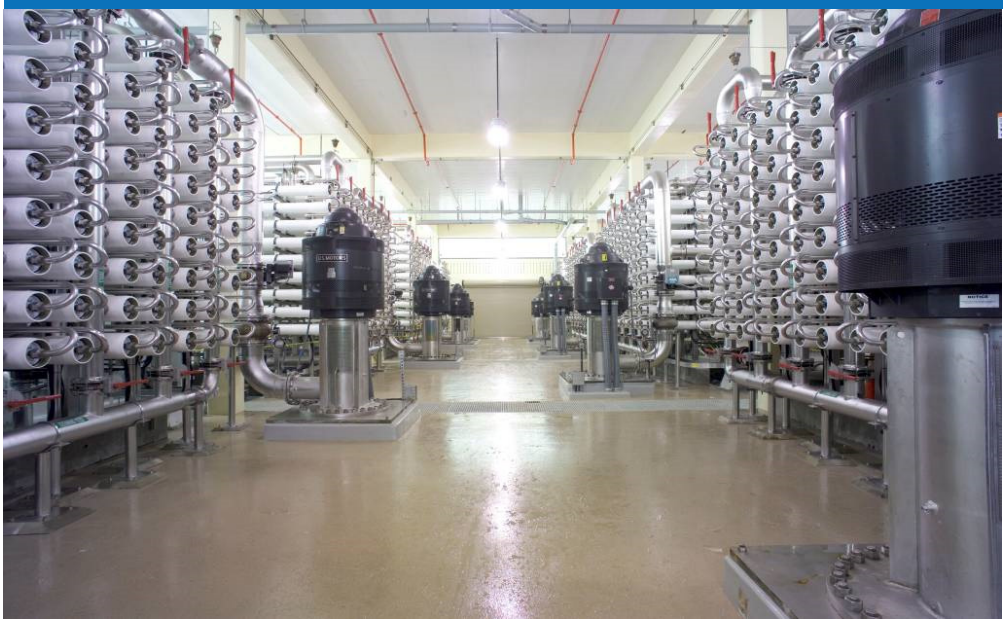
McCafferty Brinson consulting

40 mgd Membrane Softening Process Addition Glades Road Water Treatment Plant

Boca Raton, Florida



Client
City of Boca Raton

Scope of Services
Design, permitting, pilot testing, wellfield rehabilitation, pilot testing, bidding, construction administration, resident project representative, electronic O&M manuals, and start-up assistance.

Contact
Mr. Chris Helfrich
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City of Boca Raton
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Start Date
02/2000

Completion Date
05/2005

Construction Cost
$54 million

Key MBC Staff
Frank A. Brinson, P.E.
Kurt Kiefer, P.E.

Key Features
- Largest nanofiltration facility in operation in the world
- Unique ability to operate without acid or antiscalant pretreatment
- Design incorporates "convertible" skids which can reduce the concentrate flow by 50%
- New generation of low-fouling membranes specifically developed for this project
- Winner of the 2006 Florida Institute of Consulting Engineers (FICE) Grand Award for Engineering Excellence in Water and Wastewater

Note: This project description reflects the personal experience of Frank A. Brinson, P.E., while an employee of Camp Dresser & McKee Inc. (CDM), and not the experience of McCafferty Brinson Consulting, LLC as a firm.

Background

The City of Boca Raton owns and operates the 70 million gallon per day (mgd) Glades Road Water Treatment Plant. Prior to implementation of this project, the plant utilized a conventional lime softening treatment process exclusively. The plant utilizes raw water from the Biscayne Aquifer, which is characterized by high organic content, high color, and high hardness. With the passage of stringent requirements under the Disinfectant/Disinfection By-product Rule (D/DBPR) under the Safe Drinking Water Act, the City elected to implement a 40-mgd nanofiltration process addition, with membrane permeate to be blended with the existing lime softened water supply.

In May 1999, the City contracted with CDM to provide engineering services for design, permitting, pilot testing, wellfield rehabilitation, assistance with preparation of the Engineer's Bond Report, bidding assistance, construction administration, on-site resident project representative, electronic operation and maintenance manuals, and start-up assistance. CDM assigned Frank A. Brinson, P.E., as project manager. Mr. Brinson acted as project manager and engineer-of-record from initiation of preliminary design through completion of construction and start-up of the plant.

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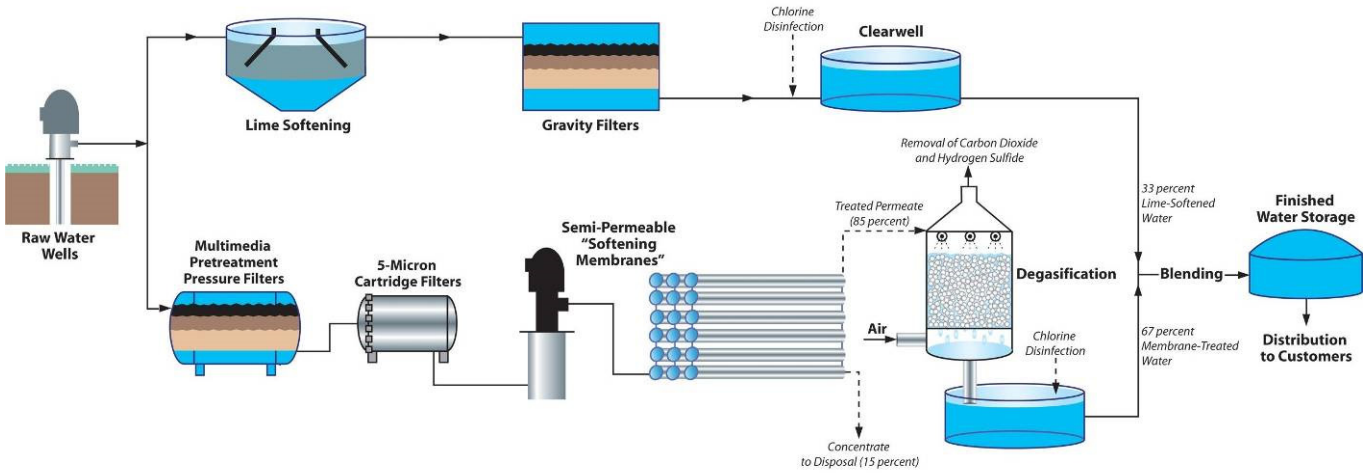
Problem

The raw water supply for the Glades Road Water Treatment plant is the Biscayne Aquifer, which provides the water supply for most of South Florida. This water supply is characterized by high levels of dissolved organic material, high color, and hardness. As with many South Florida utilities, Boca Raton's conventional lime softening treatment process was marginal at meeting the new stringent requirements of the D/DBPR. In addition, the City faced customer dissatisfaction with the high levels of color in the finished water supply.



Solution

At the onset of the project, the City established a set of specific and aggressive water quality and performance goals for the project. These included compliance with the new, stringent water quality regulations with a generous safety margin. The City established a blended water color goal of less than 6 color units (CU), which is undetectable to most consumers. In order to maintain the same "taste and feel" of the water that the customers had grown accustomed to, and to avoid corrosion control concerns in the distribution system, the City requested that hardness of the blended water be maintained between 70 and 90 mg/L as $CaCO_3$. This goal required that the membrane manufacturer exercise extremely precise control over the membrane element manufacturing process in order to customize the rejection characteristics to meet this goal.

The City also established several aggressive goals relative to process operations. Due to a seasonal limitation concentrate disposal capacity, the City requested that the design provide the ability to operate at a higher-than-typical recovery rate during

critical times. Typical membrane softening processes use a recovery rate in the range of 85 percent, which means that 85 percent of the raw water is purified to the finished product, and impurities are concentrated into the remaining 15 percent volume, which is disposed of. The Boca Raton plant can be operated at a 92 percent recovery rate, which reduces the concentrate stream by half.

Finally, the City wanted to avoid the use of sulfuric acid pretreatment due to the costs, operational complications, and potential hazards associated with handling this chemical. Sulfuric acid is typically used to prevent carbonate scaling and fouling of the membranes which can occur as the feed stream is concentrated. For a plant the size of the Boca Raton plant, this would have required a 6,000 gallon truckload of acid per day. Handling of such large quantities of concentrated acid would have represented a day-to-day safety risk to plant operations staff, in addition to the operations and maintenance costs associated with the storage and feed systems.

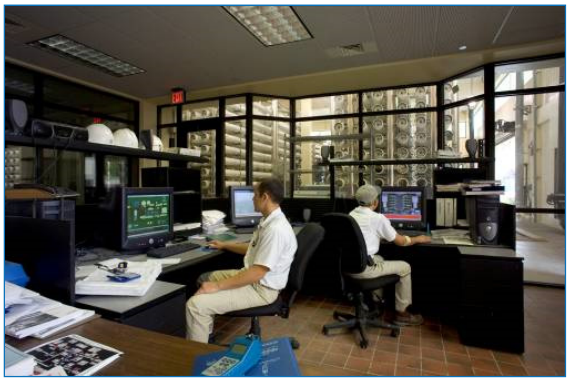
The Glades Road Water Treatment Plant is the only primary water supply for the Boca Raton service area. Since this project constituted a major modification to the existing operating facility, it was critical that provisions be made in design and during construction to avoid interruptions to existing plant operations. Detailed planning and special design provisions were made to incorporate the new facility into the existing plant without interruption of water production for the Boca Raton customers. During construction, close coordination and cooperation between the contractor and plant operations was required in order to minimize disruption to existing plant operations and maintain an uninterrupted water supply throughout the construction period. In addition, the existing plant site was very constrained, requiring an extremely compact process layout, as well as extraordinary care to protect existing facilities from damage from construction activities.

The existing raw water supply presented significant fouling issues for the pretreatment processes and the membrane process, potentially compromising plant reliability and substantially increasing operation and maintenance costs. Fouling issues included sand and silt production from the wells, colloidal fouling from oxidized iron and sulfide, as well as organic fouling of the membranes. Early pilot testing during conceptual design indicated potential extensive fouling of both the pretreatment and membrane processes with the existing raw water supply. It was evident that the raw water quality must be substantially improved for the project to be successful.

Construction contract administration was complicated by the fact that there were multiple major subcontractors and suppliers and multiple prime contracts which had to be closely coordinated to keep the project on schedule and avoid scheduling delays and potential claims. Major subcontractors under the general construction contract included the Membrane System Supplier (MSS), who was responsible for supplying the membrane skids and associated equipment, and for functional, demonstration, and start-up testing, and the Instrumentation System Supplier (ISS), who was responsible

for process control programming, testing, and start-up. To take advantage of the new low-fouling membrane technology developed by the membrane manufacturer for the project, the City executed a procurement contract to purchase the membrane elements directly from the supplier and provide them to the general contractor for installation. Detailed scheduling and contractual coordination was required between the Membrane Element Manufacturer (MEM) contract and the individual roles of the MSS, ISS, and general contractor under the general contractor's contract.

To address the high fouling potential of the raw water supply and meet the City's goal of eliminating acid pretreatment, the project team conducted over four years of pilot testing in pursuit of a stable treatment process scheme. This pilot testing effort resulted in an extensive wellfield rehabilitation program aimed at improving the raw water supply, which was completed prior to commissioning of the membrane plant. In addition, multimedia pretreatment pressure filters were incorporated into the process upstream of 5-micron cartridge filters to reduce foulants prior to the membranes. Finally, the design team worked closely with a major membrane manufacturer who developed a new generation of low-fouling membranes for the project.



The newly developed low fouling membranes operate at lower pressure and require less frequent cleaning than typical nanofiltration (or membrane softening) membranes. This results in substantial savings in power, chemical, and labor costs. These new membranes, now the state-of-the-art in the South Florida market, are being used at the Cities of Deerfield Beach and Hollywood, and are proposed to be used at Pompano Beach and North Miami Beach.

In addition to extensive membrane pilot testing, the project team worked with Dr. Harvey Winters of Fairleigh Dickenson University to evaluate the fouling characteristics of various membranes as well as the interactions of membranes with various chemical pretreatment schemes in the laboratory in pursuit of a successful treatment scheme with this high fouling potential raw water supply. Most membrane plants use sulfuric acid pretreatment to prevent scaling of the membranes which occurs as dissolved contaminants are concentrated beyond their solubility limits in the process. However, Dr. Winters ultimately found that the most stable operation appeared to be with no chemical pretreatment. It was theorized that the dissolved organics in the raw water supply formed a stable complex with these constituents, effectively acting as a natural antiscalant. Based on Dr. Winters' laboratory findings, the project team demonstrated long-term stable operation with no chemical pretreatment in subsequent pilot testing. Following this pilot testing, chemical pretreatment was eliminated from the operating protocol. The Boca Raton plant was started up, and has now been operating successfully for over 14 years with no chemical pretreatment.

The Boca Raton plant is the first large plant of its type to operate without chemical pretreatment. Elimination of chemical pretreatment has resulted in a direct chemical cost savings for the Boca Raton plant of nearly $1 million per year. This does not consider indirect cost savings associated with operation and maintenance of the chemical storage and feed systems, training, cleaning, etc. In addition, a substantial source of day-to-day safety risk to the operations staff and the surrounding community has been completely avoided at the facility.

Following the Boca Raton pilot testing, operation without chemical pretreatment was demonstrated successful on a similar South Florida raw water supply for Broward County and Pompano Beach. As shown above, resulting potential operating cost savings can be conservatively estimated to be on the order of $80 to $90 per million gallons of treated water.

Conclusion

Bids for the project were received on May 16, 2001, with the low bid approximately 10 percent below the engineer's estimate. Construction was substantially complete, on schedule and prior to the regulatory compliance date, in April 2005, with less than 5 percent change orders. The budgeted construction cost for the project was $55,300,000. The actual cost at completion was $54,069,063. The start-up phase of the project began in August 2004.

In full-scale operation, the plant has been a dramatic success. It now operates with no chemical pretreatment, saving the City nearly $1 million per year in operating costs, with a safer operating environment. The low-fouling membranes are currently operating at lower-than-specified pressures, saving the City nearly $50,000 per year in power costs. Finally, all water quality goals are being met, and the City utility staff has received numerous compliments from customers regarding the noticeable improvement in the aesthetic water quality.