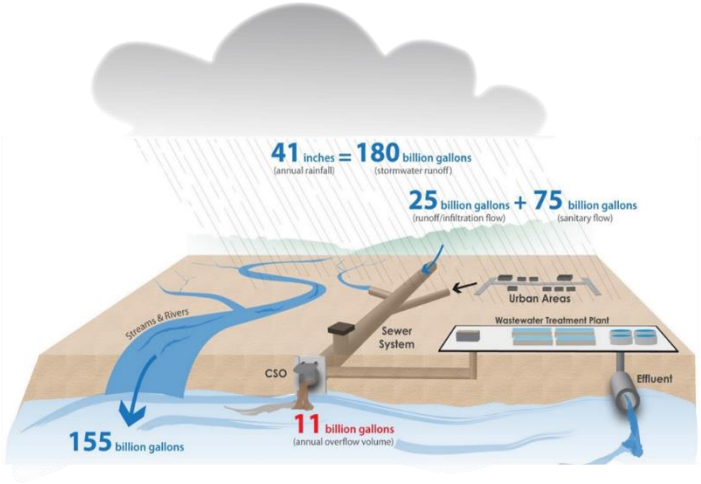
The Case for Operational Optimization

MSD of Greater Cincinnati's Wet Weather Challenge and Opportunity



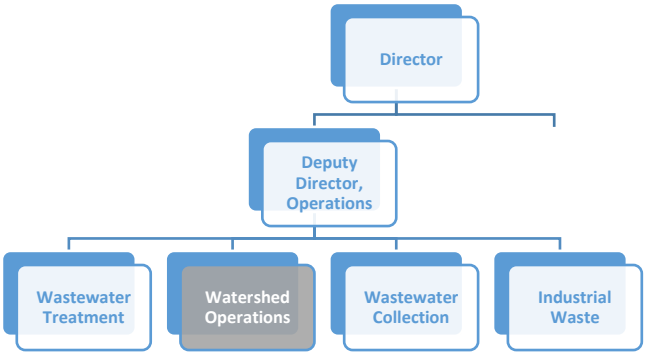
Southwest Ohio experiences over 40 inches of rain in a typical year, and, as is common in an urban environment, long or intense periods of rain can overwhelm the existing infrastructure and overflow into the nearby creeks and rivers. MSDGC's collection system contains more than 200 such overflow points. Together these overflows used to discharge over 11 billion gallons of combined flow into the Ohio River and its tributaries during a typical year. MSDGC is implementing a comprehensive multi-billion dollar, multi-decade Wet Weather Improvement Program (WWIP) to address these overflows and is approaching the end of its first phase of project implementation.

MSDGC's WWIP takes several approaches to reducing wet weather overflows. It includes a systematic effort to remove stormwater from the system through sewer separations as well as the targeted increase of conveyance capacity through pipe upsizing. However, the need to construct additional facilities to store and treat the large and sudden wet weather flows that the system experiences was unavoidable. Some of MSDGC's earliest WWIP projects were dedicated wet-weather facilities and to date five in-line storage facilities and two off-line storage and high-rate treatment facilities have been constructed specifically to address wet weather flows. These new facilities provided a *challenge*, and an *opportunity*. They challenged MSDGC to operate and maintain additional assets that had specific performance objectives with respect to wet weather overflow reduction, but also provided MSDGC the opportunity to add a new element to its approach to reducing wet weather overflows. To address this *challenge*, MSD formed the Watershed Operations (WO) Division within its organizational structure and tasked it to take advantage of this *opportunity* by implementing a new operational strategy: operational optimization.

Watershed Operations Division: Aligning Organizational Structure to New Realities

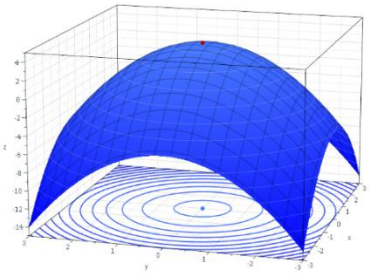
For the first 40+ years of its existence, MSDGC operated and maintained its physical assets through two operational divisions: Wastewater Collection (WWC) and Wastewater Treatment (WWT). These divisions aligned with the traditional separation of assets that has been present in the industry for decades. However, about 10 years ago a new class of assets—one designed specifically for managing wet weather—began coming online as consent decree early-action and Phase 1 WWIP projects were completed. This new class of assets have to deal with flow rates that can shift by an order of magnitude,

or more, are run intermittently based on dynamic weather patterns, are highly automated, and apply technology specific for these conditions. Initially the wet weather assets were divided between the WWC and WWT divisions, however MSD recognized the growing number and criticality of these assets. So, in 2013 MSD formed a new operating division—Watershed Operations—to operate and maintain assets specifically designed for wet weather, be they traditional, green or sustainable infrastructure. In addition to providing a central "home" for all the types of physical assets MSD must maintain to deal with wet weather, Watershed Operations (WO) also became the natural "home" for the tools, processes and people focused on wet weather compliance; hence the inclusion of the Flow Monitoring and Hydraulic Modeling groups within the WO division. MSD affected this change without increasing overall headcount or operating budget of the department but in doing so positioned itself to better address the new reality of consent decree-driven performance mandates.



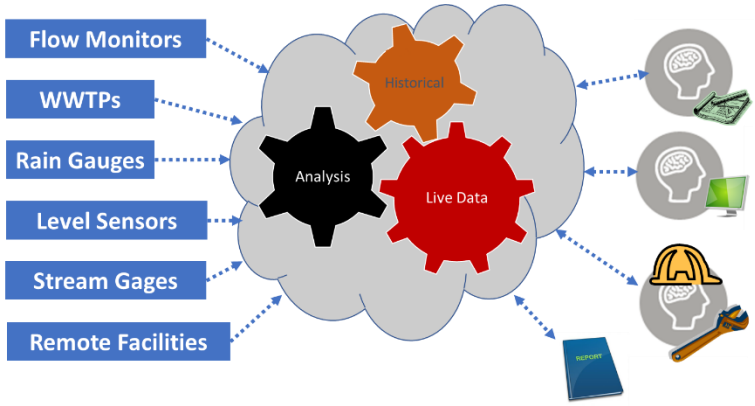
Operational Optimization: An Operational Strategy to Complement the WWIP

With a mandate to maximize benefit to the watershed at the lowest cost, Watershed Operations began operating MSD's wet weather assets and looking for ways to get every drop out of all of MSD's existing assets. Could we use all the capacity in our pipes before we had an overflow? Could we prevent an overflow by using a storage facility many miles away? Could we ensure the highest strength wastewater makes it to the treatment plant to receive full secondary treatment? The answer was yes, but only if MSD could monitor and control wet weather flows in real time. So Watershed Operations developed a new operational strategy called operational optimization. Operational optimization, as it relates to wet weather overflows, is the active control of the collection system and dedicated wet weather facilities in real-time to maximize utilization of existing infrastructure and minimize releases to the environment. This is an operational strategy that complements the progress of the WWIP. While MSD continues to identify and build new infrastructure as detailed in the WWIP, it is also implementing an operational strategy that complements the goals of the consent decree by purposefully getting the most out of existing assets, and even pushing some past their original design intent. Operational Optimization is the way MSD can build less new infrastructure, and thereby reduce the burden on its ratepayers, and still meet the required environmental benefit.



Wet Weather SCADA: Enabling Smart(er) Sewers

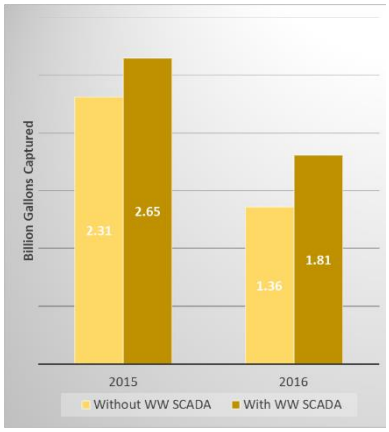
To accomplish Operational Optimization, MSD needed to gain the ability to monitor conditions in the collection system and control its wet weather facilities in real-time. Further, it was clear that Watershed Operations could not achieve these benefits in isolation—its assets are interspersed and intertwined with the existing Collection and Treatment assets and depend on their harmonious functionality. While several options for remote monitoring of a collection system exist (many sensor vendors have very capable platforms to accomplish this function) these systems lack the ability to control facilities remotely. Looking across the wastewater sector, it became clear that what MSD was aiming to do was to operate the collection system like its Wastewater Treatment Division operated a treatment plant, and to do that it needed a supervisory control and data acquisition (SCADA) system. With that vision in mind, MSD implemented a SCADA system dedicated to wet weather operations that provides it the visibility and control necessary to maximize the conveyance and treatment capacity of the entire wastewater system during wet weather.



Early Benefits of Smart Sewers

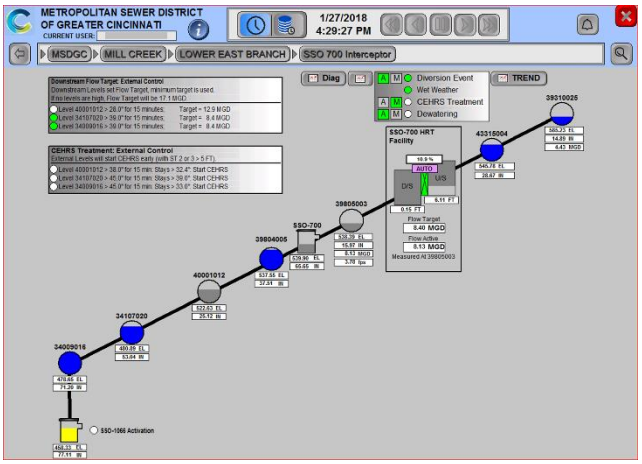
The first benefit of the Smart Sewers was the improvement of the legacy flow monitoring program. Prior to forming the WO division, all flow monitoring was performed to support projects in various stages from planning to post-construction and cost MSD between $3.5 and $4.5 M a year. In the first year of implementation of the WW SCADA system, that cost was reduced to $2.2 Million a year at the same time as the program was expanded to include all monitoring, not just of flows, done in the collection system. Currently the Remote Monitoring Group manages approximately 600 sensors in the field, four times as many monitors as was in the original flow monitoring program, for an annual cost of $2.7 Million a year.

The second benefit was demonstrated through a 2-stage study of four dedicated wet weather facilities. In the first stage of the deployment (2015), the WW SCADA provided Watershed Operations real-time monitoring capabilities at these four facilities. In that relatively wet year, these facilities prevented a total of 2.65 billion gallons of overflow, 15% more than the facilities would have been able to prevent without the added capability afforded by the WW SCADA system. In the second stage of deployment (2016), the WW SCADA added real-time control capabilities on top of real-time monitoring capabilities and saw an even bigger improvement in wet weather performance. In that year, relatively drier than 2015, those four wet weather facilities prevented a total of 1.81 billion gallons of overflow,



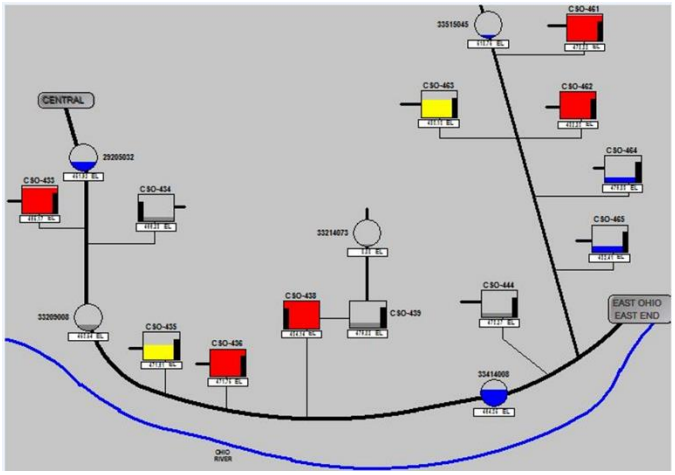
which was 33% more than those facilities would have captured prior to the WW SCADA system being in place.

The third benefit of the Smart Sewers has been the optimization of the SSO 700 HRT facility. Beyond the real-time monitoring and real-time control capabilities added to the facility, as was done at the four wet weather facilities discussed above, Watershed Operations was also looking for ways to leverage existing infrastructure beyond its original design intent to further reduce wet weather overflows. The SSO 700 HRT facility located at the boundary between the separate and combined sewer systems in the Mill Creek Basin was a prime target. Level and flow sensors had been added all along the interceptors in the Mill Creek both above and below this facility. In 2017, data from these sensors were fed back into the local controller for the SSO 700 HRT facility, so for the first time the facility could "see" conditions beyond its adjacent interceptor. In addition, more advanced control logic was programmed into the local controller so that the facility could now act upon the new data. With the new logic, the facility modulates its diversion gate to actively divert flow into the facility when conditions downstream indicate the collection system is being overwhelmed. Under extreme conditions, it completely closes the gate, isolating the upstream separated system from the downstream combined system. Not only does this virtually eliminate sanitary sewer overflows from the constructed overflow structure, but the preliminary analysis of 2017 data shows that SSO 700 overflow volume is reduced by up to 50%, even with the facility's tank overflow included.



Another benefit of the larger watershed perspective, provided by the WW SCADA, is the ability to prioritize the treatment of high strength wastes from industrial dischargers during certain wet weather conditions. For example, when the MC TP is experiencing extreme flows or the lowest reach of the interceptors are surcharging above the surrounding creek level, an industrial discharger that normally releases its wastes into the Collection System is alerted to restricted conditions and instructed to haul their waste directly to the plant. The WW SCADA detects these conditions automatically, triggers an automated signal light at the discharger's loading facility, and sends email and text messages to staff both at the discharger's facility and at MSD 's MC plant. A second discharger, located upstream of a specific CSO, has agreed to implement different operations when the downstream CSO activates. Under these "code green" conditions, the discharger reduces their releases to the combined sewer by as much as possible, as to minimize their contribution to a release to the environment. The watershed perspective, combined with the monitoring and control capabilities of the WW SCADA, helps MSD do everything it can to reduce the threat to residents, and it costs nothing to send an email or text.

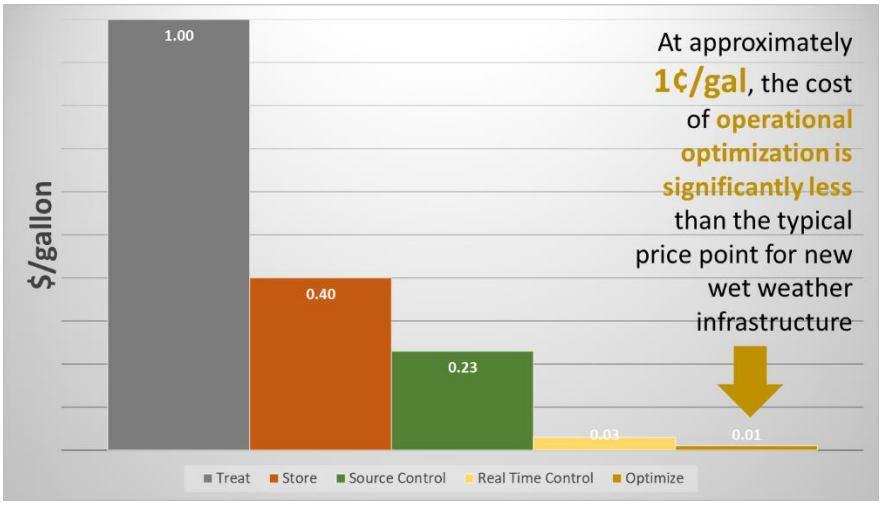
The visibility of conditions in the collection system that MSD has gained by implementing the Smart Sewers has also uncovered additional opportunities for operational optimization. By monitoring levels in the sewers and interceptors together in real time, MSD can now see times and places where overflows are occurring while capacity still remains within the receiving interceptor. As the accompanying graphic from MSD's Wet Weather SCADA illustrates, five CSOs are overflowing (red squares) while the interceptor (partially filled circles) is not full. This counterintuitive situation is created by the very real spatial variation of rainfall during a storm and exacerbated by the underflow pipe between the sewer and the interceptor being a small diameter, typically sized for a set multiple of the flow expected when the sewer was first built. However, if the underflow was replaced with a larger diameter pipe and controlled with a gate, MSD could respond in real time to that natural distribution of rainfall, capture more flow and convey that flow to the existing treatment plant through the existing interceptors. This tactic, called dynamic underflow control, was first explored in the Little Miami basin where eight CSOs were identified as good candidates for such improvements. A screening analysis that compared a planning level cost estimate to its volumetric reduction identified five locations that would achieve results at less than $0.10 per gallon. The two locations with the lowest unit cost ($0.03 and $0.01 per gallon) are currently being designed and are to be constructed by December 2019. Additional analysis of the Mill Creek Basin and the Muddy Creek Basin will similarly uncover the most cost effective locations to add these optimizations in those watersheds.



Laying the Groundwork for Water Quality Improvements

Controlling quantity has been the initial focus of the WWIP and the wet weather SCADA system, but what is even more exciting is the opportunity that the Smart Sewers provide MSD to operate is assets in such a way as to have the smallest impact on water quality. Sensors detecting water quality parameters can be tied into the same monitoring and control infrastructure as is used now to collect volumetric data, and would inform operational decisions in real time. Preliminary analysis of relative CSO strength based on land use, user account density and type is complete and would be corroborated by this data to identify when and where an overflow would pose the smallest risk to the public and have the lowest impact on the environment. With an increased number of physical controls on the underflow and overflow pipes at CSO structures integrated through the wet weather SCADA, MSD would be able to operate its system to the benefit of the entire watershed.

A Welcome Approach to Dealing with Affordability Concerns



While not explicitly required by the consent decree, this approach has been extremely well received by the industry and the USEPA. Over the last two years, MSD has presented its finding at Water Environment Federation conferences numerous times, was the most widely discussed case study in the Water Research Foundation's Intelligent Water System Focus Group's regional workshops and national summit and upon hearing about what MSD was doing, staff from the USEPA invited MSD to present directly to Office of Water and Office of Enforcement and Compliance Assurance staff. Through two live-cast webinars, each over an hour long, more than 75 USEPA staff from offices across the country have learned how MSD has implemented operational optimization, and how its Smart Sewers have improved wet weather performance at extremely low costs per gallon. As word spreads, cities from Chattanooga to Atlanta to Washington, DC are routinely contacting MSD to learn more about this approach such that now MSD is looked to across the country as a leader in finding more affordable ways to achieve compliance.