How Automated Real-Time Controls Can Provide More Consistency in Wastewater Treatment Operations

Strategic simplification with real-time automation controls can provide more consistent operations, resulting in peace of mind for plant operators plus savings in costs and time

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Managing Variability: The Key to Consistent Operations

Within a wastewater treatment plant (WWTP), operators typically face an extremely wide range of different variabilities. Managing these can often seem more art than science and is, in fact, a large part of what operators do — and what can keep them awake at night. This is especially true when the wastewater treatment process requires periodic hand-samplings, time-consuming laboratory analyses and higher than needed "just-in-case" setpoint responses. This paper will suggest ways to combat variability in WWTP operations using real-time automation and controls.

One source of WWTP variability is influent loads. These include both hydraulic and organic loads, not to mention an inorganic load that might need addressing if industrial wastewater is part of the influent stream. The frequency and extent of these loads' variabilities can be influenced by seasonal factors, such as agricultural runoffs that raise nitrogen and phosphorus loads. For example, Western Lake Erie's 2014 algae blooms occurred in August, due to Northwestern Ohio's farm runoff, poisoning Toledo's main source drinking water.

Loads can also be influenced by the characteristics of a customer base, with industrial and large institutional customers acting as potential sources of big spikes in wastewater influent. A food processor, for example, could spike the hydraulic load of its local municipal WWTP after starting up operations following a weekend's normal shutdown. A soft-drink company might spike the WWTP's influent organic load with a rush of sugar effluent that raises its biochemical oxygen demand (BOD) levels.

Reducing latency. Hydraulic load refers to the flow of wastewater into a WWTP at any point in time. Influent to large systems such as those associated with municipal WWTPs that handle flows in the millions of gallons per day (GPD) range might vary from two to five times average and never encounter a zero flow.[1] This kind of variability may or may not be enough to disrupt the bacteria-dependent biological process that is core to wastewater treatment, but operators must still keep watch on it and its implications on downstream process impacts.

In contrast, smaller specialized WWTPs of 100,000 GDP or less — like used in resorts, non-municipal residential developments and self-contained industrial operations — might experience hydraulic loads that vary by a factor of 10 or more on a weekly or daily basis. Variations in hydraulic loads can affect the vitality of a WWTP's bacteria population. Without the food supply that comes with an adequate influent flow, bacteria will die off. With too much influent, the bacteria cannot multiply fast enough.[2]

All that's just the start. Once influent enters the WWTP, operators must contend with variabilities within the biological waste stream itself. These include variables in physical and chemical composition, substrates, suspended solids, and biological activity as part of the treatment process. These components must be sampled frequently, analyzed competently and quickly, and responded to rapidly, especially when setpoints are exceeded. Real-time automation and controls can help compress these activity cycles, while drawn data is more timely, precise, accurate and — most importantly — actionable in much shorter time frames of minutes instead of hours or days.

"Chasing" discharge limits. Lacking real-time automation and control technologies that are available today, many WWTP operators ineffectively "chase" the regulatory limits of nutrient levels in their wastewater discharge by over-dosing their process streams with the required chemicals. This wastes chemicals. It can also waste significant amounts of money for cash-strapped municipal budgets.

Take the chemical management of phosphorus levels, for example. At a small Midwestern municipal WWTP serving 16,000 residents plus the town's large local food processing industry, management had to meet a 1.0 mg/L total phosphorous limit on its effluent set by state regulators. To do so, technicians were manually adjusting the ferric feed based on results from composite samples taken during the prior week. The result was they were treating the previous week's phosphorus load, not the current one.

After deploying a phosphorus controller RTC101P Chemical Phosphorus Optimization Solution from Hach Company, the WWTP was able to cut its average ferric chloride feed from 12.5 gallons per hour to 5.6 gallons per hour — a 56 percent reduction. The annual ferric chloride cost savings amounted to about $125,000, more than paying for the technology in the first year. At the same time, management saw an associated decrease in sludge production. This provides additional savings from reduced solids handling costs.

While real-time automation and control technologies cannot eliminate all the variabilities in WWTP operations, they can eliminate significant ones, such as in the example provided. This application can be part of a much larger program at WWTP facilities of what's known as "strategic simplification." This is a trend that more and more industries are undergoing around the world to reduce operational complexity, along with associated variabilities and latencies, while increasing the consistency and predictability of process outcomes and deliverables, whether products or services.

In the WWTP industry, strategic simplification aims to reduce variability wherever possible by selectively deploying these solutions as widely as possible. One benefit of achieving greater consistency in operations is more peace of mind — reducing that latent fear of the off-hours call that set limits have been breached. This is complemented by costs and time savings that will be welcomed both by WWTP operators facing tight municipal budgets, as well as by bottom line-driven operators of private WWTPs.

How Real-Time Control (RTC) Solutions Work

To learn how real-time control (RTC) technologies work, let's look at the Midwestern municipal WWTP's phosphorus control system. It automatically feeds the exact amount of precipitant needed to maintain a programmed orthophosphate setpoint. Measuring effluent flow and orthophosphate in real time, the controller uses pre-programmed algorithms to automatically adjust the ferric chloride dose ahead of the clarifiers as the phosphorus load changes. If a real-time measurement signal is lost, the controller will switch to previously entered data until the signal is restored.

As mentioned, the phos-phorus control system helped the WWTP reduce its ferric chloride consump-tion by 56 percent, saving about $125,000 in costs annually. Figure 1 shows a typical week's phosphorus load. Despite substantial pretreatment, influent phosphorus spikes are common.

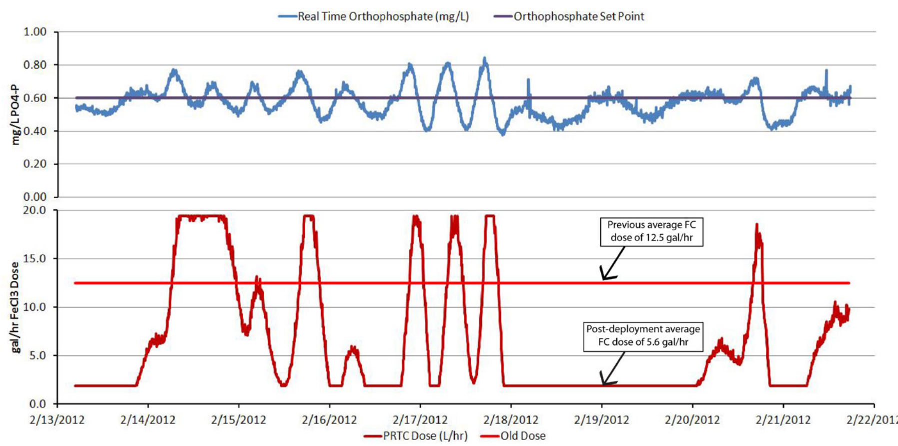

Figure 1. WWTP's weekly phosphorus load showing before-and-after ferric chloride dosing levels.

Before, when the staff was "chasing phosphorus," the average ferric chloride dose was 12.5 gallons per hour. After installation, however, with the phosphorus control system monitoring the load in real time, it automatically increases the ferric chloride dose as needed — but much more precisely and responsively — to maintain the WWTP's 0.60 mg/L orthophosphate setpoint. So, although it's clear that the ferric chloride dosing would spike to 20 gallons per hour or more, as needed, the average dose works out to less than half what it was.

The Components of an RTC Solution

Now let's consider the components of the WWTP's RTC system, which has an open architecture for other operators concerned about proprietary lock-ins. The system comes as an integrated, prepackaged solution, as illustrated in Figure 2, that comprises the following

Hach elements:

- **sc1000 Multi-Parameter Universal Controller:** This advanced, solid-state, modular controller can manage up to eight sensors directly or be deployed in wired or wireless SCADA networks with up to 32 sensors and parameters. Its intuitive, easy-to-use interface and large color touch-screen display that can be used for the monitoring and control of any number of parameters.

- **PHOSPHAX sc Digital Phosphate Analyzer:** This orthophosphate solid-state analyzer comes in a ruggedized weather-proof housing to provide continual, highly precise measurements of ortho-phosphate concentrations directly at the tank. Its detection limits can be set as low as 0.05 mg/L, with response times of less than five minutes including sample preparation. It consumes minimum reagent amounts. Output options include 4-20 mA output, Modbus RS485, Profibus, or HART. In the deployment at the Midwestern WWTP, it was set to measure plan effluent every five minutes

- **Phosphorus Real-Time Controller:** This solid-state controller responds to master commands from the sc1000 universal controller to manage in real time the flows and precise chemical discharge from the ferric chloride feed pumps into the effluent stream.

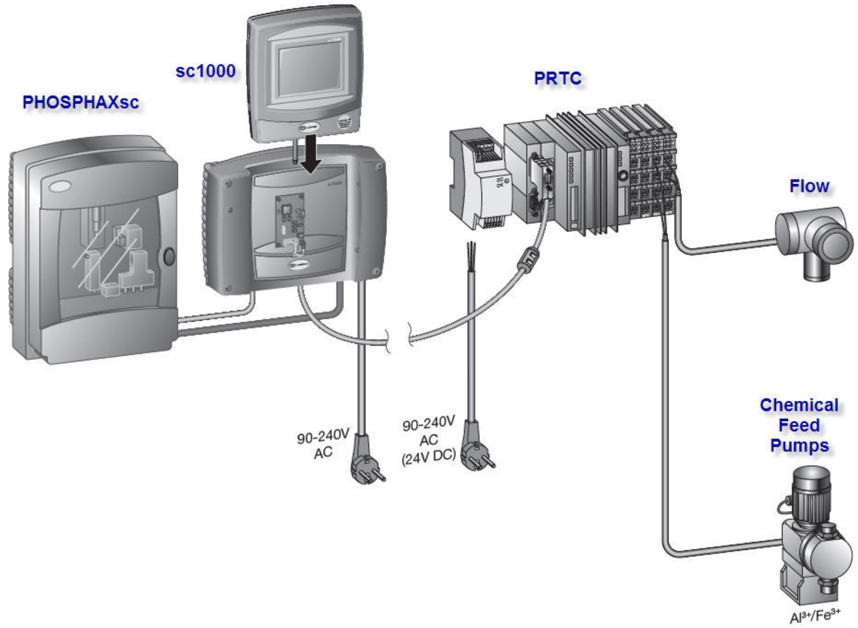

Figure 2. Component diagram of the Hach RTC101P Chemical Phosphorus Optimization Solution.

Proactive performance monitoring. Many WWTP operators strive to be self-sufficient in support of their own equipment. The simple design of this prepackaged solution using off-the-shelf components can enable them to do so. What's more, operators have to trust that the technologies they deploy work as specified 24/7. That's why the Hach's full-line of RTC solutions for WWTPs (see sidebar) comes with the PROGNOSYS predictive diagnostic system.

As a subsystem, the PROGNOSYS software continually monitors the overall RTC system's health and provides early-warning alerts for any impending instrument performance issues. It helps WWTP operators be proactive in troubleshooting, maintenance, and repairs — before minor problems become major disruptions. It also gives them the confidence to know whether changes in measurements are due to changes in the system's instruments or the wastewater stream.

Make vs. Buy: The Allure (and Pitfalls) of In-House Solutions

Many WWTP operators may opt for developing their own in-house RTC solutions for several reasons, all with the best intentions. An obvious one is to save money by buying and assembling into a system either lowest-cost components (or even higher-cost, best-of-breed ones to get the latest and greatest features and performance). A custom solution might also be desired to accommodate a wider range of functionality than prepackaged solutions might offer.

Next, to save more money on imple-menting the in-house solution, staff resources would do the logic and functional programming, then the installation and configuration. In addition to the cost-savings, other apparent benefits would include self-sufficiency and the avoidance of vendor lock-in and ongoing service and support costs.

When day-to-day gets in the way. Unfortunately practical day-to-day WWTP operating demands can cause less-welcome outcomes to the great expectations of the do-it-yourself game plan. For example, the in-house effort gets started but other priorities arise, causing its execution to become a series of fits and starts, or derailing it altogether. Or the project gets bogged down in programming issues. Either way, the RTC opportunity remains unaddressed.

Alternatively, a customized, in-house RTC solution may get built, installed, and properly configured and work just fine, as long as the individual who designed and engineered it remains on staff. Without that person available when the system goes down — and lacking sufficient documentation, which is often the case — the WWTP is left to, in effect, reverse-engineer the system to fix it or call in a third-party service provider to figure it out. Meanwhile, the plant must go back to time-consuming and costly manual procedures until the system gets fixed to avoid regulatory fines and reputational damage.

Advantages of prepackaged, turnkey RTC solutions. Because few WWTP operators can spare technical or engineering staff time to develop in-house solutions, the temptations to embark on such a project should be resisted. Or they should at least be weighed against the risks of unforeseen but time- and cost-consuming delays in design, engineering, installation and configuration due to interoperability issues among the components, software programming problems, or some combination of both.

Of course, WWTP operators might not have any alternative than in-house solutions, if not for the availability of prepackaged, turnkey RTC solutions made from proven off-the-shelf components, such as those from Hach. The advantages of this approach are many. One is faster time to system commissioning. While an in-house approach could take months or even years, the prepackaged, turnkey approach can take just weeks or even days, if a WWTP is in a hurry. In the Midwestern WWTP example, the phosphorus control system was installed, configured, and operational in less than 48 hours.

Another big advantage comes with the use of standardized, off-the-shelf components that have proven interoperability with each other as well as years of prior service in the wastewater treatment industry. In the unlikely event that a component fails, it can be replaced and the system reconfigured quickly. Hach's RTC solutions for WWTP applications come with quarterly service and support, including specific service-level agreements. Combined with the PROGNOSYS predictive diagnostic system, WWTP operators can trust in the peak performance of all our RTC solutions.

Strategic simplification with prepackaged RTC solutions can help WWTP operators quickly reduce the variability, complexity, and latency of their processes, while gaining much greater levels of consistency and predictability in the performance of those processes. The peace of mind that comes with those benefits is hard to quantify, much less be used to justify the investment in an RTC solution. However, the cost savings that accrue from dramatic reductions in consumption of chemicals and energy can often provide a return on investment in under a year. In addition, an RTC solution can help ensure continuous regulatory compliance and thereby reduce risks of fines and sanctions. ■

Hach's RTC (real-time control) solutions are complete off-the-shelf systems that adjust treatment processes in real time, keeping WWTP facilities compliant while reducing treatment costs. The four baseline systems are:

- RTC-P System: Optimizes chemical phosphorus removal by adjusting chemical dosing in real time through the continuous measurement of phosphate concentration and flow, allowing WWTP operators to maintain consistent effluent phosphorus values while reducing phosphorus use for substantial cost savings on chemicals.
- RTC-N System: Optimizes nitrification processes by adjusting dissolved oxygen (DO) concentration in real time through continuous measurement of ammonia load, allowing WWTP operators to maintain consistent effluent ammonia values and save energy. Designed specifically for continuously aerated biological WWTPs, it uses both an open- and closed-loop controller for optimal aeration control based on the desired effluent ammonia setpoint.
- RTC-N/DN System: Designed specifically for oxidation ditches and sequencing batch reactors, this system optimizes nitrogen elimination by determining the optimal times for nitrification and denitrification based on the continuous measurement of ammonia and nitrate concentrations.
- RTC-ST and RTC-SD Systems: Used for sludge thickening and dewatering processes, these RTC solutions can control polymer dosing in real time, helping to significantly reduce polymer dosing costs while also increasing biogas yield and reducing maintenance and guesswork in running sludge processing technologies.

References:

[1.] Engineering Waste Water Treatment Systems That Work. By Prince Engineering, PLC. Traverse City, Mich. http://www.build-on-prince.com/waste-water-treatment-systems.html

[2.] IBID