Tuning the Accuracy of Lift Station Flow Rates

By Gary L. Kerr,
Maid Labs Technologies, Inc.

PART 1 OF 2

To tune means to adjust for optimal or improved performance. Musical tuning entails adjusting an instrument to achieve a perfect pitch. Depending on the instrument, this continual process requires one to consider many fluctuating variables—changes in temperature, for example, or the varying acoustics of physical spaces. But much relies on intuition. Accurately determining lift station volumetric flow rates requires tuned precision, but on a more sophisticated scale.

As wastewater collection systems age it becomes important to accurately monitor inflow and infiltration at lift stations; engineers and utility managers rely heavily on flow-data accuracy in making sound decisions to improve and maintain their systems' efficiency. But, as the EPA acknowledges, today's wastewater utilities find themselves faced with increasingly tight budgets, and utilities search for cost-effective ways to monitor and record lift station flow rates—data that has never been easy to calculate.

PRE-SCADA METHODS OF MEASUREMENT

Before the advent of SCADA (supervisory control and data acquisition) or telemetry systems, the municipal industry had two ways to measure flow rates in collection systems. Utilities could install a magnetic flow meter in the effluent line or use several types of metering devices in the influent pipe of the lift station. These techniques included volumetric, open channel, and closed conduit flow measurements. Implementing these flow techniques have myriad cost variables associated with them: installation,

About The Author

Gary L. Kerr is the national product manager for Maid Labs and brings with him over twenty years of experience in product performance and monitoring of wastewater pump station. For more information, visit **www.maidlabs.com**.

manpower, site preparation, and accuracy verification.

However, in the Science and Ecosystem Support Division's Operating Procedure entitled "Wastewater Flow Measurement" made effective on August 12, 2011, the EPA clearly states that "volumetric flow measurement techniques are among the simplest and most accurate methods for measuring flow." But calculating volumetric lift station pumping capacities to produce influent flow rates may be misleading. Pump capacities constantly change due to the applied head pressure and pumping conditions. Only tuning/updating pump curves while reacting to these changing conditions can improve volumetric flow accuracies. Using this tuning method, Maid Labs, the creator of the MerMaid system, has achieved true volumetric accuracies.

PAST APPROACHES AND DIFFICULTIES IN MEASURING LIFT STATION FLOW RATES

A magnetic flow meter provides the most accurate measurement for flow data. Some manufacturers offer an overall accuracy of 0.15 percent with 0.25 percent as the standard for these meters. A typical meter would be installed on the effluent side of a lift station. From there, it accurately monitors flow output from the pump(s) and totalizes the volumes. The downside rests with the expense to install a magnetic flow meter, and the fact that few lift stations have the required 100 percent full-pipe flow. Today, a magnetic flow meter can cost as much as ten to twenty thousand dollars, and many utilities only have 10 to 20 percent of their lift stations that even qualify for these meters. While this is the ideal system to monitor flow rates, it's not practical or cost effective to install at most lift stations.

The second type flow monitoring takes place on the influent line/pipe approaching, or at, the lift station. If the influent piping at the lift station is submerged, or could become submerged, a suitable location upstream becomes necessary to monitor the flows traveling to the station. This often requires several meters to monitor the flows to one lift station. This method also requires various types of primary devices such as V notch weirs or level/flow-measuring devices which use the Manning Equation. The problem, however, resides with the overall accuracy of these devices: as the conditions change, accuracy erodes quickly. The logistics to provide this type of technology alone requires large amounts manpower. Additional workers would be needed for the installation, removal, physical maintenance, and relocation of these meters, but also for

data collection and troubleshooting problems. Considering the number of additional employees, most utilities generally cannot afford to continuously monitor lift station flow rates—even if the DEP or the EPA mandates this monitoring.

The first SCADA and telemetry systems aimed to solve the cost and practical application issues; these systems had the capability to monitor all the lift stations within the municipality on a continual basis. Telemetry systems communicated this data to the host through an assortment of methods primarily using radio or phone networks. This new method used the pump capacities supplied by the pump manufacturers or a drawdown test to set a capacity for each pump in the lift station. By recording the amount of time each pump was active and multiplying its capacity, these systems could produce a derived flow and totals for each lift station. The HMI could then report the flow data, display those totals, and store the information for future use in historical or modeling programs.

> Only tuning/updating pump curves while reacting to changing conditions can improve volumetric flow accuracies.

THE SEARCH FOR MORE ACCURATE MEASUREMENT

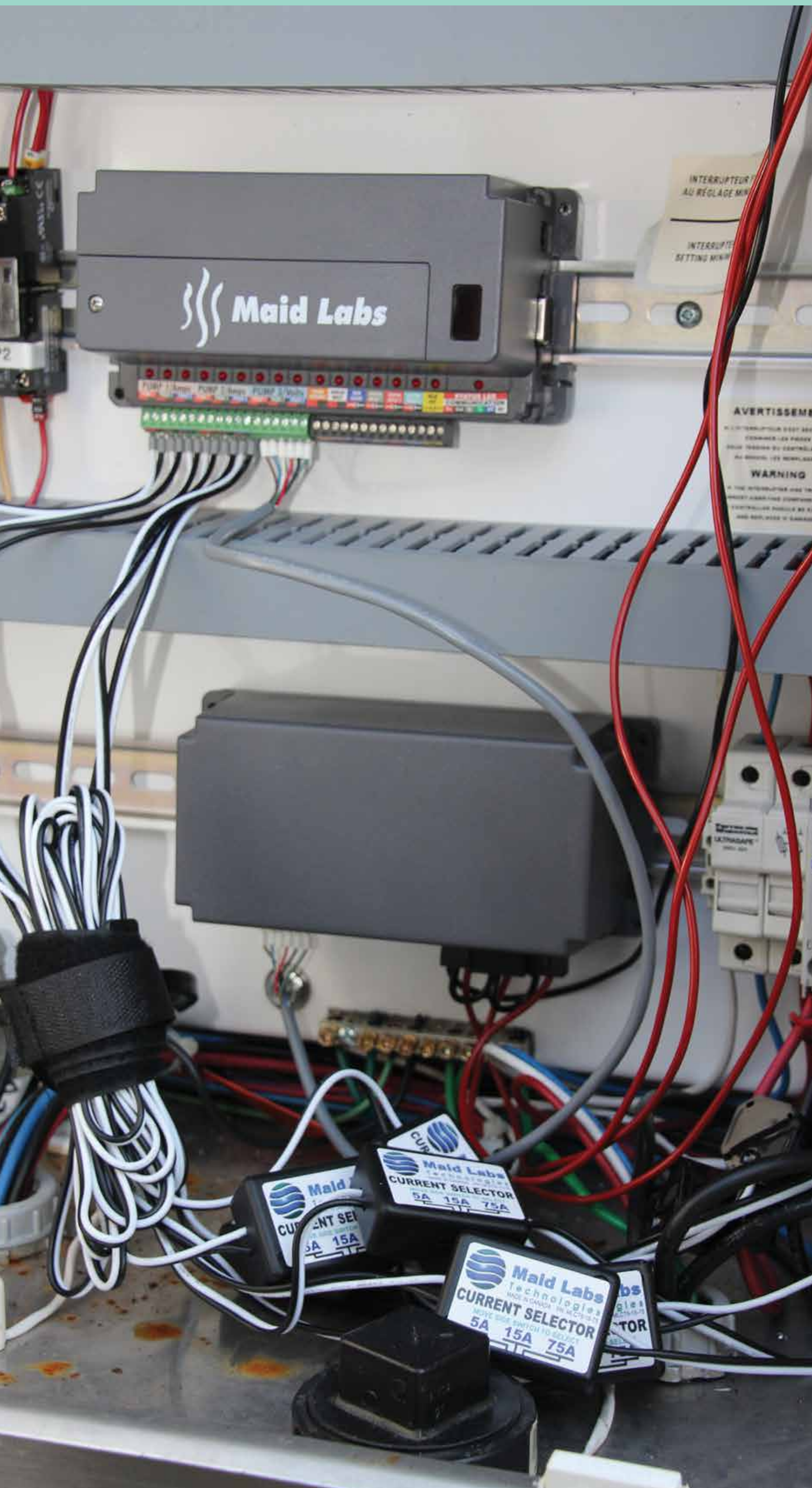
The majority of municipalities today still use this derived-flow method to record flow rates, but even this system presents a problem: limited accuracy. To derive means to deduce by reasoning or an assumed conclusion. When it comes to monitoring flow rates, deduction can never equal solid calculation, reasoning becomes little more than guesswork. A calculation based on assumption, this method derives flow rates with an overall accuracy of only 10 to 15 percent of the actual flow in a lift station. This method scores points for cost effectiveness; the system does not require additional manpower other than the maintenance on the telemetry system. The telemetry system also adds value to the utilities by providing critical data for their lift stations' maintenance divisions. However, many engineering consultants are skeptical of the utilities' flow-data accuracy and some municipalities are uncertain of their recorded data's accuracy.

In the August 2011 "Wastewater Flow Measurement" Operating Procedure, the EPA further stated that "any continuous flow measurement system that cannot measure the wastewater flow within ±10 percent of the actual flow is considered unacceptable for use in measuring wastewater flow." The problem here is certain: a system based on the derived-flow method is just not precise enough for the task at hand. To meet today's EPA standards wastewater utilities require improved methods to provide lift station flow accuracies greater than the derived 10 to 15 percent. In part two of this article, we will explore the development, difficulties, and solutions presented by tuned flow lift station monitoring. ■

REFERENCES

Salguero, Louis. (August, 12 2011). Wastewater Flow Measurement (SESD Publication No. SESSPROC-109-R3). Athens, GA: U.S. Environmental Protection Agency Science and Ecosystem Support Division. 1-16.

Stoner, Nancy and Cynthia Giles. (October 27, 2011). Memorandum: Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans. United States Environmental Protection Agency. Washington, D.C: Government Printing Office.



Tuning the Accuracy of Lift Station Flow Rates

By Gary L. Kerr,
Maid Labs Technologies, Inc.

PART 2 OF 2

Tuned flow lift station monitoring—development, difficulties, and solutions

In part one of this article, we explored pre-SCADA methods of measurement, past approaches and difficulties in measuring lift station flow rates, and the current search for more accurate measurement by today's municipalities—who appear almost trapped by limited investment capital but increasing quality regulations. In this concluding entry, we'll lay out some of the benefits provided by contemporary effective and environmentally-efficient flow monitoring solutions.

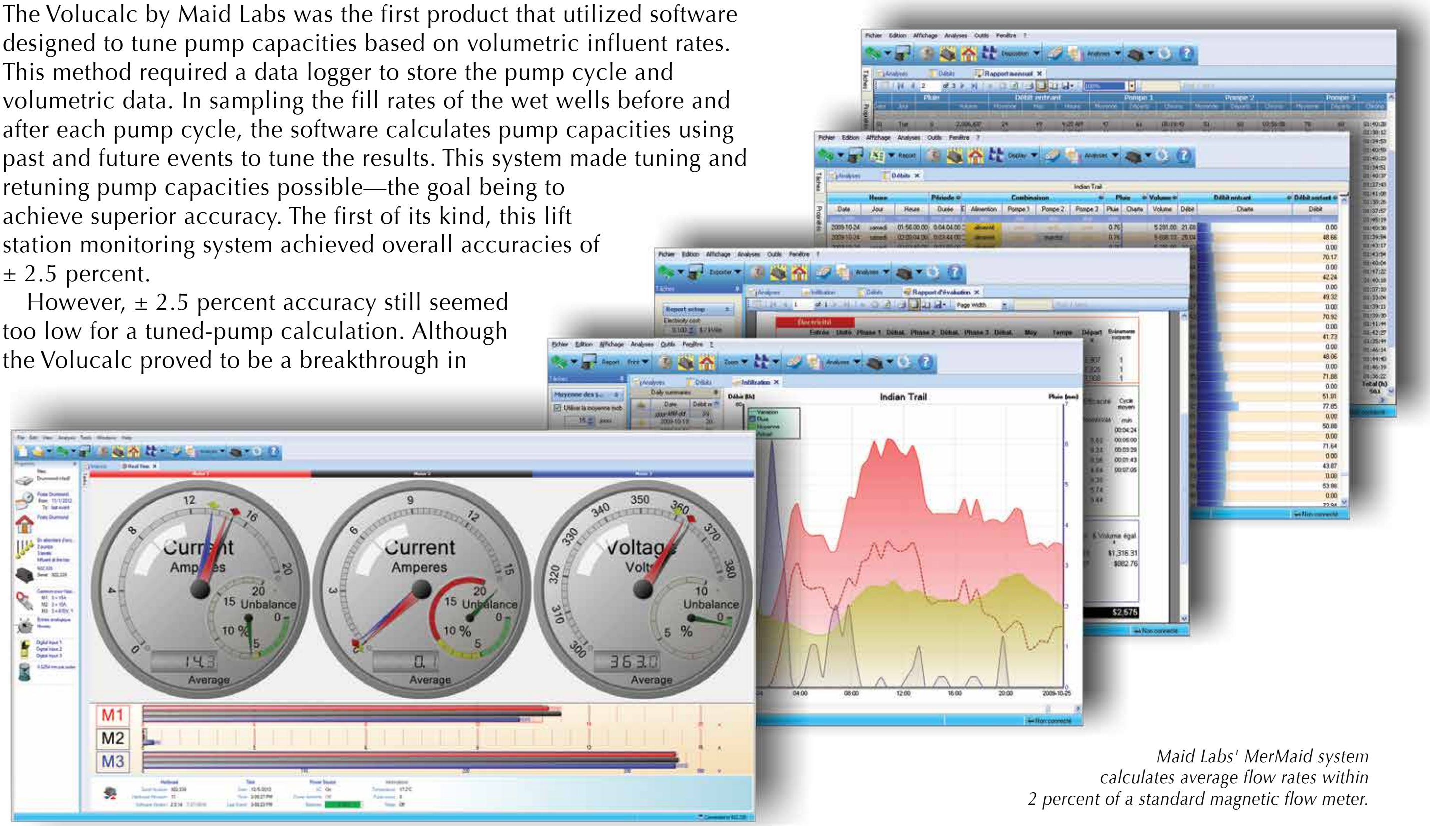
About The Author

Gary L. Kerr is the national product manager for Maid Labs and brings with him over twenty years of experience in product performance and monitoring of wastewater pump station. For more information, visit **www.maidlabs.com**.

TUNED FLOW LIFT STATION MONITORING

The Volucalc by Maid Labs was the first product that utilized software designed to tune pump capacities based on volumetric influent rates. This method required a data logger to store the pump cycle and volumetric data. In sampling the fill rates of the wet wells before and after each pump cycle, the software calculates pump capacities using past and future events to tune the results. This system made tuning and retuning pump capacities possible—the goal being to achieve superior accuracy. The first of its kind, this lift station monitoring system achieved overall accuracies of ± 2.5 percent.

However, ± 2.5 percent accuracy still seemed too low for a tuned-pump calculation. Although the Volucalc proved to be a breakthrough in accurately recording flow rates, the data recorded was still not exact enough. Part of the discrepancy rests with the algorithm this software hinges on. Developer Benoit Beaudoin of Maid Labs tested his algorithm with performance software that emulated typical flow rates generally seen in lift stations.



Maid Labs' MerMaid system calculates average flow rates within 2 percent of a standard magnetic flow meter.

The software emulations included influent flow rates based on time of day and derived rainfall as I & I events. Beaudoin also wrote an additional algorithm within this software to imitate force main pressure variances—a critical component in calculating tuned pump capacities. The EPA did not dispute the calculation results because the product software used a bucket and stop watch approach to calculate the inflow rates and pump capacities.

Aiming to address the low percentage for tuned-flow monitoring, Beaudoin's research found that in most current calculations, including drawdown tests, SCADA systems' time-stamped data, which use the manufacturers' pump curves, is just not accurate. SCADA systems derive results from a pump capacity—a capacity which does not change even though every input to calculate it does change. These calculations fail to anticipate or adjust to the dynamic effect lift stations present or the in situ pumping capacities.

LIFT STATIONS ARE DIVERSE

Wastewater flows into a wet well of many designs. Round, square, rectangular, sloped, tapered—lift station designs come in any functional shape an engineer can think up. Most lift stations collect the inflow in a wet well and pump/lift it to travel through a gravity system. Many utilities, however, use force mains or combine gravity/force main systems to transport effluent flow to be processed at wastewater plants. Variables related to pumping capacities also needed consideration; these pump capacities can vary based on size, horsepower, and type of pump(s) installed.

Also, most lift stations will experience a wide range of electrical issues from starters, contactors, alternators, and assorted relays which affect the accuracy of flow calculations. Maid Labs also found under- and over-designed station pumping capacities which impeded the force main pressures throughout the collection systems. This does not even account for the constant altering of influent flow rates or the drawdown/siphon effects on each cycle of the lift station.

CALCULATING MORE CONCRETE FLOW-RATE DATA

Now that the researchers understood why the tuned-flow system produced results with only ± 2.5 percent accuracy, the question shifted to how to overcome these dynamic properties for calculating more concrete flow-rate data. They knew the same old drawdown test would not be enough; it failed to account for changes in the influent rates, the force main pressures, the drawdown effect, or the siphon effect. The research and development department became obsessed with taking every small, potentially-overlooked detail into account. Developers had to adjust for the siphon effect, the drawdown effect, the possibility of mismatched pumps, the submersion of influent pipes, the capacity/volume of influent pipes—the list went on and on. Maid Labs had to do much more to their software to provide the overall accuracy desired in their products.

Past product successes worked to the advantage of researchers as it gave them the ability to review hundreds of raw data files. Armed with this information and dozens of lift station videos, the research and development team determined that the original emulation software produced calculated data too simplified to provide accurate tests. But the original algorithm Beaudoin developed was right, just limited! Starting over from scratch, Beaudoin created a new and highly versatile algorithm. What began as a single white board with the original algorithm expanded to three, then five, and now eight white boards of mathematical equations designed to continuously tune pump capacities.

The result of the team's effort is a complex bucket and a stop watch algorithm that successfully takes the dynamic nature of lift stations and flow rates into account. The MerMaid system is a lift station performance analyzer that calculates average flow rates within 2 percent of a standard magnetic flow meter while providing critical data on the electrical performance and efficiency of the lift station in the process.

CONCLUSIONS

In addition to addressing the concerns of utilities, the MerMaid system follows EPA guidelines for cost effective and environmentally-efficient flow monitoring. On October 27, 2011, the EPA issued a memorandum with the following subject: "Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans." The memorandum aims to encourage utilities to use "Integrated Planning for Cost-Effective Solutions." This plan raises the bar for utilities to meet the obligations required by the Clean Water Act (CWA); the EPA encourages states and municipalities to maximize their infrastructure-improvement dollars.

This plan surely did not exclude collections systems efficiency. But a collection system's efficiency is not just about flow rates: it's the combination of accurate flow data, pump capacities, head losses, and horsepower to produce usable results. Tuning the accuracy will provide key data for I & I studies, hydraulic modeling, and lift-station efficiencies. Beaudoin's dedication and Maid Labs' research has produced a product which takes the guesswork out of lift station performance and meets the current needs of utilities pursuing their CWA objectives. ■

REFERENCES

1. Salguero, Louis. (August, 12 2011). *Wastewater Flow Measurement* (SESD Publication No. SESSPROC-109-R3). Athens, GA: U.S. Environmental Protection Agency Science and Ecosystem Support Division. 1-16.

2. Stoner, Nancy and Cynthia Giles. (October 27, 2011). *Memorandum: Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans.* United States Environmental Protection Agency. Washington, D.C: Government Printing Office.