Keeping Up with the *Flow*

Major retrofit corrects problems at both ends of the process for a Missouri district

By Steve London

The U.S. Clean Water Act became the preamble for a volume of more stringent water and wastewater treatment regulations. Scores of engineers and utility plant managers have searched since then for reliable processes, technologies and equipment to help make treatment facilities comply with the evolving guidelines. Many earlier-generation plants are undergoing upgrades to meet present and future water quality standards.

ARTICLE SUMMARY

Challenge: Higher peak flows due to population growth were straining the ability of the Atherton Wastewater Treatment Plant, which was also having odor control problems and difficulty meeting more stringent regulations.

Solution: An $72-million upgrade provided the plant with new submersible mixers, a pump station, deeper clarifiers, a variable frequency drive and SCADA.

Conclusion: The system is adaptable and flexible enough to meet the state's DNR discharge requirements when the utility confronts high-peak flows of influent; the two remaining basins give the plant expansion capacity.

This includes a sewer district's plant in Independence, Mo. The Atherton Wastewater Treatment Plant (WWTP), operated by Little Blue Valley Sewer District (LBVSD), undertook the retrofit to correct operational issues at both the influent and effluent ends of the process chain. The plant supports a large service area that now takes in the high-growth suburbs on the east and far southeast reaches of Kansas City.

When built in the early 1980s, the plant was the first large-scale application of a proprietary intrachannel clarifier that qualified for the U.S. Environmental Protection Agency Innovative & Alternative program. The design reduced the primary process chain to preliminary bar screening and aerated grit removal, while relying solely on secondary treatment performed in four stand-alone 42-by-400-ft aeration/clarification basins.

The $73-million retrofit changed the plant to a more conventional activated sludge process. The scope of work included the modification of two of the four existing oxidation ditches and mothballed the other two. Four 1.48-million-gal primary clarifiers were built, along with five 2.38-million-gal secondary clarifiers and an upgrade to the influent pump station. To correct discharge problems, a five-pump effluent pump station was built; its 640-hp direct-drive pumps can overcome blocked discharge, which occurs when the Missouri River level rises and blocks the plant's normal reliance on gravity flow.

"This now allows four modes of operation depending on the flow level," said Stan Christopher, P.E., vice president of HDR|Archer Engineers. "We applied proven methods and technologies but in an innovative combination of components."

The original facility entered service in the early 1980s on the 80-acre site a mile south of the Missouri River. The plant was rated at a 40-million-gal-per-day (mgd) average dry-weather flow and an 80-mgd peak flow. Flows greater than 80 mgd were treated in a peak flow clarifier. The service area underwent significant development during ensuing years, bringing even higher peak flows and straining the plant's abilities. The plant also battled odor emissions from the solids disposal facilities. These issues and potential regulation changes for plants that discharge into rivers made the Atherton plant a prime candidate for the upgrades.

Bigger Is Not Always Better

The original design relied on mechanical mixers to maintain a 1-ft/second velocity in the 17-ft-deep sewage flow as it circulated around the perimeter of the 6-million-gal oxidation ditches configured with turning walls to further promote mixing. The aeration channels included 571 membrane diffusers that introduced fine bubbles of dissolved oxygen from the channel bottoms as the continuously charged mixed liquor underwent biological treatment.

Almost from the outset, however, the process that had worked effectively elsewhere on a small scale was ill suited for the wet-weather hydraulics of a plant as large as the Atherton WWTP.

The original mixers were long-blade, variable-speed, hydraulic-type units powered by external motors and hydraulic pumps. These mixers proved vulnerable to wear induced by the extended transfer of power to the props. The motors and even their mounting masts began failing. In addition to needing recurring maintenance, the mixers failed to deliver the consistent velocity sought for the aeration zones in the oxidation channels. A review of work orders revealed a string of recurring failures, ranging from broken prop blades to broken hoses and faulty seals that leaked hydraulic oil.

The district replaced the first-generation mixers with 16 ITT 5-hp electric submersible mixers supplied by Flygt, arranged in a double battery of eight, each at the ends of the channels. These submersible units were fitted with "banana-blade" fiberglass props that rotated at 42 rpm to steadily propel and churn the mixed liquor suspended solids (MLSS) as they flowed around the channel. Under stable hydraulic conditions, the plant performed its mission. But as many of the Atherton WWTP operators can attest, hydraulic conditions were not always stable.

The plant was sometimes confronted by excessive peak flows caused by inflow and infiltration along the municipal collection systems served by the district. In the wake of the most significant rainfall events, the peak flows presented problems at both ends of the process chain. The influent flow could then reach 10 times or more the dry-weather flow and flush the process. On the effluent side, the level of the Missouri River could block the gravity flow from the plant's 126 ft discharge line. More often than not, the river level could just as easily rise from storms far upstream from the service area as it could from local storms.

"The original process relied on stable conditions and could never really cope with our range of flows," said Bill O'Brien, the district's operations manager. "The biggest issue during times of poor performance was almost always hydraulic related. When able to be in compliance, only the plant operators' skills enabled the facility to meet the weekly/monthly quality averages reported to the state DNR [Department of Natural Resources]."

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Forging New Links in the Process Chain

Since the plant entered service, the district had hired Archer Engineers, acquired since by HDR and operating as HDR|Archer. The local engineering firm led a joint venture with CH2M Hill to design the recent $73-million upgrade. The program focused on a broad scope of measures to handle the plant's existing issues and prepare it for possibly stricter environmental regulations pertaining to ammonia, total nitrogen and phosphorous limits. Both proven and innovative design solutions applied to the retrofit.

The project increased the Atherton WWTP's capacity from 40 mgd to 52 mgd average dry-weather flow and partially addressed the issues associated with peaks. Some measures are subtle, such as maintaining deeper clarifiers. Others stand out, such as the powerful effluent pump station with five 100-mgd Flygt Model PL7121-640 HP propeller pumps recommended by engineers within locally based JCI Industries.

These Flygt PL-7000 pumps are equipped with a solids-handling propeller that features a patented self-cleaning volute that clears the propeller of all debris that reaches the pumps. The backward-swept propellers are less sensitive to fouling by debris than other propeller types. The unique concept is more reliable than more common water-type "propeller pumps" and enables the plant to consistently cope with changing river levels. Other upgrades prepared the plant to add bionutrient removal and instilled more flexibility and control over the process—not only from the central station's SCADA system but at various stages along the flow.

Two of the four existing 4.2-million-gal oxidation basins were modified. The existing intrachannel clarifiers were removed and dividing walls added to allow for a plug-flow arrangement. Dividing walls subdivide each basin into three channels with seven zones. The piping allows for a step-feed arrangement during normal peak flows. Swing zones, now incorporated into the process chain, enhance the nutrient removal and optimize the enhanced biological treatment process that achieves compliance at the lowest operating cost.

After passing through the primary treatment, the flow enters the first zone of the basin, where up to 30% of the primary effluent is pumped through the common wall by a Flygt propeller pump to the end of the second pass through the basin in Zone 5. This additional feed location allows the return activated sludge (RAS) to achieve a higher system solids retention time without increasing the loading to the clarifiers. The Flygt Model PP 4640 4-HP pumps accomplish this task by pumping up to 7.8 mgd of the primary effluent through the common wall, eliminating the need for any additional piping, throttling valves or additional pump station structures. A variable frequency drive allows a 100% adjustment of flows to optimize performance and save energy.

The RAS flow enters the first zone, where it mixes with a separate entry of the primary effluent as well as the MLSS returned from Zone 5 at the end of the second pass through the basin. The flow first enters the basin where it can be operated as a swing zone and can be either anoxic or aerobic depending on flow and treatment requirements.

Two Flygt model 4680 40-hp mixers work in conjunction with the flow from the two Flygt PP4670 20-hp recycle pumps to mix in this anoxic zone and provide homogenization of the influent, RAS and recycled MLSS. The recycle pumps are positioned strategically to save energy and equipment costs. Not only do they provide the necessary return-flow pumping but also the benefit of mixing in the anoxic zone to supplement blending requirements. The reduced number of mixers also delivers savings both in equipment cost and energy use.

After the flow has traveled two passes through the basin and oxidized the ammonia, the two 20-hp pumps return the nitrified mixed liquor through the common wall. Each pump can advance 26 mgd to the anoxic zone and thereby increase the nitrate load in which excess readily biodegradable carbon exists for denitrification. The oxygen is consumed here from the nitrate to lower the total oxygen requirement, thereby leading to reduced total energy necessary to sustain the biological process while removing high levels of nutrients. The flow advances through the basin with a tapered diffused aeration system. The system is adaptable and flexible enough to meet the state's DNR discharge requirements when the utility confronts high peak flows of influent.

The two remaining basins give this upgraded plant significant expansion capacity. But for now, the once challenged Atherton WWTP steadily performs its mission, even with some rather unique flow ranges.

Additional upgrades that are scheduled to go into construction shortly as part of Phase II of the WWTP upgrade include biosolids drying, incineration and disposal, disinfection and nitrification improvements and conveyance system improvements.

Alberici Constructors, St. Louis, served as the general contractor and accomplished the improvements while the plant remained in full operation during year-round flow conditions. WWD

Steve London is president of Steve London Associates. London can be reached at 215.361.3630 or by e-mail at slondon@comcast.net.

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