City of Sunrise Achieves Alternate Raw Water Supply With Existing Source Infrastructure

Chris Reinbold, Giovanni Batista, and Jim Dolan

Consumptive water use regulations in southeast Florida have forced many utilities looking to expand their potable water production capacity to consider alternative water supplies (AWS). The City of Sunrise was required by its 2008 consumptive use permit to obtain AWS to meet current and projected future demands. Estimates from the 2008 master plan documents indicated that the City needs to secure an additional 11 mil gal per day (mgd) by 2030. This master plan also identified numerous alternatives that were evaluated and considered for implementation by the City. The alternatives included: sourcing water from the Floridan aquifer, implementing water reclamation for irrigation and recharge, concentrate recovery at its existing nanofiltration (NF) water treatment facility, use of aquifer storage and recovery, and demand management. The Floridan aquifer was selected as a potential AWS, which the City elected to evaluate further.

The City has existing Floridan aquifer wells with total dissolved solids (TDS) concentrations ranging from 5,000 to 8,500 mg/L. Due to the high TDS, and brackish nature of this source water (chlorides being a significant contributor to the high TDS), reverse osmosis (RO) treatment is typically used to produce potable water. In order to make the decision as to how and where the City should best treat Floridan aquifer water, Carollo Engineers Inc. (Carollo) performed several study efforts for the City. The City has three potable water treatment facilities, two of which—the Sawgrass Water Treatment Plant (WTP) and the Springtree WTP—were considered as potential sites for implementation of this new source and treatment process.

At the time of the studies, the Sawgrass WTP was rated for 18 mgd of potable water production utilizing the NF process. Conversion of a portion of the NF facility to RO, as well as the construction of an independent RO treatment facility adjacent to the existing NF WTP, was evaluated. Separately, the addition of an independent RO treatment facility was also considered at the 24-mgd Springtree WTP, to be constructed adjacent to the existing lime softening and filtration processes.

The Springtree WTP was unique in this evaluation as it contained an upper Floridan well that was constructed in the late 1990s for the purposes of aquifer storage and recovery. The expectation at the time was that treated Biscayne aquifer water from the lime softening and filtration processes would be pumped into the upper Floridan aquifer during the wet season. Then, during periods of increased demand during the dry season, this fresh water would be recovered from the aquifer and retreated through the existing water treatment process to increase the City's total water production capability. Historical cycle tests, as well as permitting regulations affecting this practice, did not result in sufficient recovery of fresh water to deem the well practical for use. During these periods, however, a sustained pumping rate of approximately 3 mgd was confirmed.

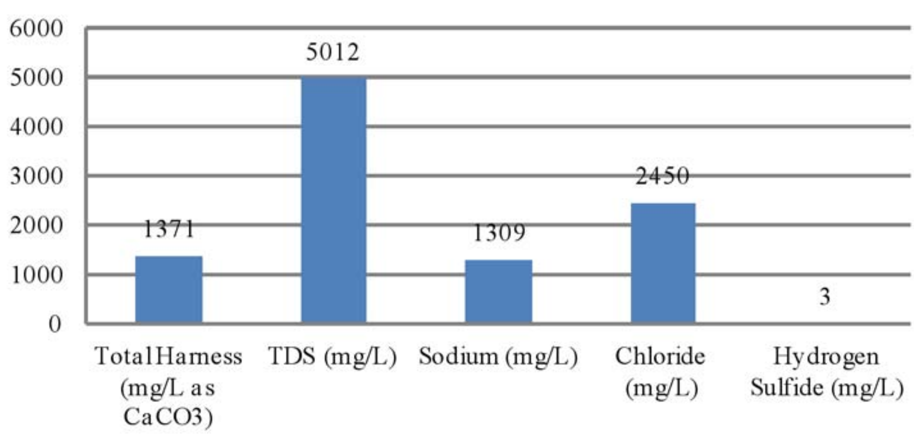

Figure 1. Key Water Quality Parameters for Springtree Floridan Aquifer

Chris Reinbold, P.E., is an associate and project manager with Carollo Engineers Inc. in Lake Worth and Hollywood; Giovanni Batista, P.E., C.G.C., is the assistant utility director for City of Sunrise; and Jim Dolan is the chief operator for the City of Sunrise's Springtree Water Treatment Plant.

As a result of the City already having this asset and related infrastructure, it was decided to repurpose it into a Floridan aquifer production well to provide the source water to the first of two RO treatment units, with an initial permeate production capacity of 1.5 mgd. This required a total raw water delivery capacity of 2 mgd of Floridan water, with the system operating at 75 percent recovery. Water quality data from the original construction of the well and historical cycle tests was utilized as the basis of design for the RO treatment system; some of the key water quality parameters are identified in Figure 1. Design and construction of a 3-mgd RO WTP was determined to be the most cost-effective alternative and was selected for implementation at the Springtree WTP.

Design of Alternative Water Supply Treatment System

In an effort to meet a regulatory compliance date identified in the City's consumptive use permit (CUP), Carollo was retained to perform the design on a fast-paced schedule for the 3-mgd RO treatment facility. In order to accelerate the construction of this facility, Carollo prepared a procurement set of bidding documents for the City to purchase modular skid-mounted RO equipment, while the detailed design and bidding of the overall facility was completed. It was decided to use a system supplier approach for the procurement package so that all of the specified equipment and systems were competitively bid and sourced through a single reverse osmosis system (ROMS) supplier. This system-supplier approach was developed so that there was one source of responsibility for meeting the contractual requirements of the procurement bidding documents, and for providing warranties for the treatment system components. The purchase order to the RO system supplier was issued by the City in May 2012.

The unit processes, which comprised the RO treatment facilities, included raw water pumping, which was a repurposing of the existing aquifer storage and recovery (ASR) well to a Floridan production well; pretreatment (with sand strainers, followed by cartridge filters and addition of sulfuric acid and antiscalant); RO feed pumping; two-stage RO treatment, with an interstage boost pump with energy recovery; degasification; chlorination and sodium hydroxide addition for pH control; concentrate disposal; and the associated membrane clean-in-place system and scavenger tanks (for waste blending, neutralization, and disposal). A schematic of this treatment scheme is shown in Figure 2.

Another unique project challenge encountered due to the implementation of RO treatment at the Springtree WTP was associated with concentrate disposal. A deep injection well was identified as necessary, and was to be constructed on a parallel, but not converging, schedule with the RO treatment plant. The City needed the plant to be in operation to meet the CUP regulatory requirement, but the construction of the well was estimated to follow the RO treatment system construction completion by one to two years. During the time frame between RO system completion and the completion of the injection wells, it was determined that the treatment of the concentrate would be through the nearby Springtree Wastewater Treatment Plant (WWTP).

Unique Features of New Reverse Osmosis Treatment System

The Springtree Complex has been in continuous operation, producing potable water and treating wastewater since the 1970s. Limited land was available within the existing property for construction of this new RO treatment system. In addition, the existing facility is located near a high school, day care center, assisted living center, and other strip commercial businesses. This resulted in the addition of neighbor-friendly features to the design documents.

The Floridan aquifer in the Springtree areas has levels of dissolved hydrogen sulfide of up to 3 mg/L; the potential odor from removing this from the membrane treated water was considered. To address this concern, two stage air quality control units were designed in conjunction with the degasification process.

The local community development department also recommended working with the nearby high school to cooperate on ways to minimize the visual impact of the new structures, and City of Sunrise and Carollo personnel met with high school staff to facilitate ideas on how to accomplish this.

It was decided that a mural with student- designed artwork would be applied to the wall of the RO facility facing the high school's football stadium. Several concepts were developed as to how this mural would be installed. It was decided that a digitally printed adhesive wall mural would be applied to the kynar-coated metal building exterior. This type of banner is ultraviolet (UV) resistant and removable if the City chooses to replace it with refreshed artwork in the future.

In addition to the wall mural, it was decided, with the City's urban forester, that the landscaping

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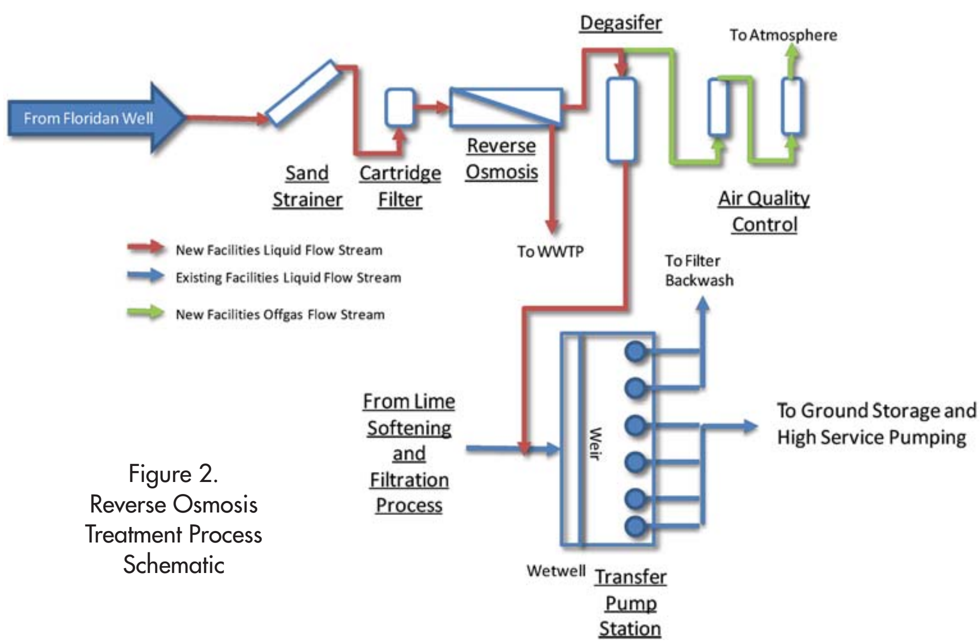

Figure 2. Reverse Osmosis Treatment Process Schematic

Figure 3. Wall Mural and Photo Rendering

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facing the adjacent high school should be visually appealing. A landscape architect was retained and an alternating height row of sabal palm trees was added to the landscaped area at the property boundary to accomplish this. Figure 3 shows a conceptual rendering of the wall mural with landscaping in the area, as well as a photo of the actual installation.

Construction and Related Activities

Once the design was complete for the RO treatment facility and the ROMS supplier's bid was accepted, advertisement and bidding was performed for the construction of the overall facility. The approach used in the design documents was that the equipment to be furnished by the ROMS supplier was identified throughout as owner-furnished and contractor-installed. Dates were provided in the contract documents for the contractor to include in his schedule when he was responsible for accepting delivery of these items. It was also described that if the contractor's progress on the RO facility was not to a level of completeness that the equipment could be offloaded and directly installed; then, the contractor was responsible for properly storing this equipment. The purchase order to the construction contractor was issued by the City in August 2012. A brief timeline of the construction activities is identified in Figure 4.

Raw Water Quality Considerations

It was known during the design period that Biscayne aquifer water treated by the lime softening and filtration facility had been placed into the ASR well over the period of several years. Analytical testing was performed during design, and again during construction, to determine the water quality parameters that would be encountered at start-up. As anticipated, the water more closely resembled the "fresh water" from the lime treatment facility, rather than the background brackish water originally encountered in the well, due to significantly lower chlorides, higher total organic carbon (TOC), and other water quality parameters. Evaluations were conducted in cooperation with the ROMS supplier to evaluate the RO system performance with these differing water quality parameters.

The scenario encountered was challenging to evaluate because the water at the time of start-up would continually increase in TDS until background conditions were realized. This time period was estimated to be anywhere from three months to a year, based on records of the water previously injected into the well for aquifer storage, and anticipated well flushing impacts; ASR well flushing was initiated during the design and construction phases of the project. A "worst case" scenario was established, which provided the recommended acid and antiscalant doses, as well as energy recovery device settings. Because the TDS were so low, it was assumed that the energy recovery device would be required to operate in a bypass mode until such time as the TDS increased to a point that second-stage membrane feed pressure would allow its use. Fortunately for the commissioning team, the water quality at the time of start-up had changed slightly due to the well-flushing activities, and the use of the energy recovery device was deemed possible. Figure 5 shows a few of the key water quality parameters of the well water quality as tested during the construction period and compared to the background documented conditions and resulting permeate conditions.

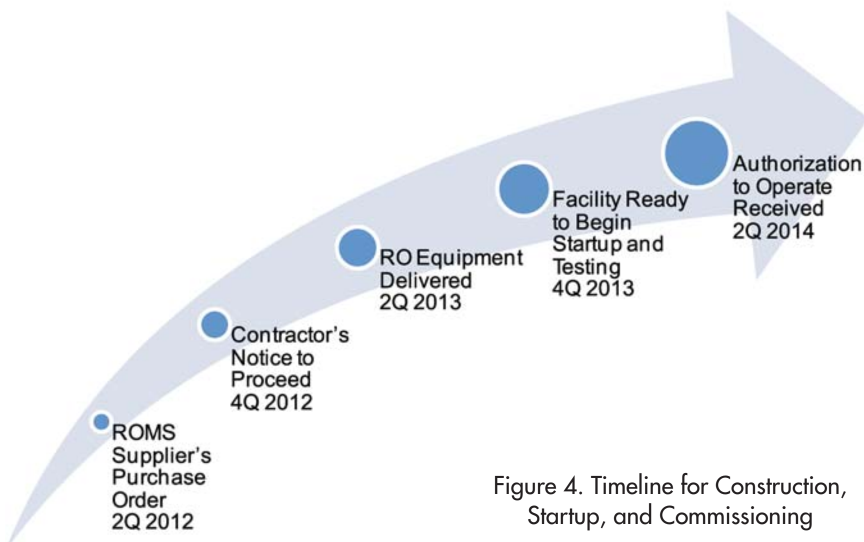

Figure 4. Timeline for Construction, Startup, and Commissioning

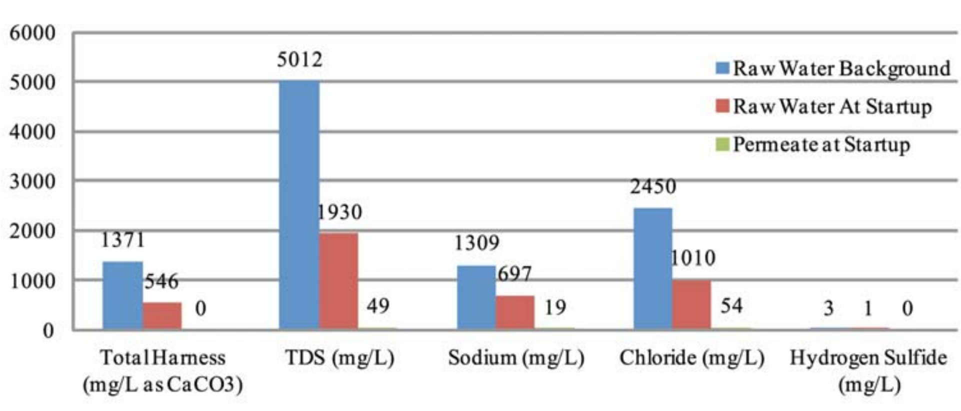

Figure 5. Key Water Quality Parameters as Tested During Construction

Start-Up and Commissioning

Start-up and commissioning of the Springtree RO WTP occurred in January 2014. A combination of on-line instrumentation data, as well as manual measurements, were collected and analyzed during the continuous seven-day performance test. As discussed previously, because the RO concentrate was disposed into the Springtree WWTP, the Florida Department of Environmental Protection (FDEP) required the development of a specific operating procedure to achieve the regulatory approval necessary to perform this action. This operating procedure required that the City's wastewater consultant determine a conditioning period recommended for the existing WWTP biological process. Based on literature reviews and the consultant's experience with other

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facilities, a period of 24 hours was established to gradually increase the TDS (particularly chlorides) from the RO plant into the WWTP.

Since the turndown of the RO treatment unit does not have sufficient flexibility to go from zero to maximum concentrate flow (rather, the unit is better operated at design flux and permeate production capacity within a specific range), WWTP seeding with raw Floridan water through the start-up bypass was utilized. The control system was set up so that the concentrate valve could be manually modulated to increase the raw water flow through the start-up bypass, which accomplished the conditioning process. After the 24-hour conditioning period, the start-up procedure allowed for the RO unit to be operated at design conditions. A 24-hour conditioning period was also instituted for periods when the RO unit would be shut down for an extended period of time. This shutdown process was essentially the reverse of the start-up conditioning process.

Following a successful commissioning period, the regulatory compliance documents were submitted to the Broward County Health Department. After completion of the comment and response period, the Springtree RO WTP was cleared for continuous operation and blending of the treated RO effluent with the lime softening and filtered water. The plant was placed in continuous operation in late April 2014.

Lessons Learned

Start-up and commissioning for this facility occurred without any major interruption or significant delays. The lessons learned from this project are briefly described as follows:

- Thorough planning and good design allowed the City's existing ASR well to be transformed into a Floridan aquifer production well. Utilizing this existing infrastructure allowed the City to proceed at a rapid schedule, since the permitting efforts associated with this item were minimal. This repurposing also saved the City significant cost by not having to drill and/or install new production wells.
- It was demonstrated through this project that RO concentrate can successfully be treated through a conventional biological-activated sludge WWTP. There was hesitation by the regulatory agencies when this concept was first presented as to how the bacteria would react. With the operating strategy that was developed for seeding, the biology, and the additional monitoring that was performed, there were no significant detrimental changes observed by the WWTP operators.
- The blending of higher hardness and alkalinity water from the lime plant was beneficial with the low-mineral and low-alkalinity RO permeate. Plant staff elected not to add sodium hydroxide to the permeate so that the near neutral pH of the permeate slightly lowers the pH of the lime-softened and filtered water. This was an added water quality benefit of utilizing these two treatment processes in parallel. The average annual flow for the Springtree WTP is around 11 mgd, and the RO permeate blend represents about 14 percent of the total when operating.
- By working collaboratively with the community development department and the neighborhood stakeholders, it was demonstrated that the cooperation led to an improvement in the community. This collaborative approach is recommended for projects where there are community concerns and/or a significant number of active community stakeholders.
- Although standard for the industry, the normalization routines for the RO unit are also something that could be streamlined. Numerous calculations are performed to compare the current operating conditions to the baseline operating conditions, and minor time delays in readings of instruments resulted in significant fluctuations. At one point, several months after start-up, the normalized salt passage began increasing significantly. Throughout extensive troubleshooting, and even removing an element for controlled performance testing, it was determined that minor fluctuations in raw water quality and changes in the TDS to conductivity ratio used in the calculations were the source. Once the TDS-to-conductivity ratio was adjusted to better match actual conditions, the system has remained in a stable state of operation.

Conclusions

Through the utilization of existing infrastructure, the City was able to address several goals. Some of these goals were driven by regulatory requirements, while others were cost-focused.

The implementation of an RO treatment system at the Springtree WTP has effectively increased the potable water production of the facility from 24 to 25.5 mgd. The total construction cost for this project was $8,760,669, which was comprised of an owner-purchased RO system for $928,634, plus the construction contract to build the facility and install the equipment for $7,832,035. It is important to note that many of the common facilities were sized to accommodate an expansion to a total facility capacity of 3 mgd, although only the first 1.5-mgd phase was commissioned. Although the alternative water supply is only needed during periods of high water use (typically during the dry season), plant staff operate the facility year-round.

To optimize potable water production costs while exercising the equipment, the facility was not operating every day at the time of this original writing; however, it now operates continuously. The successful implementation of RO treatment at the Springtree WTP resulted in CUP compliance through AWS utilization, provided more capacity, improved water conditioning, improved community integration, and is viewed as a successful project by all of the entities involved.