# Distributed I/O and Remote I/O Solution Improves Performance and Reliability of Water Treatment Plant

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In Central New York State, recent upgrades at a municipal water plant have provided the means for operators to enhance their process for meeting the water quality needs of customers. As part of the upgrades, the facility modernized its control system utilizing a Distributed I/O and Remote I/O solution. This technology reduced wiring costs for field instrumentation while improving operational readiness and reliability.

## Background

The Onondaga County Water Authority (OCWA) supplies water from Otisco Lake and Lake Ontario to more than 345,000 retail and wholesale customers via 91,000 metered connections located in suburban Onondaga County and parts of Madison, Oneida and Oswego counties.

A treatment plant owned and operated by OCWA, which treats water from Otisco Lake, supplies approximately half of OCWA's water. Located in the Town of Marcellus, New York, the facility has undergone infrastructure improvements designed to enhance its overall performance. OCWA recently rehabilitated four existing filter units and added two new filters to improve the plant's water quality, increase its reliability, and comply with state and federal regulations governing municipal drinking water plants.

## Process Description

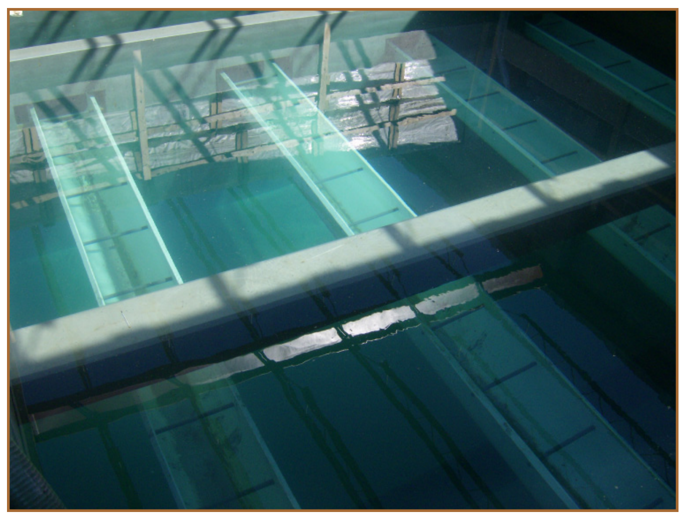
OCWA has two intake pipes located in Otisco Lake. The water entering these pipes is immediately chlorinated to provide disinfection and to discourage the growth of zebra mussels. The water then travels, by gravity, approximately five miles to OCWA's water treatment plant in Marcellus (Figure 1).

***Figure 1.*** *OCWA's water treatment plant in the town of Marcellus, New York, has undergone infrastructure improvements designed to enhance its overall performance.*

Water first enters the Rapid Mix tank where a coagulant (polyaluminum chloride) and a taste and odor control chemical (powdered activated carbon) are added. After 30 seconds of mixing, the water enters the Contact Basins where calm conditions allow the coagulant to make small particles adhere together to form larger particles. Some of these particles settle and are cleaned out later. The contact time in the basins also allows the powdered activated carbon (used during times of high algae growth in the lake) to absorb organic taste and odor causing chemicals.

After approximately one hour of contact time, the water enters the filters. Particles are removed as the water passes through one of the six filters. These filters contain granular activated carbon and sand. The filters are washed periodically and the water used to do this is collected in lagoons and allowed to settle. It is then recycled back to the start of the treatment plant to be treated again (Figure 2).

***Figure 2.*** *As part of the treatment process, filters containing granular activated carbon and sand are used to remove particles fromthe water.*



After filtration, the water is once more disinfected with chlorine and fluoride is added. The water is stored in large tanks located at the treatment plant to provide adequate contact time for the chlorine to work. Once the water leaves the tanks, orthophosphate is added to provide a coating for pipes in the distribution system, which is done in order to prevent the leaching of lead and copper from the pipes.

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## Operational Challenges

Operational reliability is critical to the effectiveness of any water treatment facility. If automation systems and the processes they control are not dependable, the plant faces the risk of non-compliance with local, state or federal water quality guidelines.

At the Marcellus water treatment plant, OCWA undertook an ambitious project to update its processes and technology to meet new and proposed state health department and EPA regulations. This effort involved expansion of the facility from four to six filter beds, as well as the modernization of various mechanical systems and chemical processes. The plant also upgraded its overall control and instrumentation system in order to enhance automation performance, improve reliability, provide for simple and cost-effective expansion, and reduce operating and maintenance costs.

As part of the control system modernization, OCWA decided to upgrade its legacy Bristol-Babcock 3335 Remote Terminal Units (RTUs) with Emerson's ControlWave Programmable Automation Controllers (PACs). Plant management sought to improve the performance of control room operators by transitioning from manual analog control to a fully automated SCADA system utilizing Ethernet and MODBUS network communications (Figure 3).

***Figure 3.*** *Original analog control system at Otisco Lake Water Treatment Plant, Onondaga County Water Authority.*

In addition, OCWA wanted to reduce wiring and instrument maintenance costs at its water treatment facility. This would require the elimination of multiple long cable runs between sensors, actuators and controls, and a solution for collecting multiple sensor/control pairs near their point of installation. Such an approach would do away with hundreds of previously installed twisted pairs, cable trays, complex wiring diagrams, and associated maintenance.

## New Technology

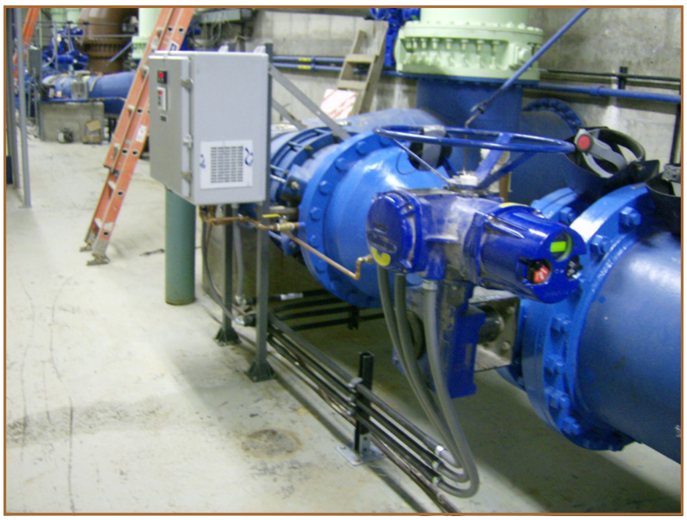
In October 2008, the Marcellus facility began the task of replacing outdated analog control equipment with the latest technology, and moving all process automation functions to an online SCADA system. The project called for replacing existing RTUs to provide a scalable platform suitable for a variety of small applications, as well as control strategies spanning the entire plant; and gaining the ability to leverage modern digital signal transmission (Figure 4).

***Figure 4.*** *Process functions are now controlled through a PC/PLC-based control system.*

Key to the control system upgrade was the implementation of Distributed I/O and Remote I/O—specifically a solution employing isolated I/O modules to eliminate signal loop interference on the Ethernet control network. This would stop ground loops and signal aberrations at any location from affecting other measurements in the facility. Digital communications, in place of analog signals, also eliminates sensor and control signal degradation (and associated calibrations) and cross communication (noise) commonly associated with "analog-only" communications.

Various automation equipment suppliers now offer modular I/O systems that can be used as a relatively low-cost method of bringing field devices from the plant floor into a SCADA or control system using Ethernet. These systems can communicate with each other and other computers over standard Ethernet using off-the-shelf Ethernet hubs, switches and/or routers, and viewed from a wireless laptop, web browser, spreadsheet or third-party HMI.

***Figure 5.*** *As part of the improvements, automated valves were installed and connected to the instrumentation network.*



After considering alternative vendor offerings, OCWA's project team decided upon the NET Concentrator System® (NCS) from Moore Industries. This smart I/O system takes advantage of "cable-concentrating" technology, which eliminates point-to-point cable, conduit and wire trays by sending process monitoring and control signals between the field and control room on a single digital communication link. The system provides true signal isolation, with isolated modules for both analog and digital I/O. All discrete and analog signals are digitized, packetized and communicated via Ethernet communications using standard Ethernet cables, LAN switches and routine Ethernet hardware (Figure 6).

***Figure 6.*** *Moore Industries' NET Concentrator System (NCS) provides a solution for Distributed I/O and Remote I/O.*


The Distributed I/O and Remote I/O System functions as a universal signal gateway that interfaces with OPC-compatible DCSs or PLCs, and works over 10/100Base-T Ethernet (MODBUS/TCP) and MODBUS RTU networks. The system includes a communications module plus multiple I/O modules. Each I/O module supports multiple analog or discrete channels that interface to remote sensors, switches, actuators and displays. Each analog input channel incorporates its own 20-bit A/D input. This guarantees that no resolution from the existing analog transmitters will be lost when the signal is transmitted over the Ethernet network to the host system.

At the Marcellus water treatment plant, the Distributed I/O and Remote I/O communication module digitally communicates signals to a network concentrator in a peer-to-host network. The use of digital communication with error correction and high-speed Ethernet LAN cable assures signal integrity and minimizes signal degradation that could otherwise exist with traditional home-run analog signals.

## Control Architecture

For OCWA engineering and operations personnel, the peer-to-host Distributed I/O system provides a reliable method of transferring monitoring and control signals to and from the PLC-based control system. In this configuration, five remote I/O stations are situated along the Ethernet network in different areas of the plant. Each station contains 10-15 I/O modules. For monitoring applications, the system collects signals from analog transmitters or discrete devices. It concentrates the signals and, when polled by the network master, sends them over the Ethernet network directly to the main PLC control panel. For control, process commands from the host are transmitted over the network and converted to analog or discrete form to control valves, pumps, motors and other types of proportional and on/off control elements.

Once field device data is delivered to the computer-based host, SCADA software provides a user interface supporting data acquisition, alarm management, data logging and reporting, historical data collection and trending, and supervisory control functions (See Fig. 7).

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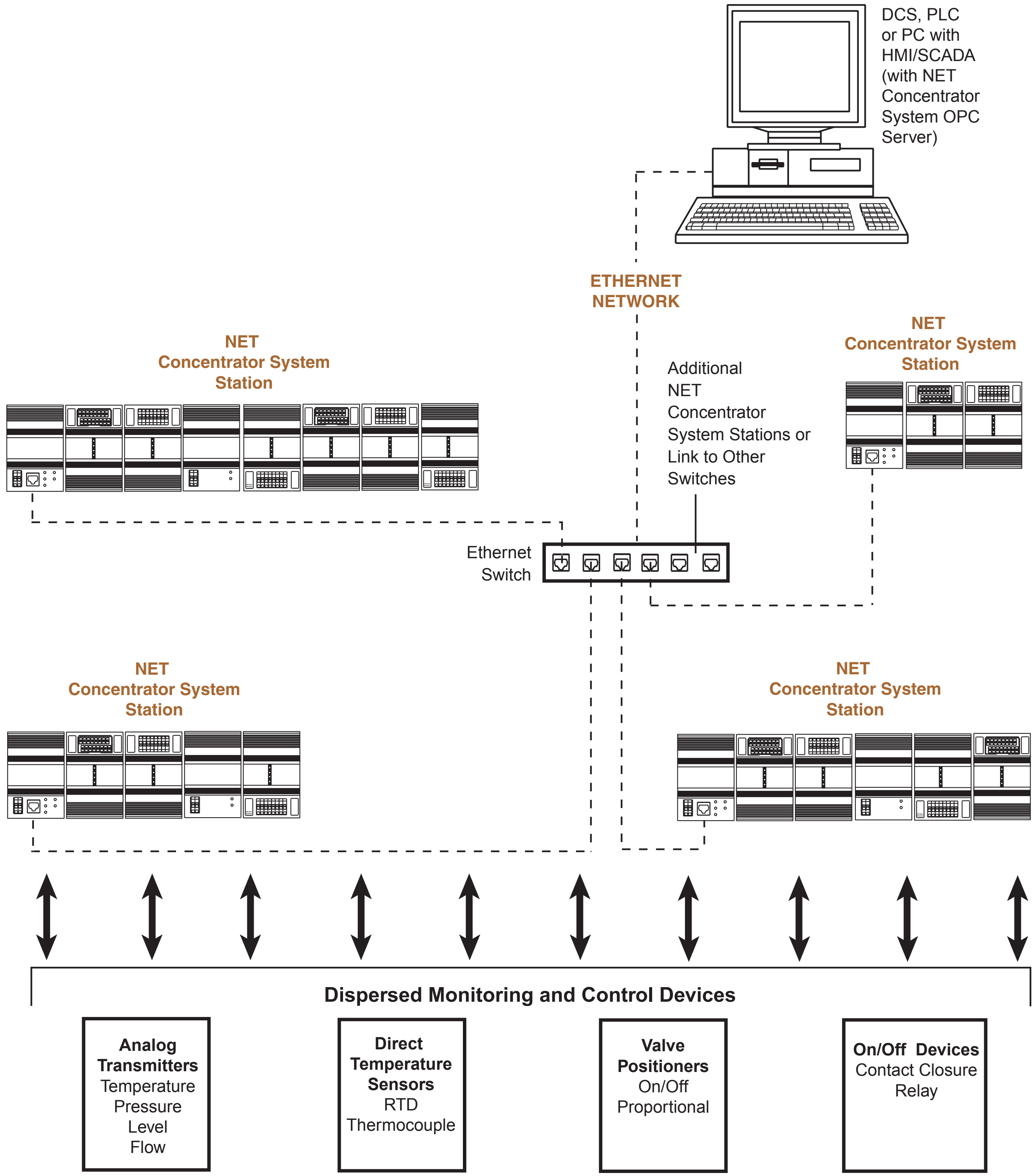
***Figure 7.*** *In a peer-to-host system, multiple field concentrators network to handle signal inputs and outputs.*



The use of a field concentrator makes it easy to connect both existing and new process control signals and sensors to the control strategy. Such an approach expands control schemes by concentrating I/O remotely—and significantly reduces wiring costs. The use of analog input modules with a built-in 24V power supply per input eliminates the need to run wiring from the modules to another terminal or auxiliary 24V power supply, thus helping to make remote control panels smaller.

With the Distributed I/O and Remote I/O system, operators can now view I/O within the plant directly from a local HMI or wireless laptop. This allows the operator to monitor and make adjustments to the facility operations from anywhere in the plant. The I/O signals remain fully accessible, even in the event of a main control system failure. In addition, there is a less frequent need for technicians to go into the field to troubleshoot flowmeters, pressure transmitters, valves and other devices.

## Project Results

The new PLC, SCADA, and Distributed I/O and Remote I/O systems at the Marcellus water treatment plant have extended process automation and enabled operators to manage potential problems safely and swiftly. They have also helped to reduce hard-wiring costs and maintenance requirements. Most importantly, the new equipment has proven to be very reliable, which was one of OCWA's criteria for technology investments.

Thanks to improved data acquisition and control capabilities, OCWA personnel are better equipped to handle issues that arise at the plant. Managers, operators and technicians can view the water treatment processes from any one of the onsite HMIs or computers. What's more, they can monitor and control the company's water distribution operations without ever leaving the Marcellus site.

The ability to closely monitor filter beds and other processes with real-time field data has reduced operator reaction time, and ultimately improved plant efficiency. It has also increased security and allowed for more accurate reporting of water quality.

From an engineering and maintenance perspective, the recent technology upgrades provided additional troubleshooting tools in a convenient package, which is independent from the control system. All I/O is visible though the plant's Ethernet network—even in the event of a complete PLC shutdown.

## Conclusion

OCWA can now maintain a consistent, high quality water treatment operation without unexpected downtime and costly repairs. And plant operators have gained the necessary means for real-time monitoring of plant processes to ensure the quality of water meets all applicable requirements.

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