OPTIMIZATION

Helping Small Water Plants Improve Their Product

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If you ask people who work with drinking water systems if they want to provide a better product to their communities, they will undoubtedly answer yes. Providing the best possible water is, after all, the goal of all involved in this vital work. And while system personnel support this ideal, they'd hasten to add, "we can't afford to buy new equipment or fund new construction projects, though." But, what if they could deliver better water with little or no additional investment? Optimization is a way systems can achieve this goal.

Optimization is a process that identifies and addresses performance limitations at individual water treatment facilities in order to obtain improved performance. Using this methodology, many water treatment plants can meet—and perhaps exceed—regulations without spending more money. This makes optimization a particularly valuable tool for small, resource-limited systems, which still must comply with increasingly stringent regulations.

"I learned about this as part of a state optimization training program," says Zane Satterfield, engineering scientist with the National Environmental Services Center and previously district engineer with the West Virginia Bureau of Public Health. "One of the small towns we worked with during the training—already a well-run and well-maintained system—was able

to improve their water quality and perform certain tasks more efficiently as a result of the assessment."

Multi-State Optimization

The U.S. Environmental Protection Agency (EPA) launched regional optimization initiatives in the late 1990s in the southeast (EPA Region IV) and southern U.S. (EPA Region VI). As a result of these programs, some states achieved tremendous improvements in plants previously of concern in terms of risk to public health. EPA's optimization initiatives were subsequently extended to several other geographic regions of the country.

"One of the most cost-effective ways a state can improve an existing plant's ability to protect the public health is to optimize the performance of treatment technologies already in place," EPA notes on their Web site. In fact, EPA optimization team members have observed that some plants' performance improved when staff just started tracking turbidity values in a systematic fashion.

The primary way EPA encourages these efforts is through the area-wide optimization program (AWOP). According to their guidance for implementing an AWOP, "because state drinking water programs have direct contact with treatment plants, state programs play the major role in implementing AWOPs. State staff develop criteria to prioritize systems and evaluate system performance. Then, they use the most appropriate tools and assistance to optimize system performance and address public health risks."

Stop Pathogens at Every Step

The multiple barrier approach is a concept that guides surface water treatment so that each stage, or unit process, of treatment removes microbial contaminants. For example, bacteria or protozoa that are not removed during settling can be eliminated through filtration or during disinfection. Thus, optimization of surface water treatment plants involves monitoring and performance goals for each of the treatment "barriers." Optimization monitoring and performance goals are listed in Table I.

Continuous monitoring of each filter's turbidity is one of the requirements of the Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR, or simply LT1). EPA recognized that continuous monitoring of individual filter turbidity was one of many challenges that small systems face. So, the LT1's compliance deadline was set for January 2005, while systems serving more than 10,000 people had to comply with the parallel rule, the Interim Enhanced Surface Water Treatment Rule, three years earlier.

As Table I indicates, the settled water turbidity goal depends on the raw water turbidity. The filter backwash performance goal calls for a recovery period (to 0.1 NTU) of 15 minutes, during which time the turbidity should not exceed 0.3 NTU.

The initial work promoting optimization has been with sur-

Table I

Summary of Optimization Monitoring and Performance Goals

Minimum Data Monitoring Requirements

- Daily raw water turbidity
- Settled water turbidity at four-hour time increments from each sedimentation basin
- On-line (continuous) turbidity from each filter
- One filter backwash profile each month from each filter

Individual Sedimentation Basin Performance Goals

- Settled water turbidity less than 2 NTU 95 percent of the time if raw water turbidity is greater than 10 NTU, or
- Settled water turbidity less than 1 NTU 95 percent of the time if raw water turbidity is less than or equal to 10 NTU

Individual Filter Performance Goals

- Filtered water turbidity less than 0.10 NTU 95 percent of the time (excluding 15-minute period following backwashes) based on the maximum values recorded during four-hour time increments
- Maximum filtered water measurement of 0.30 NTU
- Initiate filter backwash immediately after turbidity breakthrough has been observed and before effluent turbidity exceeds 0.10 NTU
- Maximum filtered water turbidity following backwash of 0.30 NTU
- Maximum backwash recovery period of 15 minutes (i.e., return to less than 0.10 NTU)
- Maximum filtered water measurement of less than 10 particles (in the greater than 2 micron range) per milliliter (if particle counters are available)

Disinfection Performance Criteria

- CT values to achieve required log inactivation of Giardia and viruses

What's up with turbidity?

Turbidity is caused by particulates in the water and is synonymous with cloudiness. Measured in NTUs [Nephelometric Turbidity Units], it is significant because excessive turbidity can allow pathogens to "hide" and, hence, be resistant to disinfection.

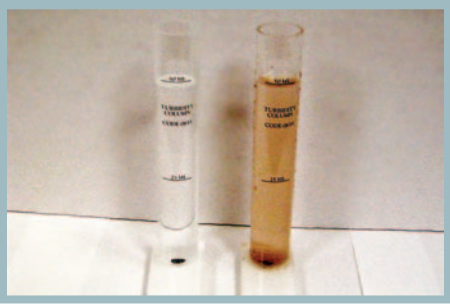

Photo courtesy of The State University of New York at Oneonta

face water systems. New efforts are underway to apply optimization concepts to groundwater systems and to reducing the formation of disinfection byproducts.

Comprehensive Performance Evaluation

The foundation of optimization work is the comprehensive performance evaluation (CPE), a thorough assessment of a plant's design, operation and maintenance practices, and administration. The CPE answers the critical question of whether the plant's performance can be optimized to produce high-quality water without construction of new components. If the plant, as built, can be optimized, then technical assistance can be effective. Occasionally, CPE results conclude that the design is inherently limiting performance. In such cases, a new plant must be built to insure optimization.

The four major components are of a CPE are: (1) assessment of plant performance, (2) major unit process evaluation, (3) performance-limiting factors identification and prioritization, and (4) assessment of comprehensive technical assistance applicability.

Assessment of Plant Performance—evaluating existing data and conducting field evaluations to determine the status of the facility relative to achieving optimization goals. With this assessment, evaluators can begin to identify possible causes for less-than-optimum performance.

Major Unit Process Evaluation—assessment of the treatment potential from the perspective of capability of existing processes.

Performance-Limiting Factors (PLF) Identification and Prioritization (design, administrative, and operations and maintenance)—For example, how efficient is the maintenance program? Is training adequate? Priority-setting is based on whether each PLF has a:

- Major and long-term effect
- Moderate effect on a routine basis or major effect periodically
- Minor effect

Assessment of Comprehensive Technical Assistance Applicability—Could technical assistance mitigate the PLFs?

A team of people, including those familiar with plant design, operations, and managerial principles conducts the CPE. The CPE is usually performed over a period of three days, characterized by the following activities:

Entrance meeting—takes place with the mayor, town officials, and representatives of the state primacy agency, operators, and superintendents; provides an opportunity to explain what will be done and why.

Plant tour—gets the team familiar with the physical plant and allows for a preliminary assessment of the plant's flexibility (e.g., with respect to processes and chemical feeds); serves as a foundation for discussions.

Data Collection—performance assessment, including backwash turbidity profiles, individual filter turbidity performance, and field evaluation, allows verification of accuracy of flows, dosages, backwash procedures, etc.

Major Unit Process Evaluation—determines the performance potential at peak instantaneous operating flow.

Interviews—focus on factors limiting performance, based on what was seen.

Performance-Limiting Factors Identification—Analyzing design, administration, and operations, and establishing a magnitude or ranking of priority.

Exit Meeting—Involves the same players as the entrance meeting and explains what was found. Points to discuss include:

- overview of treatment optimized goals;
- plant performance assessment;
- evaluation of major unit processes;
- prioritized performance-limiting factors; and
- assessment of applicability of follow-up, i.e., whether the existing plant can be optimized by plant staff, with or without technical assistance from an outside party.

RCAP's Optimization Experience

Recognizing the benefit to small communities with whom the Rural Community Assistance Partnership (RCAP) works, RCAP began training its field staff about optimization in 2003. More than 60 staff members participated in a day-long training about optimization concepts and exercises. This classroom workshop included qualitative and quantitative data from a real CPE to assess the plant's performance relative to optimization goals, generate a list of performance-limiting factors, and determine whether the plant could be optimized with technical assistance.

During spring 2004, 12 RCAP field staff participated in a CPE training event. This CPE training was conducted at a small water plant in the Northwest and gave RCAP staff the opportunity to apply the concepts they had learned in the classroom workshop the previous year. (Prior to the field training, all participants were asked to review an interactive CPE training CD, referenced below.)

Participants divided into teams to perform filter assessments, backwash profiles, major unit process evaluations, interviews, and examinations of historical and current plant performance. The CPE team found that the plant performed very well, meeting optimization goals much of the time. The only performance-limiting factor identified was that the mayor and plant supervisor had simply not set optimized performance goals. The team believed that the plant could be optimized if they set the goal to do so, even without technical assistance. (Ironically, some team members mentioned that they might have learned even more from a poorly functioning plant!)

Trained RCAP field staff members have taken the concepts they learned to their respective jobs working with small communities across the country.

Priority-Ranking Tool for Surface Water Systems

System Name:		
Water System Inventory Number:		
Regulatory Compliance for the Past 2 Years		
# Acute MCL Violations	# violations X 40 points	
# MCL Violations	# violations X 20 points	
# Treatment Technique Violations	# violations X 20 points	
# Monitoring and Reporting Violations	# violations X 5 points	
Sanitary Survey Results for Most 2 Recent Surveys		
# Overall Unsatisfactory Ratings	# ratings X 40 points	
# Overall Need Improvement Ratings	# ratings X 20 points	
# Individual Items (1-14 only) Rated U *	# ratings X 10 points	
# Individual Items (1-14 only) Rated I *	# ratings X 5 points	
Operational Data Based on 1 year		
Filtered Water Turbidity		
# Days Max Filtered Turbidity >1 NTU	# days X 20 points	
# Days Max Filtered Turbidity >0.5 NTU	# days X 10 points	
# Days Max Filtered Turbidity >0.3 NTU	# days X 2 points	
# Days Max Filtered Water Turbidity > 0.1 NTU	# days X 1 point	
Settled Water Turbidity		
# Days Settled Turbidity >10 NTU	# days X 5 points	
# Days Settled Turbidity >5 NTU	# days X 2 points	
# Days Settled Turbidity >2 NTU	# days X 0.5 point	
Raw Water Turbidity		
# Days Raw Turbidity >250 NTU	# days X 5 points	
# Days Raw Turbidity >100 NTU	# days X 2 points	
# Days Raw Turbidity >50 NTU	# days X 1 point	
# Days Raw Turbidity >25 NTU	# days X 0.5 point	
Is the plant operated 24 hours per day?	no = 20 points	
Does the plant have more than one clearwell?	no = 20 points	
	TOTAL SCORE	

*Sanitary Survey Rating Items ("U," unsatisfactory, and "I," improvement needed, are defined categories)

1 = Quantity		8 = Sedimentation/Clarification	
2 = Protection from Contamination		9 = Filtration	
3 = Security		10 = Equipment O & M	
4 = Raw Water Pumping		11 = Chemical Storage	
5 = Raw Water Line		12 = Chemical Feed Rooms	
6 = Flash Mix		13 = Chemical Injection pt/station	
7 = Flocculation		14 = Distribution Water Quality	

Source: South Carolina Department of Health and Environmental Control

It is important to note that the LT1 requires certain follow-up actions if the individual or combined filter turbidity exceeds 1.0 NTU in two or more consecutive readings. Options for follow-up actions include additional reporting, filter self-assessments, and/or CPEs.

Help With Optimization

Two tools have been developed to assist states and individual water systems with their optimization efforts: (1) a method for priority-ranking a group of treatment plants and (2) optimization assessment software.

Ranking plants according to the risk they present to public health is particularly valuable for technical assistance providers, tribal officials, or state drinking water agency personnel who want to set priorities for their optimization work. A thorough, yet simple priority-ranking tool developed by the South Carolina Department of Health and Environmental Control is presented in Table II. (This worksheet is available as a pdf on the NESC Web site at *www.nesc.wvu.edu.*) Using this tool, the highest-scoring plant presents the greatest public health risk and, hence, is the top priority to receive assistance.

The second tool is a computer-based spreadsheet to tabulate and graph long-term trends in turbidity values for settled and filtered water. A graph depicting turbidity values for raw, settled, and filtered water over a 13-month period is presented in Figure 1 (right). A sample graph showing trends in filtered water turbidity appears in Figure 2 (right). This free software can be downloaded from the Center for Drinking Water Optimization Web site. (See resources listed at the end of this article.)

Worth the Effort

Undertaking an optimization effort isn't easy. It requires an honest and comprehensive examination of every aspect of a treatment plant's operations. Care must be taken to involve all those who work with the system.

When properly done, however, optimization can be a huge benefit to small water utilities. By assessing and documenting the plant's functional limitations, system staff can deliver the highest quality water possible. Best of all, they can usually do this without additional expense.

Optimization in the Palmetto State

South Carolina implemented an AWOP program in 1997, one of the first in the country to do so. The state has enjoyed much success with optimization since then. One small system showed marked improvement over a four-year period. In 1997, there were 76 days when the plant's settled water was greater than 2 NTU and 72 days when the filtered water was greater than 0.1 NTU. They also had one day when the filtered turbidity was greater than 0.5 NTU and one day when it was greater than 1 NTU.

By 2001, there were two days when the settled turbidity was greater than 2 NTU and only three days when the filtered turbidity was greater than 0.1 NTU (but still less than 0.3 NTU).

State officials are enthusiastic about these results. "The AWOP model has given South Carolina drinking water staff and management a tool to evaluate all surface water treatment plants with respect to optimization," reports Douglas Kinard, manager of the state's Drinking Water and Recreational Waters Compliance Section of the Department of Health and Environmental Control. "These evaluations are then used to determine the level of technical assistance that would benefit each surface water system. The program has provided a framework to help those surface water systems that are not optimized and may have difficulty doing so. There have been documented performance improvements at several surface water treatment plants across the state."

For More Information

Additional information about optimization may be obtained at the Center for Drinking Water Optimization's Web site www.cdwo.org. *The optimization assessment software mentioned in the article may also be downloaded from this site.*

The U.S. Environmental Protection Agency (EPA) publishes the handbook Optimizing Water Treatment Plant Performance Using the Composite Correction Program, 1998 Edition *(EPA/625/6-91/027) and the companion training CD* Introduction to Comprehensive Performance Evaluations *(EPA/625/C-01/011). Copies of the handbook and training CD may be ordered by contacting the National Service Center for Environmental Publications at (800) 490-9198.*

EPA also provides the publication "Implementing AWOPs through the Capacity Development and DWSRF Programs" on their Web site. Go to www.epa.gov/safewater/smallsys/pdfs/awop-capdev-dwsrf.pdf *to download a copy.*

The Rural Community Assistance Partnership (RCAP) provides optimization training through staff at its six regional affiliates. To learn more, visit the RCAP Web site at www.rcap.org *or call (888) 321-7227. You may also e-mail Joy Barrett, director of training and technical services, at* jbarrett@rcap.org.

Joy Barrett, Ph.D., is the director of training and technical services with the Rural Community Assistance Partnership. Before re-joining the staff of RCAP in 2003, Dr. Barrett was the director of a national center for drinking water optimization.

Figure1

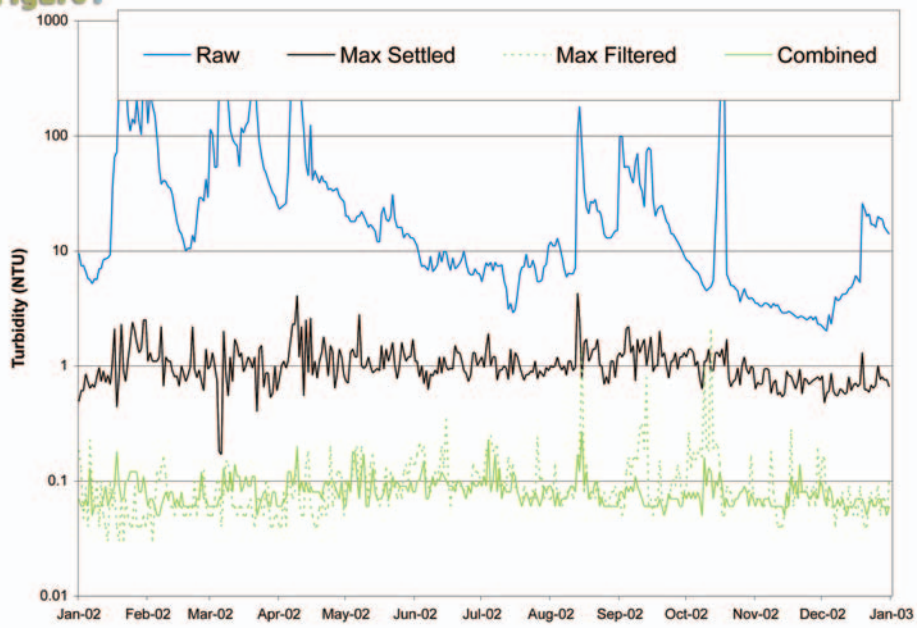
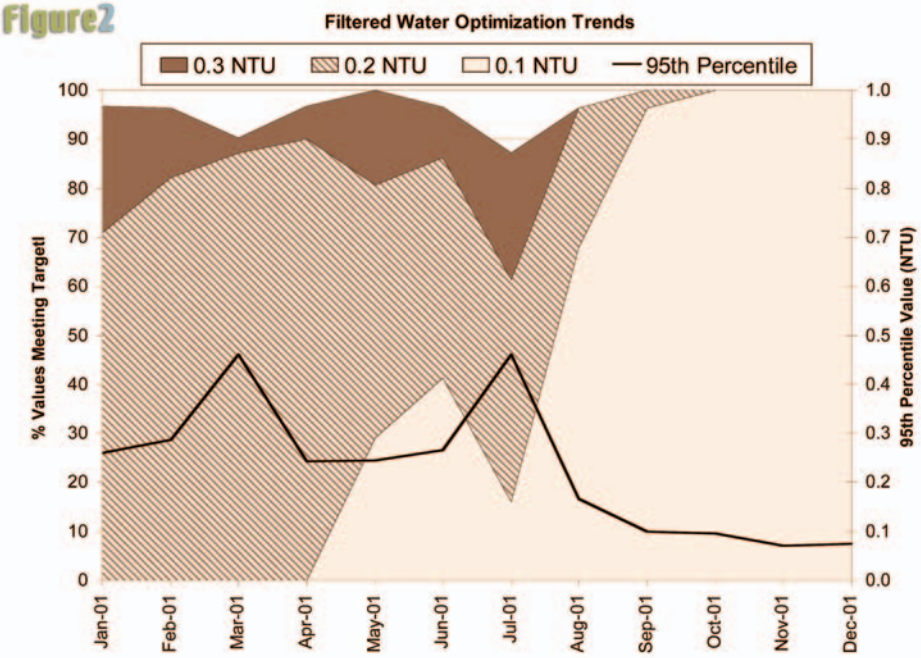
Figure2