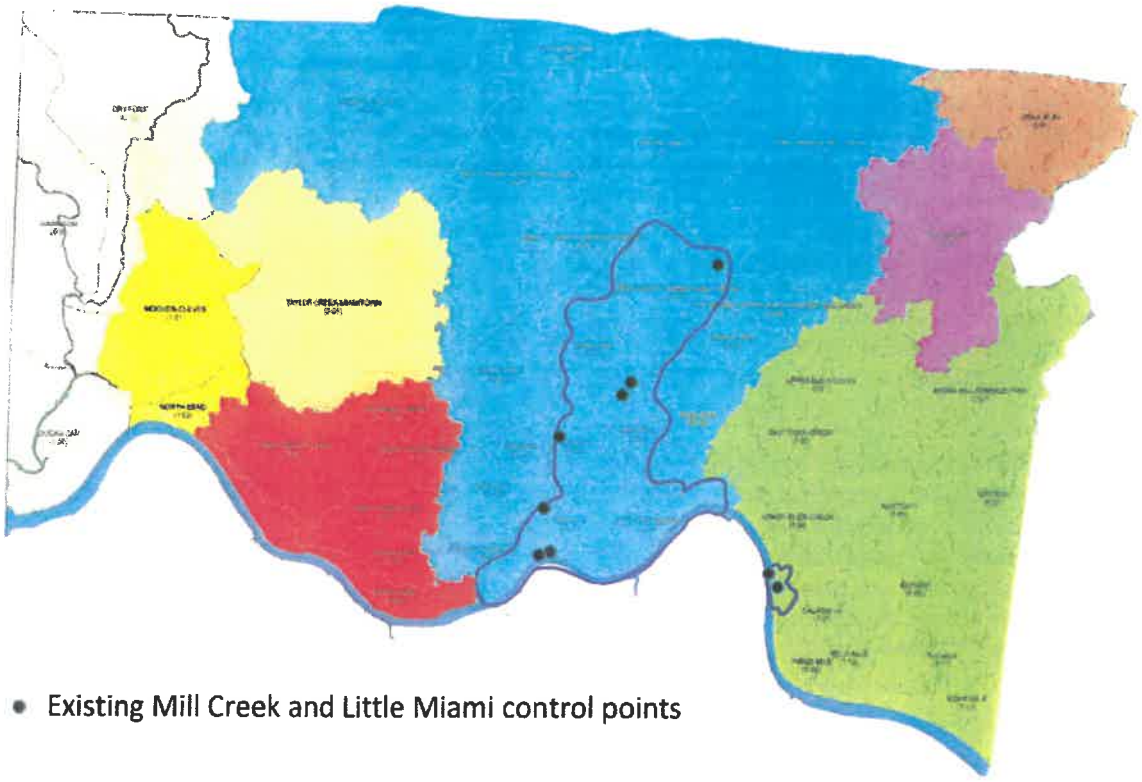
MSD sought to identify new ways to maximize capacity, repurpose existing sewer pipe, and develop a robust and dedicated SCADA control system to better effect the control of CSOs than traditional methods of static weirs and dams, and more costly measures like deep tunnels. MSD began by asking such questions as: "What if we could use all available capacity in our pipes before overflows occurred?" and "What if we could use an unused storage tank to reduce overflows many miles away?" MSD recognized that its best opportunity in managing a "dumb" system was to make it "smart:" to innovate by turning upside-down the traditional uses of sewer infrastructure and re-thinking the best use of its existing infrastructure. What if over 100 miles of interceptor and large diameter trunk sewers and several wet weather facilities, linked to a modern remote command and control SCADA system, could maximize the conveyance and treatment capabilities of this extensive infrastructure during rain events? Rather than manage system problems during wet weather, what if the paradigm was shifted, leveraging technology to operate the MSD collection system as an extension of the receiving treatment plant? Dynamic adaptability and flexibility would augment – and maybe even supplant – a static sewer system that was continually expanded over the last 100 years.

If a sewer collection system was to become "smart" and innovatively operated like a treatment plant, MSD would need to possess real-time command and controls to monitor, evaluate, and operate/control sewage flows throughout its pipe network. MSD created such a system through advanced, reliable, and low-cost cellular-based remote monitoring technology, installing over 140 sensors to "see" what's happening in the system. MSD also gave the new system a "brain" consisting of a new SCADA-based system platform on which it is building the visualization and analytic tools, similar to what is used to monitor and control treatment plant processes.

In early 2015, the District deployed its new Wet Weather SCADA system covering Mill Creek, its largest service basin. MSD is now able to guide wet weather control based on flow predictions and real time data, detect some instances of

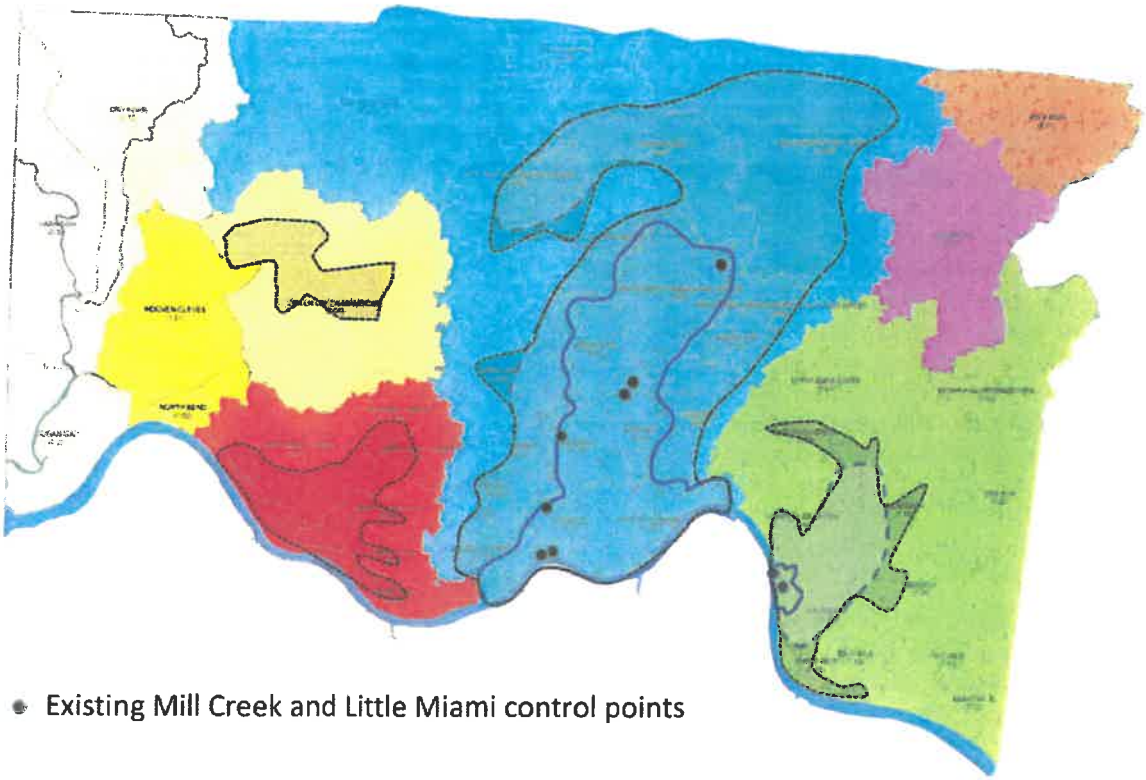


Wet Weather SCADA System Coverage June 2015



- Existing Mill Creek and Little Miami control points

Wet Weather SCADA System Coverage June 2016



- Existing Mill Creek and Little Miami control points

river intrusion, and provide advanced alerts to operations and maintenance staff. This connectivity leveraged tying the existing wet weather control facilities developed under the Consent Decree into the new Wet Weather SCADA system.

This transformational technology provided real-time observation of the District's wastewater system over a large geographic area. Within the first several weeks, it was used to manage storage tank dewatering at a wet weather facility, avoiding 1.4 MG in overflow at a location nearly 11 miles away. It was also relied on to isolate large volumes of river intrusion during a period of Ohio River flooding, allowing the MSD treatment plant operators to direct the more concentrated wastewater to the plant for treatment. By limiting the intake from areas with higher river intrusion, the water temperature intake at the receiving plant also rebounded, resulting in more effective BOD treatment.

Added to this matrix of smart system command and control is an opportunity to dynamically maximize and re-purpose the MSD wastewater collection and treatment system to serve new ends: to develop an interactive – rather than reactive – system that will enable its static components to change the physical status at various points in the system, the ability to make a change in the physical system that modifies the hydraulic conditions, and thereby stores, conveys or treats more sewer flows.

Summary

Like Aesop's crow, MSD was faced with what seemed like an insurmountable problem and invented or innovated its way to a new, more affordable solution.

MSD's identification of technological innovation to manage wastewater evolved through a need to comply with its federal Consent Decree with scarce local resources. Its use of real-time controls allowed MSD to maximize its capital assets, both those that were required under the Consent Decree and those that were part of an existing system, creating a next level evolution of the traditional sewer system designed to collect wastewater through gravity and treat sanitary flows at a system endpoint. It allowed for on-going development of an adaptive sewer system that, while nearly 200 years old, is still able to serve the needs of its customers, grow to allow changing development to succeed, and be able to help in controlling costs of Consent Decree improvements. And, it recognized the reality that "legacy city" sewerage utilities can and must still protect the public health and the environment in an era when the sunk costs of the existing system must continue to be of value in order for it to fulfill its duty.

The authors of the article are City of Cincinnati employees working at the Metropolitan Sewer District of Greater Cincinnati. The Sewer District is a State of Ohio county sewer district, that is based upon a collaborative arrangement between 43 Greater Cincinnati municipalities, townships, villages, and the County of Hamilton, and is situated in the southwest corner of the state. It is managed by the City of Cincinnati's Department of Sewers under a 50-year agreement with Hamilton County, executed in 1968.

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References

1 Aesop's Fables, "The Crow and the Pitcher," http://www.aesopfables.com/cgi/aesop1.cgi?1&TheCrowandthePitcher&&crowpitc2.ram

2 As defined by the International City/County Management Association, "legacy cities" are "former industrial powerhouses and urban economic hubs rich with history and culture dotted throughout the Northeast to the Great Lakes regions that experienced dramatic decline through the 1980s." See http://icma.org/en/icma/knowledge_network/blogs/blogpost/1436/New_Strategies_for_Revitalizing_American_Legacy_Cities. Also see A. Mallach and L. Brachman, Regenerating America's Legacy Cities, 2013, Cambridge: Lincoln Institute of Land Policy. Approximately 772 urban communities across the U.S. contain "legacy" sewers infrastructure, mainly located in the Northeast, Great Lakes regions, and Pacific Northwest.

3 Ohio River Valley Water Sanitation Commission. Chartered by the 74th U.S. Congress in 1936 and ratified in 1948, ORSANCO was a mid-20th century multi-state effort at water pollution control, and a forerunner to U.S. environmental protection efforts that led to the U.S. Environmental Protection Agency in 1970. ORSANCO, First Annual Report, 1948-1949, 1949, Cincinnati.