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The challenges in operating a small wastewater treatment facility

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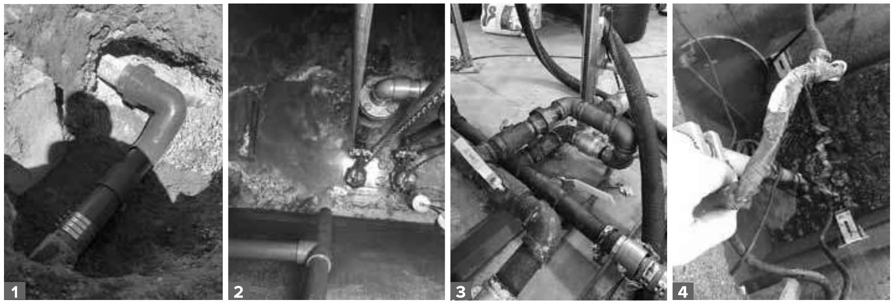
ABSTRACT | Over the past 30 years, small, decentralized wastewater treatment plants have proliferated in remote areas without municipal collection systems. That growth has been accompanied by the emergence of an uncommon set of challenges that need attention. This article discusses some of the challenges in this service sector that threaten the proper operation of those systems. Included is a case study on typical operational failures encountered: improper equipment replacement or use, failed/failing equipment, neglected operational components that could extend service life, out of range process settings, and occasionally a general disregard to examine or to operate the facilities based upon designer and manufacturer intent. New contractual start-up assessment methods are discussed, along with troubleshooting methodology, with a brief emphasis of the benefits of strong communication between operators and relevant engineers to resolve issues and provide innovative solutions to system and industry shortfalls.

KEYWORDS | Small wastewater treatment facilities, operation and maintenance, process assessment, operations management

Before discussing the inherent challenges of operating a small wastewater treatment plant, it is necessary first to identify why this topic is both important and necessary. As the populations of both the United States and Massachusetts grow, it can reasonably be expected that the number of small, decentralized, wastewater treatment plants will continue to increase, as it has over the past 30 years. As we start up these facilities around the state, understanding the recurring challenges in the industry and the means to solve them will help to prevent future facility malfunction, deterioration, and diminished performance. Through a better understanding of the problems, we can focus on innovations needed and which industry aspects require more attention.

One challenge all treatment facilities face is the passage of time—the biggest enemy of a small wastewater treatment plant. Unlike a municipal facility that is overseen, in many cases, by one governing body and operation group for its entire lifetime, operational contracts for small wastewater treatment plants often rotate annually, biannually, or every five years. Exacerbating this issue, often these facilities are overseen by a secondary owner-management group that provides limited oversight of the facility and its finances year over year. Even when the same operations firm does oversee a facility for a long time, typically various operators are rotated through the facility semi-regularly. Rare is a situation in which the same operator manages a facility for an extended duration. What is created by this cycle of revolving and intermittent oversight is a discontinuity in operation. With such a discontinuity in operation, each new contracted operator must sort through old data and logbooks to understand a site's history, challenges, and reactions to seasonal conditions. Too often, maintenance is delayed until maintenance contracts rotate, at which point the new operator has to repeat the legwork required to understand the site's intricacies and remedy ongoing issues. Long-standing issues are often remedied only after catastrophic failure, and it is not uncommon for excessive time to be spent on resuscitating treatment facilities when the process failure could have been averted by simple, more timely solutions. When beginning work on any new project, identification of the site history, to the best of one's ability, is paramount. Many days of anguish can be saved by drawing on the work of others, regardless of their reported successes or failures.

Finances also pose a major challenge for treatment facilities, regardless of the operator or operations company. All financial decisions ultimately are



1. Repaired aeration line 2. Overdosing sodium bicarbonate resulted in blockages and precipitation in feed lines 3. Improper materials used on heated line 4. Temporary spliced wiring job that becomes long-term

handed down by the facility owners, whether a home ownership association, a management entity, or an individual owner. Often the owner's concern is not for the long-term condition of a facility but more with the annual financial burden. One key factor in stabilizing operations is a strong financial commitment by the owners to maintain their facility to design standards. A common thread through most facilities with poor operational history has often been the direct or indirect neglect by the owner and operator for mainly financial reasons. This neglect is often manifested in the form of delayed pumping of primary treatment tanks, ignoring of preventative maintenance and needed equipment repair or replacement, neglect of heating equipment within the treatment building, a poor stockpile of spare equipment and essential parts, and/or simply inadequate time spent on operational assessment to analyze facility issues because of budgetary restrictions or the assignment of too many facilities per operational staffer. Especially in the post-Covid-19 world where supply chains are a challenge in all areas of the economy, better financial management by owners can have long-term positive effects on the facilities. A sound financial approach also saves money, as it can preclude major facility breakdowns that often result in expensive temporary solutions (such as pumping and hauling wastewater and expending extensive operator overtime). If all facilities were stocked with at least one spare of each critical piece of equipment, potential downtime could be greatly decreased, repairs could be made quickly, and processes would less often see major changes to operational performance. A change in financial management approach to these facilities clearly could prevent many issues from emerging.

Regarding the breakdown of equipment within a treatment facility, most often the question is not if, but when. With the inevitable equipment breakdown comes repair and replacement, two instances where the treatment plant risks diverging from its initial design intent. Small wastewater treatment plants are not the easiest facilities to maintain and repair. Often unit process and component redundancies are significantly reduced, and the demand for continuous operation of critical components leaves little opportunity for downtime without significant cost to the facility owner. To this end, it is not uncommon for "patches" to be applied to major portions of the process as interim solutions. When replacement equipment or parts are not readily available, these temporary fixes may become long-term solutions, and over time the urgency to reinstate the full functional use begins to dwindle.

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In most situations when a system experiences long-term effluent compliance issues, the root cause can be traced to a mechanical failure and the attendant repair method. To prevent repair issues from becoming causes of breakdown, operators, engineers, and technicians must work together to identify the best solution and how it can be accomplished with as little deviation as possible from the intended system design.

The challenge of staffing wastewater treatment plants shows no signs of easing, especially if growth continues in constructing and commissioning small treatment facilities. Following the Clean Water Act of the 1970s, a concerted effort was made to recruit, educate, and employ operators for newly constructed facilities. This trend has waned over the years, leaving the industry short of qualified workers. Since the benefits of working for a municipality generally outweigh those of employment with a smaller company, hiring staff for small remote treatment facilities becomes increasingly difficult. One solution has been the hiring of retirement-age municipal operators wanting to work three to five more years before final retirement. Another solution has been to recruit individuals from outside the profession who have helpful experience or attributes for the operator role, such as a military background, experience in the automotive or HVAC industry (and thus comfort with power and control systems), some post-secondary education, an affinity for manual labor,

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and a disciplined and self-starting work attitude. A successful operator is one who can consistently generate quality results, an outcome which requires disciplined adherence to standardized operating procedures, attentiveness to all aspects of the facility, and a proactive approach to preventing breakdowns. Potential candidates should be determined and able to solve problems and to increase their subject matter knowledge. Without these characteristics, new operators may be out of place within a treatment facility, especially after they obtain their certification and are assigned one-person treatment facilities to operate.

As a case study, a 10,000 gpd (37,850 L/d) facility had historical chronic issues with fecal coliform exceedances. All other effluent characteristics had met compliance, aside from two minor violations which were due to chemical dosing issues. Such exceedances can typically be characterized as either a "point" failure or a "nonpoint" failure. Prior attempts to resolve the issue had approached it as a "point" failure, theorizing that the UV unit at the tail end of the system was not properly disinfecting the effluent and was thus causing the issue. Instead, the problem was ultimately resolved when an effluent grab sample taken showed a murky tint; this led to the examination of the effluent analysis results of the past year along with a physical inspection of the UV unit to confirm proper operation. The data showed that various process-related issues were likely affecting the UV process performance. This characterized it as a "nonpoint" failure. The further investigation, described below, illustrates some of the challenges of operating a small wastewater treatment facility.

The first and most compromising aspect of the previous operation was that the facility operators did not fully use the flow equalization tank volume. Rather than allowing the water to be held back for a steady flow of treatment through the entire 24-hour day, the tank-level settings caused the flow to be sent through the system only during the limited hours of daytime operation; no flow was being pumped through the plant during the night. The second problem was caused by faulty replacement of a float at the feed station to a tertiary treatment unit. Instead of having a relatively small liquid-level variation between the ON and OFF floats, the pump cycle depth between the floats was over 36 in. (91 cm), raising the chamber liquid level above the sanitary influent tee from the previous tank. The improper float levels allowed process water to back up over 1 ft (30.5 cm) into two aerobic tanks. When the ON float was finally activated, the large volume of water that was being pushed forward surged through the final clarifying tank, causing almost all of the solids to accumulate at the end of the system, beyond the point where they could be reasonably and easily removed. The buildup of solids at the tail end of the facility, coupled with an already tinted effluent stream due to extended solids contact time, caused limited fecal coliform treatment through the overwhelmed UV system.

At this facility, a safety net for occasional solids excursions had been installed, in the form of a self-cleaning sand filter. This unit had been manufactured by a company that had since been purchased by another firm that finally dissolved the filter company; therefore, manufacturer information about the filter was unavailable. With instructions about how to troubleshoot the filter scarce, as time passed the operators lost control of the unit. Reactivating this unit was a key to maintaining a high-quality effluent discharge; however, even ideal filter operation would likely not have prevented the problems caused by the up-front solids imbalance and hydraulic issues. Safe to say, several common, interrelated challenges played a role in the failure of the facility's disinfection system.

The following remedial process was used on the case study above and can be applied to the start-up of any new contract or troubleshooting operation. Initially, and before any adjustments are made to a system, the facility must be observed for a period and all possible information gathered. This means reaching out to anyone with knowledge of specific repairs, previous issues, and above all else, the engineering documents presented at start-up. Often overlooked, these manuals can answer the very questions that a new operator may have. However, in cases where many process changes have been made since construction, a deeper history is needed. Understanding the theory behind the operation has little meaning if the equipment is not functioning. At this stage, all equipment should be tested, and if possible, any automatic cycling should be monitored. After observing the facility and making any essential repairs, the operator must create a hypothesis of effective system performance and draft a course of action. It is then vital to gain control of the facility, specifically in the areas you would like to adjust. But instead of starting with abstract actions, first slowly adjust the factors that can be most simply charted and noticed as deviations from conventional wisdom. For instance, if a process is having trouble removing nitrate, the operator could first gradually adjust the carbon feed source to observe the effect of that before focusing on anoxic detention times. Once control has been established, continue methodically moving the facility in the direction needed with caution. Moving slowly while understanding the effect of every change that is occurring is preferable to making rapid, drastic adjustments that could veil a viable solution.

Once the operation is under control, the system can be fine-tuned. This process includes verifying that all equipment is installed according to facility design, all floats function fully and are set at proper levels, all filters and settling zones work, and all process settings optimize treatment rather than hinder it. During this phase it is important to recognize any area where money is being wasted. One of the operator's main objectives is to run the facility properly and as efficiently as possible. This can be done by reducing chemical and electricity use to the minimum point necessary. For example, if an aeration blower can be run for 8 hours instead of 10 hours a day without any ill effect on the system, it should be done. During this stage, correspondence with the design or contracted engineer is recommended. Informing the appropriate parties on the state of facilities and inspection results will help to determine anything overlooked and future steps to improve the facility. If there are looming dates, such as the expected end of a piece of equipment's useful life, it is best to discuss this well in advance with owners and management. Conversations with engineers will also help to determine additional equipment required to perfect the treatment process or reduce any negative impact on the facility's surroundings.

The final stage of any start-up or remedial process is to standardize a procedure of operation that includes all preventative maintenance, recording of process settings and levels, and dates

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for equipment updating. Weekly, monthly, and yearly checklists for essential functions should be produced and adherence to these standards maintained. When this stage is taken seriously, the opportunity for breakdown or failure is significantly reduced.

As an industry, our objective is, and should be, the reduction of the human impact on our surrounding water resources. To accomplish this, we must ensure that all facilities receive the attention needed to remain in or return to compliance. The previously stated challenges should identify some of the major roadblocks to this objective, along with the countless smaller challenges that affect all facilities. Overcoming these challenges is no easy matter, but through improved approaches to operating and maintaining facilities, better owner/user knowledge of the system and processes, and a strong financial commitment by owners, we can set a higher baseline of success throughout the small, decentralized treatment industry.

ABOUT THE AUTHOR

Robert D. Lilley is a regional supervising wastewater operations manager for Small Water System Services (SWSS) in Littleton, Massachusetts. His firm provides water and wastewater O&M services to municipal and private clients primarily for facilities of 100,000 gpd (378,540 L/d) or less. Mr. Lilley also manages new contract facility assessments for SWSS and oversees operator troubleshooting and equipment repairs and upgrades. Prior to SWSS, Mr. Lilley worked in the environmental remediation field, with turnkey construction experience building and commissioning systems throughout the Northeast.