Probing FOR IMPROVED BNR

Automating suspended solids control helps a plant maintain consistent nutrient removal

Robin E. Bain and Walter S. Johnson

The 88-mgd (333 080-m^3/d) Clark County Sanitation District treatment plant in Las Vegas, Nev., was recently expanded to meet growth demands and new ammonia permit limits — a wasteload allocation approximately equivalent to 0.71 mg/L. The plant includes an activated sludge process consisting of eight 11-mgd (41 635-m^3/d) aeration basins, each with a dedicated secondary clarifier. During the plant's first year of operation, staff achieved biological phosphorus removal in aeration basins by shutting off the mixed-liquor recycle into the anoxic zones, which provided for denitrification primarily to restore alkalinity.

The cost savings from reduced chemical usage and solids production were substantial ($52/ton, or $57/Mg) and sustainable as long as biological phosphorus removal was consistent. Encouraged by the cost savings, staff investigated process control techniques to maintain reliable biological phosphorus removal.

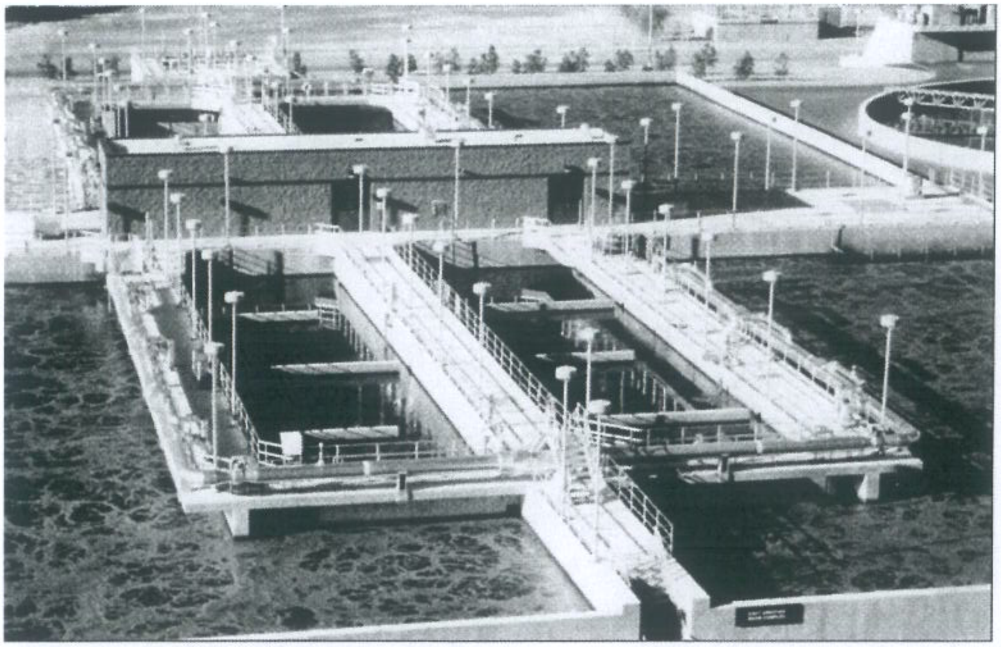
Conventional Control

In any activated sludge process, maintaining mixed liquor through diurnal flow patterns is a key performance parameter. Waste activated sludge (WAS) flow rates determine the mixed liquor suspended solids (MLSS) concentration. At Clark County, operators initially followed the conventional procedure of controlling solids inventory by collecting a grab sample of mixed liquors and then analyzing the MLSS concentration. After establishing a target MLSS, operators used a simple algorithm to calculate the new wasting rate (Q_{WAS}), as follows:

After being moved to several locations, a probe that measures mixed liquor suspended solids was placed in the oxic zone in the corner of the lagoon — far from excessive air turbulence, but close enough to maintain minimum velocities across the probe.

New Q_{WAS} = Previous Q_{WAS} × [actual MLSS (grab sample) ÷ target MLSS]$^{0.5}$

(The square root smooths out the multiplication factor and reduces the shock of change on the biological system.) After determining the new wasting rate, staff would manually adjust



the valve position. However, phosphorus and ammonia removals were inconsistent, so they took a closer look at the activated sludge process.

Problems With Grab Sampling

Normally, operators would grab an MLSS sample and a return activated sludge suspended solids (RASSS) sample from each basin between 6 and 9 a.m. and calculate a 7-day average to determine wasting rates for a particular day. The 7-day averages had been chosen primarily to make up for the lack of better, more representative data. To identify the cause of the nutrient removal problem, staff conducted hourly sampling of the MLSS and RASSS for a 2-week period, and found a substantial range of actual suspended solids concentrations.

As a time-delayed, reactive procedure, manually adjusting mixed liquor through WAS flows has always been an art. Compared with the actual average MLSS in the basins, as seen in the diurnal samples, an MLSS grab sample taken anytime between 6 to 9 a.m. could vary by ±15%, and the RASSS sample by ±40%. Operators realized that adjusting wasting rates based on grab samples was potentially a cause of the inconsistencies. In addition, the procedure required substantial operator time and, for practical reasons, could not be performed more than twice a day. Staff began seeking a way to obtain real-time MLSS data, with the ultimate goal of being able to automatically control mixed liquor through the on-line instrumentation and a distributive control system (DCS) system.

Integrating Probes

Operators installed in an aeration basin a device consisting of a probe, meter, and transmitter that was designed to analyze suspended solids in slurry and send data to the plant's computer. After being moved to several locations, the device was placed in the oxic zone, 4 ft (1.2 m) from the surface and far enough horizontally from excessive air turbulence, but close enough so that minimum velocities of 2 ft/sec (0.6 m/sec) could be maintained across the probe. This location reduced probe fouling and frequency of cleaning. For several months, staff monitored actual MLSS using the on-line device, compared

Cost of the Automatic Control System

Description	With	Without
Annualized Capital Costs[1]	$13 560	$0
Annual Operation and Maintenance Costs		
• monitoring and controlling WAS flow and activated sludge process	$2 450[2]	$42 050[3]
• lab supplies	$260[4]	$3 620
• electricity	$270[5]	$0
TOTAL	$16 540	$45 670
Annual cost savings:	$29 130/yr	

Payback: $91 000[6] ÷ $29 130 = 3.1 years

[1] The capital recovery factor is 0.149, based on a 10-year lifetime and 8% interest.

[2] Operator time to calibrate and clean probes is 3 hr/d every 14 days, or 0.21 hr/d. Personnel costs (including salary, benefits, uniforms) are $32/hr. 0.21 × 32 × 365 days = $2450/yr.

[3] Operator time to collect samples, perform lab tests, and calculate adjustments was 3.6 hr/d. 3.6 × 32 × 365 = $42 050/yr.

[4] Lab supply use was reduced also because tests would be run once every 14 days for calibration instead of every day. 26/365 × $3620 = $260/yr.

[5] Electricity use by each probe is 25 VA.
25 × 1.732 × 0.9 PF × 0.001 = 0.039 kW
0.039 for 16 probes is 0.62 kW.
0.62 kW × 24 hr/d × $0.05/kWH = 0.74/d
0.74/d × 365 = $272/yr

[6] Total cost of 16 probes

concentrations with the target MLSS, and made manual valve adjustments through the computer.

After staff felt comfortable that the MLSS probe device was collecting accurate data, they discontinued daily grab sampling and lab analyses altogether. The computer loop was modified to actuate the WAS flow valve, eliminating the need for manual adjustment. Related to a setpoint MLSS, the probe device signals the valve to adjust its opening, allowing for automated, constant MLSS control.

Automatic wasting can be achieved in a DCS system either by a sophisticated proportional integral derivative loop control system or by an algorithm. The following equation is a modification of the previous wasting rate equation and uses the 24-hour average actual MLSS as determined by the probe device.

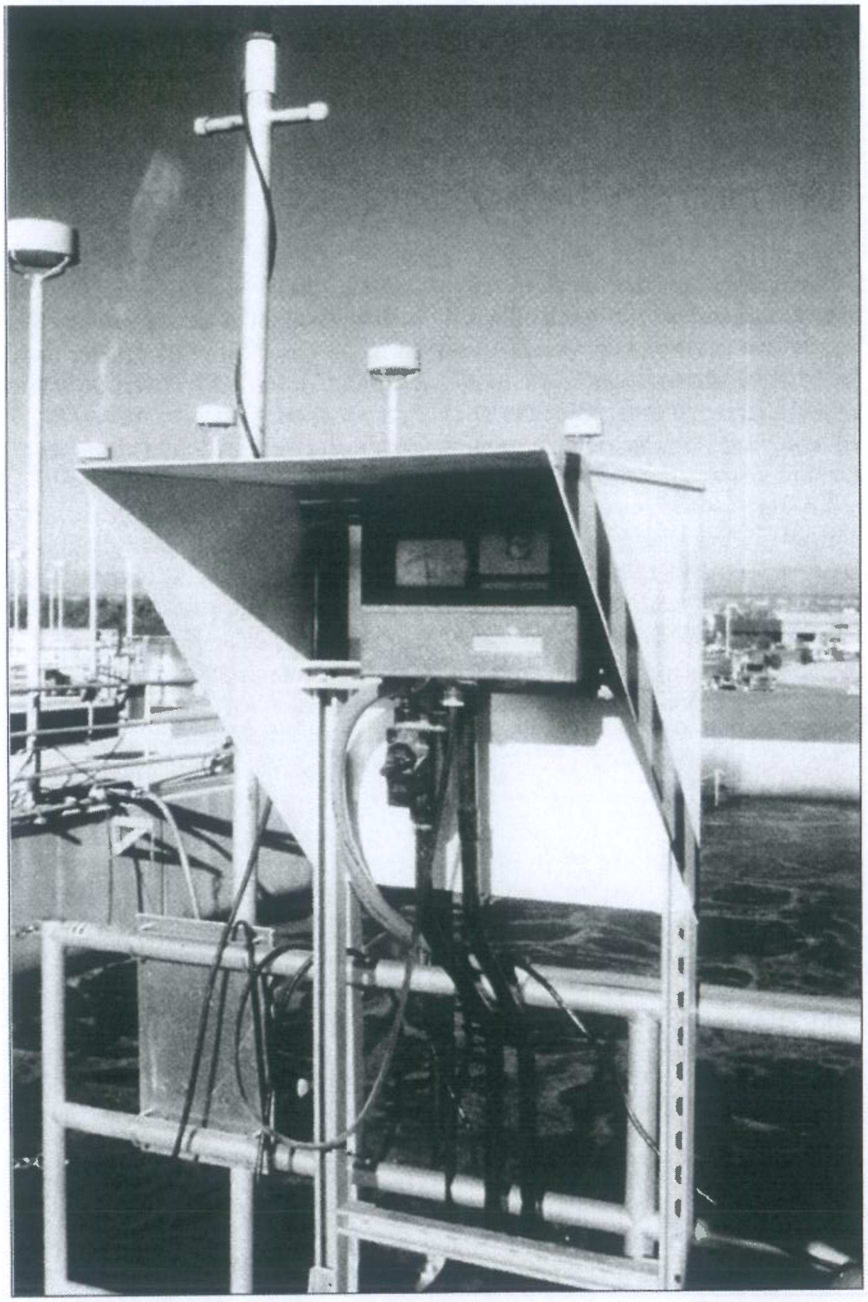
$$\text{New } Q_{WAS} = \text{Previous } Q_{WAS} \times [\text{actual MLSS } (\textit{24-hr average})/\text{target MLSS}]^{0.5}$$

The operators found the algorithm worked well when using MLSS concentrations measured by the probe. Compared with the manually controlled basins, the on-line basin was superior in maintaining MLSS concentrations near target levels. The on-line basin with constant MLSS control also was improved aesthetically with minimal scum and good color. In March 1997, constant MLSS control was implemented in all seven active basins using wasting instructions calculated from the data acquired from probes in the two test basins.

Better and Cost Effective

A comparison of ammonia removal from total plant flow before and after constant MLSS control shows that ammonia levels have been consistent and well below National Pollutant Discharge Elimination System permit limits. Phosphorus removal also improved in consistency and reliability, as demonstrated by the two basins that had been working off of the probes since early 1996.

A cost evaluation was prepared to determine the benefit of implementation of a fully automated control system with probes in all basins (see table, p. 24). Annualized capital costs were estimated to be \$91 000/yr, and annual cost savings were approximately \$29 000/yr with a payback period of 3 years. The district felt that the improved nutrient removal, coupled with the cost savings of reduced operator attention and lab time, was



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Return activated sludge (RAS) probes and transmitter box were installed along with MLSS probes. The probes provide a more accurate measurement of suspended solids in RAS than grab samples.

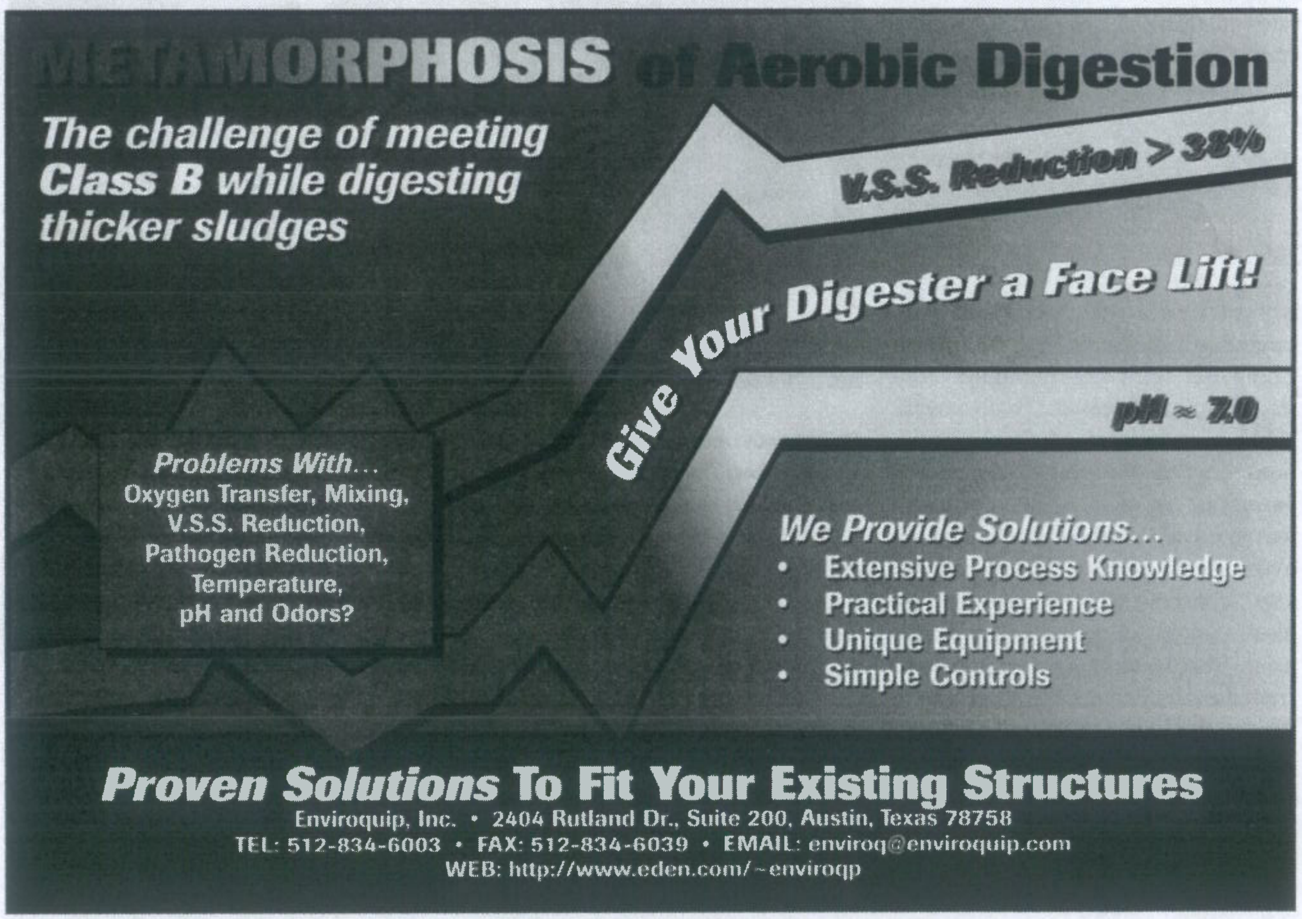
enough to warrant the switch to fully automated control. As a result of making the switch, the plant also has reduced ferric chloride use. When considering savings due to reduced ferric addition and resulting solids production and disposal, the payback period is 0.5 to 1.3 years.

A Step Beyond MLSS Control

Every operator dreams of achieving a constant solids retention time (SRT), particularly for situations in which extreme flow variations flush solids through the aeration basin. SRT is calculated as pounds of solids under aeration (based on MLSS), divided by pounds of solids wasted per day (based on RASSS). The use of constant SRT provides better control over the activated sludge process because SRT is a better parameter than MLSS. Constant SRT accounts for and is adjustable to changes in WAS concentration, whereas constant MLSS does not. Automatic monitoring of RASSS and MLSS concentrations provides for automatic constant SRT control. The district has installed RASSS probes in all basins and is using automated constant SRT as the preferred process control method.

The use of on-line suspended solids probes can greatly enhance process control in activated sludge systems and can specifically improve the reliability and stability of BNR processes. In addition, Clark County found that the costs of probe installation, operation, and maintenance are far less than manual sample collection, lab analyses, and subsequent calculations and manual equipment adjustments. The automated method can be readily implemented at facilities with SCADA systems or those suited to a computer-controlled wasting process.

Robin E. Bain, now with Parsons Engineering Science in Las Vegas, Nev., was plant operations manager from 1993 to 1996, and Walter S. Johnson is a process control specialist at Clark County Sanitation District in Las Vegas.



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