When upgrading its water resource recovery facility on Spring Creek, the Springfield (Ill.) Metro Sanitary District designed with operations in mind. By bringing together operators and designers, the district found more-sustainable solutions and enabled a smoother transition from manual to automated control.
Springfield Metro Sanitary District

From manual to automatic at Spring Creek of

How designers and operators teamed up to smooth the transition

Adrianne Eilers

When the time came for the Springfield (Ill.) Metro Sanitary District to replace the water resource recovery facility (WRRF) located on Spring Creek, staff members faced a leap into the future. The original Spring Creek facility had served the community for 84 years. To achieve a similar return on investment from a new facility would require the most advanced equipment, processes, and technology.

Converting a manually operated facility to a fully automated one posed a significant transition for the district's staff, but despite the growing pains, the changes were made more manageable through close collaboration between the designers and district staff so that operational and maintenance needs could influence the decision-making process and be incorporated into plans.

To make the transition from conventional activated sludge to biological nutrient removal, it was essential from the beginning of design for the design team to interact with the district staff. Weekly meetings included relevant design team members and the district's leadership, along with operations and maintenance staff. Design decisions were explained to the district, and timely feedback ensured that all team members were comfortable with the equipment selection, sizing, and operations. The feedback also allowed for operators' practical knowledge to be incorporated into the design.

Multiple flows

Springfield is a combined sewer overflow (CSO) community, a configuration that prompted a unique design solution for the new facility. The new WRRF provides screening and grit removal not only for its current influent flow of 302,800 m^3/d (80 mgd) and a projected peak influent flow of 408,780 m^3/d (108 mgd) but also for an additional 151,400 m^3/d (40 mgd) of CSOs.

Designing for the wide range of flows created challenges for the layout of the influent pump station – which follows screening and grit removal. In the current design, after 454,200 m^3/d (120 mgd) of wastewater flow is screened and degritted, the flow must be split, with 302,800 m^3/d (80 mgd) being sent through the new facility and 151,400 m^3/d (40 mgd) routed to the existing CSO treatment facilities across the street.

Efficient split

To arrive at an optimal solution, multiple iterations and layouts for the influent pump station were completed. The preliminary design used submersible dry-pit pumps in two separate wet wells – one to handle the WRRF influent flow and the other for CSO flow. However, using two standby pumps incurred increased equipment, operations, and maintenance costs. Based on past experience, district operations staff also had concerns about maintaining submersible dry-pit pumps safely. These concerns were brought to light early in the process, and the decision was made to find an alternative design.

The next design concept employed a single common wet well and one set of pumps. The discharge manifold was laid in so that flows could be transferred between the Spring Creek facility and the CSO treatment facilities across the street.

Here again, a cascading series of consequences became apparent. First, the large peak influent flow would require pumping, which, in turn, would require large-diameter discharge piping and valves.

Determining the correct isolation valve was difficult. Plug and butterfly valves would add significant costs to the project, while more affordable knife valves typically are not used in influent wastewater applications because of the potential for leakage due to debris buildup.

Added to the flow-splitting challenge was ensuring that a

consistent flow of 302,800 m^3/d (80 mgd) would be pumped to the new facility continuously during CSO flows. The situation meant that automatic control of a large-diameter valve would be required to limit the flow to the CSO facilities. An automatically controlled valve required significant capital cost and may not have allowed accurate flow control due to potential limiting modulating capabilities.

The final concern related to pump hydraulics was how the wide flow range would affect pump-flow capacity. As the influent flow increases and multiple pumps are brought on-line, the additional flow achievable by each pump diminishes; this is because the head loss through the force main increases with the increased flow.

The pump hydraulics in this design option did not allow for the selection of efficient pumps along the wide flow range, so it was decided that yet another layout option should be considered.

Headbox solution

Would a headbox solve the problem? Since the head losses were not vastly different from the influent pump station to the new facility and between the influent pump station and existing

Installing pipe galleries beneath the new facility enabled the district to eliminate buried valves, house process equipment, and provide additional indoor working space for operations and maintenance personnel. Crawford, Murphy & Tilly

CSO facilities, a headbox proved to be a viable option and was incorporated into the final plans.

The headbox is located approximately 5 m (15 ft) above grade and enables flow to be split between the wastewater and CSO treatment facilities through a downward-acting weir gate. As the influent flowmeter reading approaches 302,800 m^3/d (80 mgd), the gate begins to lower, and CSO flow is diverted over the gate to the existing CSO facilities. The weir gate then maintains a maximum of 302,800 m^3/d (80 mgd) flowing to the WRRF.

The influent pump station consists of three 56,775-m^3/d (15-mgd) low-flow vertical turbine pumps and four 113,550-m^3/d (30-mgd) high-flow vertical turbine pumps, with space available for a fifth high-flow pump for future build-out.

Each pump is piped to the headbox individually, where it discharges above the high-water level. Baffle plates were installed between the discharge pipes to prevent water from entering the adjacent discharge pipe. Because the pumps discharge above the high-water level, check valves and isolation valves were not necessary and were eliminated from the design.

By piping the pumps independently, the rate of pumping for one pump does not affect the others as the influent flow increases. To provide a seamless transition of pumping rates, variable-frequency drives were installed to provide turndown capabilities during low flows.

Compared to the previous two design options, the headbox concept provided a simpler system. It eliminated piping, 13 large-diameter valves, and one standby pump. These changes, in turn, reduced the maintenance and operations time at the influent pump station. In addition, the headbox enabled pumps to be sized to provide a seamless transition of flows along the entire flow range from 37,850 to 567,750 m^3/d (10 to 150 mgd). The result is a more operator-friendly facility that maintains constant flow by matching the pumping rate to the influent flow rate.

How the treatment process works

The new Spring Creek water resource recovery facility is able to handle a daily average flow of 121,120 m^3/d (32 mgd), with a peak flow of 302,800 m^3/d (80 mgd). The new process incorporates five phases: preliminary treatment, primary treatment, secondary treatment, disinfection, and post-aeration.

Preliminary treatment

The preliminary treatment process will handle a future peak flow of 408,780 m^3/d (108 mgd), along with an additional 151,400 m^3/d (40 mgd) of combined sewer overflow (CSO). Preliminary processes consists of four sets of components:

- Three 13-mm (0.5-in.) bar and rack screens, each with a screenings grinder and washer/compactor that can handle 189,250 m^3/d (50 mgd) each.
- Three 6-mm (0.25-in.) perforated-plant screens, each with a screenings washer/compactor that can handle 189,250 m^3/d (50 mgd) each.
- Two 283,875-m^3/d (75-mgd) vortex grit-removal systems, each with a grit classifier.
- A 567,750-m^3/d (150-mgd) influent pump station that uses a headbox to transfer flow to the existing CSO facilities and to the primary treatment process.

Primary treatment

The primary treatment process consists of four 43-m-diameter (140-ft-diameter), 3-m-deep (10-ft-deep) primary clarifiers with associated scum and sludge removal processes.

Secondary treatment

The secondary treatment process runs in a modified University of Cape Town activated sludge configuration, which allows for the biological removal of phosphorus and total nitrogen. The two parallel trains of vertical-loop reactors provide a combination of aeration and mixing in the system and are designed to run anaerobic, anoxic, and oxic processes.

The tank design enables operators to change the anoxic and oxic tank configurations to provide the most effective treatment possible. In addition to the activated sludge tanks, six 43-m-diameter (140-ft-diameter), 5-m-deep (16-ft-deep) secondary clarifiers with associated scum and sludge removal complete the secondary treatment phase.

Disinfection and post-aeration

Following secondary treatment, ultraviolet disinfection satisfies the seasonal disinfection requirement. A post-aeration system uses both a cascade aerator and diffused aeration to ensure proper dissolved-oxygen levels prior to discharge.

Exhuming valves

One of the primary design objectives that arose through consultation with management and operations staff was the desire to minimize buried valves on the process piping. The staff had experienced operational and maintenance issues with buried valves at the existing facilities.

The solution was a concrete pipe gallery that extends from the operations/laboratory building to the east cluster of the secondary clarifiers – a distance of 580 m (1900 ft). The gallery provides underground access to valves, pipes, fittings, flowmeters, and pumps that normally would either be buried or located in separate structures. The access corridor is located on the south side of the activated sludge tanks. A center corridor runs between the parallel trains of the activated sludge tanks and connects the south corridor to the north corridor. The gallery provides access to equipment associated with the east and west clusters of the secondary clarifiers, the activated sludge tanks, and the primary clarifiers.

The corridor also houses the blowers and the chemical-feed system required to operate the facility. Piping within the corridor ranges from 75-mm (3-in.) plant water piping to 1500-mm (60-in.) influent process piping.

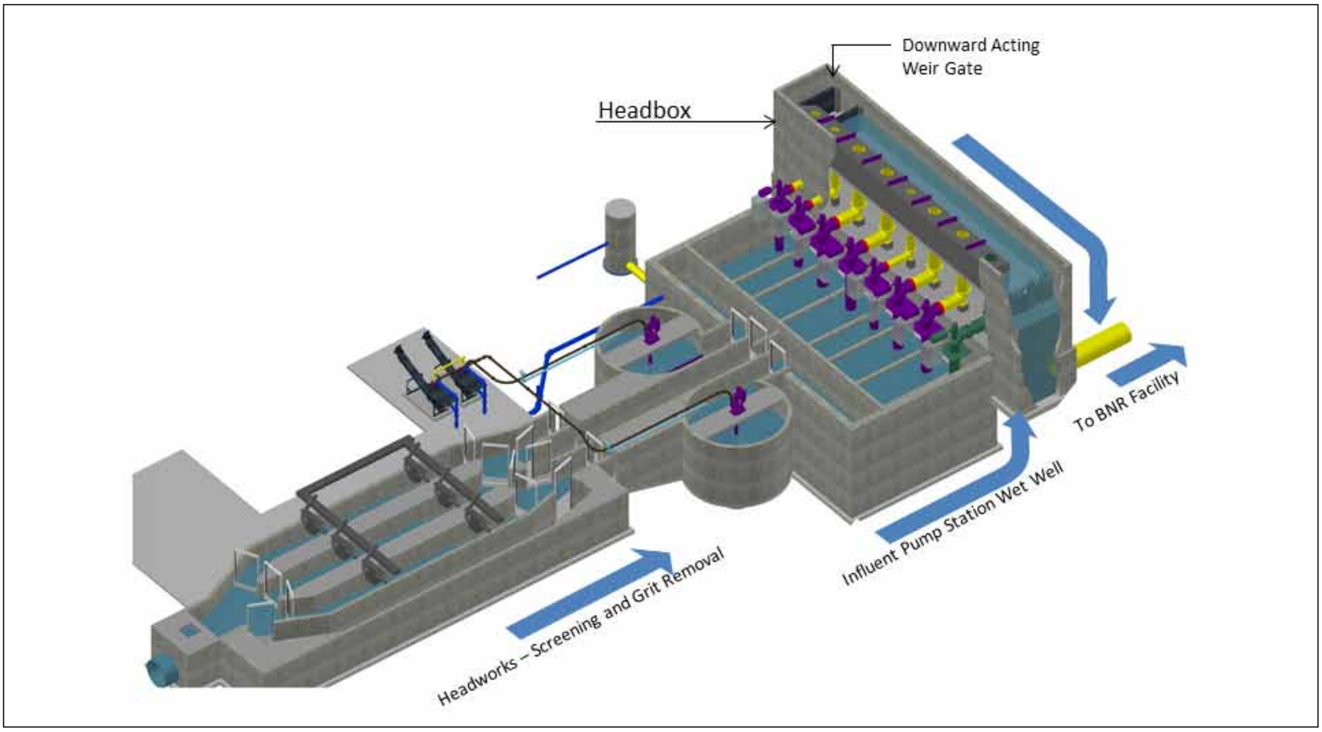
Having access from the operations building, staff members do not have to step outside to check on a significant portion of the equipment. The corridor also provides a sheltered space to maintain and repair equipment.

The corridor also eliminated the need for structures to house such equipment as the primary sludge pumps, primary scum pumps, internal recycle pumps, return activated sludge pumps, waste activated sludge pumps, drain pumps, chemical-feed system, and blowers. The gallery eliminates a potential safety hazard of confined-space entry points that would be associated with the various pump stations and structural vaults needed to house the underground equipment. With easier access to the equipment and valves, district staff spends less time getting access to the equipment and more time on maintenance and operations.

Automating controls

Most of the original Spring Creek WRRF was operated and maintained manually. Operators collected daily operational data by hand, and a card-catalog system tracked equipment maintenance. The switch to an almost completely automated system clearly would require a significant adjustment by the district staff.

To simplify the learning curve, a collaborative process was implemented from the beginning. The integration of the automated systems was treated as a design element, rather than a turnkey process. During the design, several visits to other WRRFs were



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BNR = biological nutrient removal.

completed to ensure that the operations staff was comfortable with the automated control system that would be used. In addition, before startup, nonpotable water was circulated through the new facility to verify that the equipment and automated systems were working properly. An effluent recirculation line, originally designed to return a portion of disinfected effluent to the influent pump station to provide additional flow during low-flow conditions, was used to maintain forward flow of nonpotable water through the facility to enable staff to become familiar with the equipment operations and automated controls prior to official startup. Concurrent with recirculating the nonpotable water, the staff was being provided with manufacturer equipment training and operations and maintenance training. Recirculating flows enabled the staff to receive hands-on equipment training with the entire facility in operation.

The new WRRF incorporates a supervisory control and data acquisition (SCADA) system that includes more than 4000 input and output points. The system features instant equipment-failure alarms, along with instant feedback from various flowmeters, probes, and other equipment, all at the touch of the staff's fingertips. The SCADA system monitors various parameters in real time and adjusts the process to optimize treatment.

For example, variable-frequency drives are installed on the pumps, blowers, and disc aerators and integrated into the SCADA system to provide precise control over motor speed so that current needs can be met without wasting energy. Using the SCADA system optimizes the equipment by providing real-time adjustments. The system also enables the staff to track the trends of various parameters and tweak the overall operation of the system to provide the best treatment possible.

In addition to the SCADA system, a computer maintenance and management system keeps track of equipment needs. This system gives the staff instant access to the required maintenance schedules for each piece of equipment. The program develops daily, weekly, and monthly maintenance schedules to ensure that all equipment is maintained according to its specifications in their respective operations manuals. Operations and maintenance manuals are loaded into the system, granting quick access to any system user and eliminating the need for multiple sets of printed manuals.

Pulling it all together

An essential part of the design for the Spring Creek WRRF was the integration of operations personnel. Their involvement carried all the way through to construction and startup. Operations staff accompanied the consultant to other WRRF facilities that used similar equipment and technologies so that they could become familiar with that equipment prior to their formal training. When the plant was ready to go live on July 16, 2012, the district staff was prepared to make the leap from a manual to a fully automated environment.

The district and its engineering partners now are working together on improvements to a second treatment facility located on Sugar Creek. A collaborative approach is being used again, along with the lessons learned from the Spring Creek project.

While the Spring Creek facility consistently meets its effluent permit requirements, the true benefits of the new technology may not be realized for years to come as operations are refined and performance is optimized by district staff.

As with all new or upgraded WRRFs, the startup and early operation of the plant has required some troubleshooting. However, the close collaboration between the design team and district staff unquestionably made possible a smoother transition from a mostly manually operated activated sludge plant to a fully automated biological nutrient removal facility.

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