

Waterscapes

In This Issue Nutrient Removal and Facility Optimization

Wastewater treatment plant owners, operators and engineers across the country are facing new and increasingly more stringent discharge permit limits, and thus more challenges to nutrient removal. Regulatory agencies are restricting the allowable discharges of nutrients such as nitrogen and phosphorus to surface water bodies; these nutrients are further limited in groundwater infiltration rates and land applications.

Meeting these challenges while protecting the investment requires the innovative use of existing facilities to maximize treatment capacity and performance while helping to soften the economic impact of additional permit requirements. Implementation of advanced technologies — such as biological phosphorus removal — and ongoing applied research and process optimization can facilitate this somewhat daunting task.

This issue includes articles on process innovations that reduce operating costs; applied research on biological phosphorus removal process performance; and regulatory impacts on phosphorus-rich biosolids disposal.

Optimizing a Large Nutrient Removal Plant

By Heather Stephens, PE

To protect water quality in the slow-moving Tualatin River, treatment plants operated by Oregon-based Clean Water Services must meet stringent nutrient limits. During the summer permit season (May through October), the 40-mgd Durham AWWTF must achieve an effluent phosphorus limit of 0.07 mg/L; during late summer, it must meet an ammonia-nitrogen limit as low as 0.4 mg/L.

The nutrient limits were initially established in 1989, and Clean Water Services was given a demanding compliance schedule to upgrade its facility. Given the limited worldwide experience with meeting very low nutrient limits, the new standards posed a challenge to HDR's design team.

Based on full-scale pilot testing conducted at Durham AWWTF, the plant was initially configured to remove phosphorus using a combination of chemical precipitation, biological uptake and effluent filtration. The activated sludge process was configured with a series of anaerobic, anoxic and aerobic cells, and two internal recycle streams to provide EBPR, BOD removal, nitrification and denitrification. The denitrification step was not needed for permit compliance (there was no nitrate limit), but was used to recover alkalinity and reduce the cost of lime addition.

During the initial years of operation, Clean Water Services was primarily concerned with permit compliance and relied heavily on chemical precipitation for phosphorus removal. Initial alum dosages in 1993 averaged 170 mg/L; however, through continuous process improvements and optimization, the alum consumption was reduced to 60 mg/L by 1997.

By that same year, plant staff had gained confidence that they could reliably meet the effluent limits, and a team of operations specialists from HDR and Clean Water Services initiated an active program of applied research and process optimization to enhance performance and reduce operating and capital costs. This effort focused on improving EBPR performance, which had been erratic to date. It appeared that the performance of this system was compromised by inadequate concentrations of VFAs in the primary effluent and the presence of oxygen in the anaerobic zone.

To address the VFA issue, two primary sludge thickeners were converted to the UFAT process (see *Patented Fermenter Process, SSM Drive Innovations* in this issue of *WaterScapes*). Returning the elutriate from the UFAT tanks to the activated sludge process sufficiently augmented VFA levels to allow consistent biological uptake of phosphorus.

Several steps were taken to reduce the introduction of oxygen to the anaerobic zone, including eliminating primary-effluent flow-split structures that entrained air; trimming the mixer blades in the anaerobic zones to minimize air entrainment resulting from vortex formation; and investigating nitrate levels in the return activated sludge (which turned out to be negligible).

To meet the increasingly stringent ammonia-nitrogen limits, equalization tanks were built for dewatering centrate, and this ammonia-laden stream was metered back to the activated sludge process to avoid spikes in ammonia loadings. Also, the large, final-stage aerobic basins were converted from a complete-mix to a plug-flow reactor (PFR). The PFR provided more stable performance and was better able to attenuate peak ammonia loadings. Finally, the relative sizes of the anaerobic, anoxic and aerobic basins were optimized to eliminate sludge bulking issues and maximize treatment capacity.

With these process improvements, a number of benefits have resulted:

- **Stable performance during summer permit season.** The improved EBPR achieves ortho-phosphorus concentrations of

0.2 to 0.3 mg/L in the secondary effluent, and the full plant achieves total phosphorus concentrations of 0.04 to 0.05 mg/L in the final effluent. Final effluent ammonia-nitrogen levels are typically below 0.05mg/L, and nitrate-

nitrogen concentrations range from 5 to 7 mg/L.

- **Reduced operating costs.** Alum is used only for effluent polishing, and the dosage has dropped to 20 mg/L. Lime usage has declined slightly. Overall sludge production has been reduced substantially, and the elimination of alum in the primary sludge has achieved a more stable solids handling system. The overall operational savings exceed \$500,000 annually.
- **Reduced capital costs.** The experience gained from the process improvements has resulted in simpler, less expensive biological nutrient removal basins with fewer walls, pumps, pipes and valves. The reduced sludge production has resulted in smaller solids-handling processes and has extended the capacity of existing facilities.

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The evolution of the Durham Advanced Wastewater Treatment Facility involved continuous process improvements and optimization.