

# High-Performance WWTP Process Control

*Advanced Machine Learning finally arrives at the Aeration Basin*

## Overview

Outperforming expectations is one way to view the capabilities Dr. Alex Ekster brings to wastewater treatment plants (WWTPs) throughout the United States. The knowledge and methods Dr. Ekster's expertise in designing, optimizing, and automating WWTPs typically save operators anywhere from 15%-50% in energy savings, with some clients saving up to \$1,000,000 per year in energy costs.

Dr. Ekster developed the SRTmaster in 1998 to optimize the microbiological population in the aeration basin. Dr. Ekster has proven that the SRTmaster control system can be set to +2.5% accuracy, versus 15-20% in a typical plant.

The SRTmaster optimization includes:

- Increasing plant capacity by as much as 30% due to improved sludge settle-ability.
- Reducing foam.
- Decreasing disinfectant usage due to lower secondary effluent TSS.
- Providing up to 30% reduction of aeration energy usage.
- Reducing polymer consumption by as much as 25%.
- Decreasing in-process control related laboratory TSS tests by up to 90%.

***"I give my highest recommendation to the SRTMaster.  
It has done wonders for our plant."***

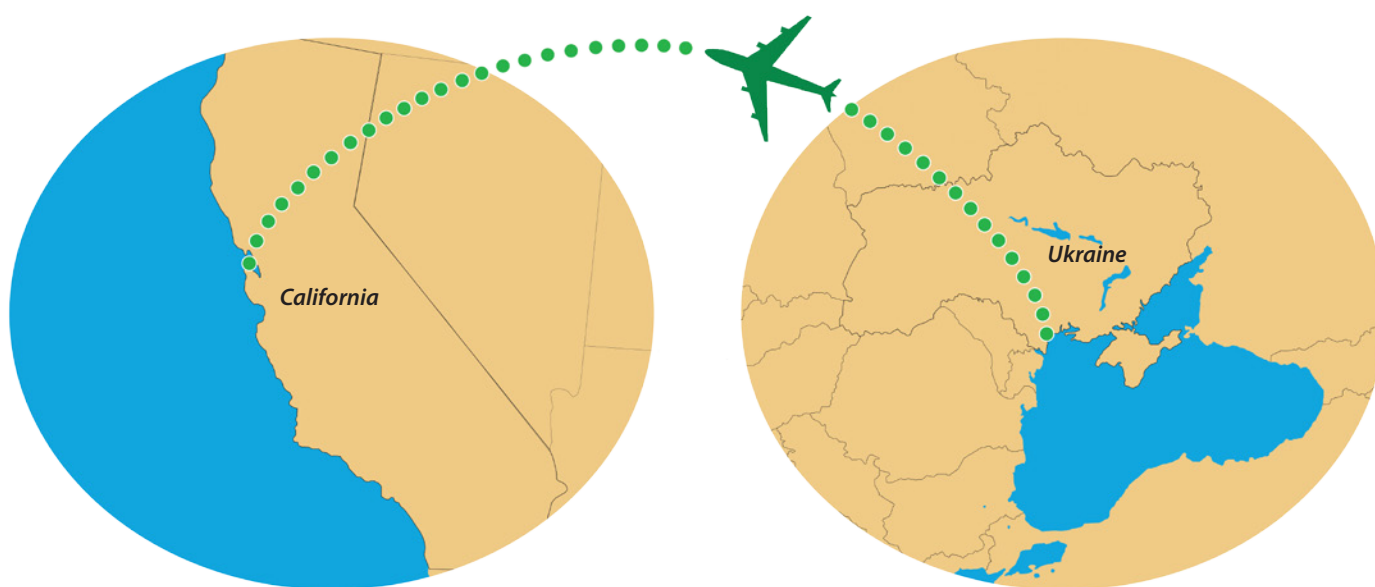
Gilbert Perez, Operations Manager  
Victor Valley Water Reclamation Authority (10.7 MGD)  
Victor Valley, CA



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## The 80's

As part of the Soviet Union, Ukraine experienced a tumultuous time of Soviet leadership during the 1980s. From Brezhnev's (1964-1982) economic and social stagnation, followed by the short span of KGB Chief Yuri Andropov (1982-1984), the return of Brezhnev's policies under Konstantin Chernenko (1984-1985), and up through the more liberalizing steps of Mikhail Gorbachev (1985-1991). It was under the more open policies of Gorbachev that Alex Ekster was able to leave Ukraine.



**Dr. Alex Ekster** received his PhD in Environmental Engineering, specializing in the water and wastewater industries. He has also authored many papers on improving/optimizing processes without the requirements of heavy investments in capital improvements. Within 2 months of his arrival in the U.S. (even with his limited English at this time), Dr. Ekster was hired as a Senior Design Engineer by Metcalf & Eddy because they recognized his knowledge in water and wastewater projects would be a major asset to the company.



*Dr. Alex Ekster*

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## Proven Proficiency

It is important to note that Dr. Ekster went from Metcalf & Eddy to being a Chief Engineer with the San Jose/Santa Clara Regional Wastewater Treatment Plant (SJ/SC-RWTP) for 12 years (1990-2012). This plant treats an average of 110 million gallons per day (MGD) for more than 1.4 million residents and 17,000 businesses.

Dr. Ekster was incredibly fortunate to work for SJ/SC-RWTP and it was very fortunate to have hired Dr. Ekster. In the early 90s, the rapid growth of the semiconductor industry in Silicon Valley resulted in large amounts of copper being discharged into the area's drainage system.

At the same time, SJ/SC-RWTP had been directed to have a zero tolerance for the copper discharge – mandating that either industry growth stop or the plant had to improve copper removal from the wastewater. Dr. Ekster demonstrated his capabilities by increasing the safety of the wastewater by completely removing copper and nitrate, while also increasing the plant capacity by 50% and saving 15% of energy usage in the aeration basin. For recognizing his achievement, the Water Environment Federation (WEF) awarded Dr. Ekster its highest honor with the Philip Morgan Medal.



*San Jose/Santa Clara Regional Wastewater Plant*

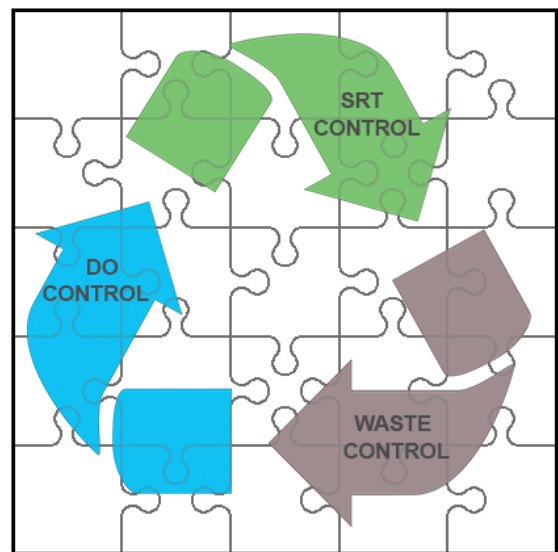
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## Forward-Thinking

Early in his career, Dr. Ekster realized that process optimization is impossible without robust process automation. However, automation for wastewater treatment processes at the time was behind the automation of other industries. Continuous changes in the quantity and characteristics of the water and wastewater influent requires continuous changes in the operating parameters to maintain optimized performance. In wastewater environments, there are three processes that must be optimized:

- SRT control
- Dissolved oxygen (DO) control in the aeration basin
- Waste control

All three processes must work together seamlessly to provide the highest efficiency. Only computers can perform such second-to-second changes in the operating parameters, and only reliable instrumentation with a rapid response time is capable of supporting the performance requirement. The general reluctance to allow computers to manage all of these aspects sacrifices energy and efficiency due to a lack of automation.



***“The optimized control by the SRTmaster leads to more effective bacterial selection and has been an effective tool to control filamentous growth.”***

Alex Miott, Sr. Process Engineer  
Oceanside Treatment Plant (17 MGD), Southeast Treatment Plant (57 MGD)  
San Francisco Public Utilities Commission  
San Francisco, CA

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## Pushing Technology into the 21st Century

The traditional control algorithms for wastewater process management were based on steady-state models; that is, nothing changed in the process (influent amount, influent content, temperatures, and process components such as forced air and microbes) from the time of startup. This made for an easy, yet impractical, wastewater model. A dynamic mathematical model was put into practice during the 1980s to increase process stability and control during startup and failures. This model took the variables into account to increase process reliability.

Almost 40 years later, the same wastewater model is used with its same deficiencies, with many being site-specific. The efficiencies in the model require the dissolved oxygen (DO) changes occur every 15 minutes using the baseline calibration. But the baseline calibration can take months to perform, and then changes by the time it is implemented - the theoretical practice versus reality has always fallen short for proper wastewater management. The problem is using a linear equation to solve a nonlinear condition; however, linear control cannot stabilize DO control, which historically has long time delays.

Dr. Ekster started **Ekster & Associates** (E&A) in 2001 (while still at SJ/SC-RWTP) the same year he developed the SRTmaster, an advanced control system that optimizes activated sludge microbiological population in realtime. The SRTmaster helps plants increase capacity up to 30%, save up to 50% in chemicals, and significantly improve treated water quality.



Dr. Ekster and his team developed a predictive control algorithm that not only eliminates the faulty elements of the standard linear wastewater model, but also provides timely alerts that inform operators about impending problems – essentially bullet-proof reliability of the wastewater control system. This predictive control model has proven to be the best approach for activated sludge.

E&A won a California Energy Commission grant in 2004 to develop a model-based dissolved oxygen (DO) control system. With this funding, Dr. Ekster's team developed a control system implementation that saved 15% energy usage. However, rather than resting on his laurels Dr. Ekster continued developing and identified several areas for improving the performance of his concept:

- Lagging air flow control due to slow flow meters
- Inability of activated sludge models to provide accurate real-time predictions of DO.
- Inadequate speed of the CPU and computational capability



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## Taking WWTP Operations to the Next Level

On its own, SRTmaster provides advancement in wastewater process control that is unparalleled in efficiency and responsiveness. The fact that it is scalable to the MGD of any wastewater plant without high equipment expenditures makes it unique in its approach to improving performance. The return-on-investment (ROI), frequently shortened by rebates from power companies, is more commonly several months rather than several years.

Adding DO control to the SRTmaster proved to be a daunting task. To control DO correctly, the flow meters monitoring the dissolved oxygen to the aeration basin had to have a response time no greater than ½ second to maintain

control. Any delay in readings is problematic – it takes only a couple of seconds to double to the flow. In this case, the flow meters in use had a 20 second delay. This caused the DO to continually hunt because of the delayed flow reading and the late corrective response.

Dr. Ekster began testing all types of instrumentation available from various vendors, and in the process became a recognized expert in water quality analyzers. It also allowed him to develop relationships with instrumentation manufacturers where he could offer suggestions aimed at instrumentation improvements. Dr. Ekster researched thermal flow meters because of their known capabilities, but was most impressed with the response time of Kurz Instruments thermal mass flow meters.

Dr. Ekster found only one company manufactures flow meters capable of meeting the ½-second response requirement. The flow meters manufactured by Kurz Instruments have repeatedly gone head-to-head with other thermal flow meters and always shown the fastest response time to changes in the flow stream, the highest accuracy, and the highest reliability.

***I LOVE your SRTmaster. The SRTmaster is a perfect machine. A wonderful tool that helps me to dial in my activated sludge plant.”***

Larry Bateman, Operations Manager  
Post Point Wastewater Treatment Plant (55 MGD)  
Bellingham, WA

The Kurz Model 454FTB flow meter impressed Dr. Ekster for its speed of response, but there was also a large amount of noise that affected flow measurement. Dr. Ekster reached out to Kurz with an idea for brand new instrumentation and Kurz began developing a low-noise, ultra-fast flow meter.

It took several years for E&A to improve its Model Predictive Control using new control algorithms with recently developed learning models that use “big data.”

Meanwhile, Kurz developed its Model 410FTB flow meter with a 0.25 second response time and a noise level less than 0.13%.

***“We have successfully used the SRTmaster to reduce foam, reduce pin floc, and to stabilize SVI.”***

Kevin Dickinson, Senior Operator  
EBMUD Wastewater Treatment Plant (168 MGD)  
East Bay Municipal Utility District  
Oakland, CA

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## City of Chico, CA



The Chico wastewater treatment plant has been using the SRTmaster since 2014 with the expected success. In late 2017, E&A installed its new aeration control system called **DO/Nmaster™** into Chico with 15 Kurz 410FTB flow meters, 15 DO meters, 15 motorized valves, and three ammonia meters. All flow meters and valves are connected to the SCADA system. After several months of fine-tuning, the DO/Nmaster started to control the aeration process exceeding the most optimistic expectations:

- The 47.1% energy savings amounts to a savings of more than \$200,000 per year.
- The verified energy savings awarded the plant a PG&E rebate of \$121,000.
- Greenhouse gas reduction equaled 900 metric tonnes/year of CO<sub>2</sub>.
- Effluent total suspended solids (TSS) were reduced to less than 5mg/l (a typical plant is 7-15mg/l), which led to improvements in disinfection. (Previously observed Winter disinfection problems did not return even though the Winter with the DO/Nmaster experienced double the flow.)
- All the newer regulations are requiring lower nitrogen levels. Due to the achieved simultaneous nitrification-denitrification, total nitrogen concentration was substantially reduced.



***“The City of Chico uses two programs from E&A - the SRTmaster system to control sludge age and enhance process reliability, and the DO/Nmaster that provides advanced control and automation to improve DO and blower performance. These systems provide exceptional performance, increasing overall plant performance and reliability while reducing long-term costs and maintaining regulatory compliance. I highly recommend E&A products and services.”***

James Carr, Wastewater Treatment Manager  
City of Chico Water Pollution Control Plant (12 MGD)  
Chico, CA

# High-Performance WWTP Process Control

## Summary

Traditionally, there has been little motivation for wastewater facilities to improve the efficiency and automation of their facilities. The main objective of plant operations has been to operate within their EPA permit rather than focusing on saving energy. Municipal budgets are determined well in advance, and management isn't usually eager to ask for less money. Entire budgets must be spent to ensure a higher budget during the next round of funding, especially when any excess funds are supposed to be repaid to the public. This makes management reluctant to support any methods that lower the needs of the budget, and the public isn't aware it has a voice.

There is also a general resistance to incorporating new automation methods when operators are comfortable with the way things are done, even when those ways are known to include limitations, inadequacies, and deficiencies.

Even the engineering companies hired to design processes are not paid to consider lower cost improvements; it is much easier to use processes that are already in place at other facilities. In addition, low bids and deceptive claims in order to get a bid, make it difficult for unique and new concepts to get a footing into the industry.

Historically, municipal WWTP upgrades were evaluated on the lowest bid. However, increasing energy costs and the need to reduce environmental impact mean that projects should be evaluated and awarded based on the lowest cost of ownership, not just the initial bid cost.



Using the SRTmaster with the DO/Nmaster greatly improves water quality and reduces energy consumption, making this wastewater solution with a short ROI a win-win investment.

Dr. Ekster continues to share his experience with optimization and automation through dozens of professional papers, inclusion in multiple WEF Manuals of Practice, and workshops at local, national, and international conferences. He is always pointing out that robust automation is the cheapest and most cost-effective method for increasing plant capacity, saving energy and chemicals, and relieving operators from dealing with the minutiae work better performed by instruments and controllers so they can focus their efforts toward mission-critical tasks.

The SRTmaster with DO Control is the next level in precision wastewater management. Working with honest manufacturers and trusted engineering firms is the only way to ensure the most efficient and economical processes are put into place to support wastewater facilities, plant operators, and the communities they serve.