ABSTRACT

The Brown County Water Improvement District No. 1 (BCWID) owns and operates an integrated water treatment plant that consists of a 7.5 MGD conventional and 9.0 MGD membrane plant. Through the lens of BCWID's experience, the unique advantages and challenges associated with an integrated water treatment plant are:

- Flexibility of integrating the plant piping and hydraulics to function in a separate parallel conventional/membrane mode or conventional as pre-treatment,
- Flexibility in having common components such as raw water terminal storage, clearwells, high service pumping, and chlorine and ammonia feed facilities,
- Cross-training plant staff in both conventional and membrane operations and maintenance,
- Integration of regulatory reporting.

In addition, an evaluation of membrane pretreatment to improve flux rates was conducted.

KEYWORDS

Microfiltration, direct coagulation, integrated treatment, conventional treatment

INTRODUCTION

Brown County Water Improvement District No. 1 (BCWID) is a wholesale supplier of raw water used for irrigation and treated water used for municipal purposes in Brown and Coleman Counties of central Texas. The water treatment facilities at BCWID consisted of two conventional flocculation/sedimentation/filtration plants, one of which was constructed in 1938 and the other constructed in 1985. A water supply availability and demand assessment for both existing and potential future customers was conducted in 2001 (Freese and Nichols, Inc.). It was determined that the District would need an additional 7.5 MGD of treated water capacity. Furthermore, it was recommended to abandon the 1938 treatment plant due to aging infrastructure.

Since Lake Brownwood, the District's water source, had good water quality with low turbidity (5 NTU) and low total organic carbon (TOC) (2 – 4 mg/L), it was determined that, pending a pilot study, membrane treatment would be a viable option to provide the 7.5 MGD of additional
capacity. A microfiltration (MF) pressure type system was selected for pilot testing to evaluate the feasibility of a membrane treatment system. The pilot test confirmed that no pretreatment was required, and the system was given the highest flux rate approved in the State of Texas (80 gfd; changed to 75 gfd following a recalculation of the flux by the manufacturer). The membrane plant was designed to operate in tandem with the existing conventional plant with four modes of operation: (1) in parallel, (2) membrane-only, (3) conventional-only or (4) in series with the conventional plant performing pretreatment for the membrane plant. As such, both treatment plants are completely integrated. After construction and operation of the membrane plant, the design team performed a side-by-side comparison of membrane (9.0 MGD) and conventional (7.5 MGD) treatment plants. The membrane plant demonstrated 23% lower operational cost when compared to the existing conventional plant.

It is the objective of this paper to highlight the unique advantages and challenges of the integrated conventional and membrane treatment. In addition, this paper will discuss the District’s operational (chemical) modifications to the pretreatment scheme to achieve the piloted flux rate, specifically by adding a coagulant ahead of the membrane filtration process.

TREATMENT PLANT DESCRIPTION

The BCWID treatment facility consists of a 7.5 MGD conventional treatment plant and a 9.0 MGD microfiltration membrane plant. The process flow diagram for both facilities is detailed in Figure 1. Both treatment plants are integrated in order to allow for the following modes of operation:

- Parallel Treatment (capacity = 16.5 MGD),
- Conventional-Only (capacity = 7.5 MGD),
- Membrane-Only (capacity = 9 MGD), and
- In-Series (capacity = 9 MGD).

Whenever operated in series, water is diverted following conventional sedimentation to the head of the membrane plant (see dotted line in Figure 1).

Figure 1 – Process flow diagram for Conventional and Microfiltration Plants
INTEGRATED WATER TREATMENT CONSIDERATIONS

Benefits of Integrated Treatment

Several benefits arise as a result of integrating the conventional and membrane treatment plants:

- **Flexibility** - Operators have a heightened degree of flexibility for operating the treatment plant. If needed, entire plant shut-downs can be conducted for maintenance or improvements. Furthermore, the conventional treatment facility can act as pre-treatment for the membrane plant if the source water quality temporarily becomes challenging to the membrane plant (e.g. TOC spike during large rain event, lake turnover or switching raw water intake zone).

- **Common Components** – As shown in Figure 1, the conventional and membrane plants share several components including the terminal storage reservoir, high service pumping, chemical feed facilities, sludge lagoons and clearwells.

- **Cost Savings** – As a result of the above two aspects as well as the decreasing cost of membrane treatment, capital savings of $3.6 million was estimated for the membrane expansion compared to a conventional treatment plant expansion. BCWID also determined that operating costs were lower for the membrane plant ($107/MG) when compared to the conventional plant ($138/MG).

Challenges of Integrated Treatment

Although the integrated conventional and membrane treatment plant provides several benefits, it also introduces unique challenges including:

- **Training Plant Staff** – Plant staff must be cross-trained on both conventional and membrane operations and maintenance. This requires a great deal of commitment from the operators in order to learn both types of systems. From the experience at BCWID, it was found that high quality and continuous training must be a priority. In order to provide an additional level of redundancy, the District has even trained and certified several maintenance staff members to operate the water treatment plants.

- **Regulatory Reporting** – Due to the integrated nature of the treatment plants, BCWID has three different monthly operating reports (MORs) that must be submitted: (1) conventional, (2) membrane and (3) in-series (if operated). Additionally, BCWID must sample and track disinfection zones for both conventional and membrane treatment. From the experience at BCWID, it was found that the unique nature of BCWID’s regulatory reports were oftentimes alarming to regulators; therefore, it was essential that BCWID developed an open line of communication with the regulators in order to quickly address and resolve any misunderstandings. Additionally, automated MORs were made possible using data downloaded from the supervisory control and data acquisition (SCADA) system.

- **Disinfection Requirements** – In the State of Texas, disinfection requirements differ for membrane and conventional treatment. Specifically, membrane treatment plants without pretreatment (coagulation/flocculation or coagulation/flocculation/sedimentation) do not receive a virus removal credit. Care must be taken in order to design for the chemical dosing necessary in order to fulfill the additional CT requirement for 4-log virus inactivation.
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- **Electronic Recording and Reporting** – At the time of the membrane plant improvements, the existing SCADA system for the conventional plant was 25 years old. Updating and integrating the old SCADA system proved difficult and eventually required the assistance of a specialized integrator.

**IMPROVING MEMBRANE FLUX WITH PRETREATMENT**

Membrane piloting testing conducted in 2003 indicated that gross flux rates of 75 gfd (at 20°C) were possible without pretreatment; however, the maximum flux achieved by the full-scale membrane system was approximately 45 gfd (at 20°C). The lower output of the membrane plant was problematic since the conventional plant needed to be shut down in order to implement improvements that were financed via time sensitive State funding. Given the low flux rates of the membrane plant, the District could not comfortably shut down the conventional plant without compromising their ability to meet water demand. As such, pretreatment options were evaluated in order to improve the membrane plant’s flux rates.

The historical TOC concentrations within Lake Brownwood (raw water source) were evaluated in order to determine if the water quality changed from the time of the pilot study (Figure 2). It was determined that the TOC concentrations increased from 4 mg/L to 5 mg/L from the time of the 2003 pilot testing. Jar testing revealed that a relatively small dose of aluminum chlorohydrate (ACH) without flocculation could improve membrane flux; therefore, a full-scale demonstration of the concept was conducted.

![Figure 2 – Historical TOC concentrations of Lake Brownwood](image)

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The full-scale testing to determine the efficacy of precoagulation to improve flux rates was conducted as described by Landes and Allen (2013). A low dose of ACH (5 mg/L) was added in the chemical mix basin upstream of the microfiltration units (see Figure 1). Each of the membrane plant’s seven racks (40 microfiltration membrane modules each) was tested individually. Throughout each test, flow rate, percent valve opening, transmembrane pressure (TMP) and temperature were measured. The tests were performed 2 days after a clean in place (CIP) event, when the membranes were expected to be optimally clean and then 28 days after the CIP when the membranes were more likely to be fouled. The results of the tests are shown in Figure 3. During the first round of tests (2 days after the CIP), only 2 of the 7 racks did not reach the targeted flux rate of 75 gfd. As a result of some minor operational changes (increased influent pressure header setpoint from 35 psi to 40 psi), all 7 racks met the targeted flux rate during the second round of testing (28 days after the CIP). It has been reported previously that coagulation is the most successful pretreatment for fouling reduction (Huang et al., 2009); therefore, alternative pretreatment strategies were not evaluated given the success of the tests on each rack.

Following the successful testing of each rack individually, the District made efforts to test the entire system at design capacity (9 MGD) over a period of nearly three continuous days. The system was able to achieve design capacity without problems thereby allowing the District to move forward with the conventional plant expansion.

![Figure 3 – Results of the ACH precoagulation test for each membrane rack](image-url)

**CONCLUSIONS**

BCWID was able to achieve capital and operating savings by implementing an integrated conventional and membrane treatment plant. The integrated treatment system provided a number of unique advantages as well as challenges that were systematically addressed.
Following a full-scale feasibility test, coagulation was demonstrated to improve the reliability and capacity of the membrane plant.

REFERENCES


Landes, N.; Allen, J. (2013) How Can So Little Do So Much? Doubling Membrane Flux with 5 mg/L of Precoagulant. Proceedings of the SCMA 2013 Annual Conference; San Antonio, TX, July 31 – August 2; South Central Membrane Conference: Austin, TX.