Breaking Through Cost Barriers Associated With Developing an Alternative Water Supply by Integrating With an Existing Treatment System

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In Central Florida, water is typically supplied by groundwater wells that draw water from the Upper Floridan aquifer (UFA). The three management districts responsible for administrating water resources in this region—Southwest Florida Water Management District (SWFWMD), South Florida Water Management District (SFWMD), and St. Johns River Water Management District (SJRWMD)—have determined that traditional UFA water sources are reaching sustainable withdrawal limits. Increased use will result in adverse environmental effects, such as lowering levels of surface water bodies and saltwater intrusion into the UFA. In an effort to provide consistent guidance, help identify alternative water resources, and promote long-term planning, the Central Florida Water Initiative (CFWI) was formed. As described on CFWI's website:

"The CFWI is a collaborative water supply planning effort among the state's three largest water management districts (WMDs), the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (DACS), and water utilities, environmental groups, business organizations, agricultural communities, and other stakeholders."

Through this collaborative effort, the following guiding principles for CFWI were established:

1. Identify sustainable quantities of traditional groundwater sources available for water supplies without causing unacceptable harm to the water resources and associated natural systems.
2. Develop strategies to meet water demands in excess of the UFA's sustainable withdrawals.
3. Establish consistent rules and regulations for the three WMDs that meet their collective goals and implement the aim of the CFWI.

These principles were established to guide long-term water resource planning throughout the CFWI planning area, which is shown in Figure 1. The area encompasses over 5,300 sq mi and consists of parts of Orange, Osceola, Seminole, Polk, and Lake counties.

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Applying these principles, the CFWI developed regional water supply plans (CFWI RWSP) in 2015 and 2020 that provide information on current and projected water usage, as well as the availability of UFA sources within the CFWI planning area.

As indicated in the 2020 CFWI RWSP, the UFA allocations currently permitted within

Conceptual rendering of the Polk Regional Water Cooperative West Polk Lower Floridan Aquifer Water Production Facility.

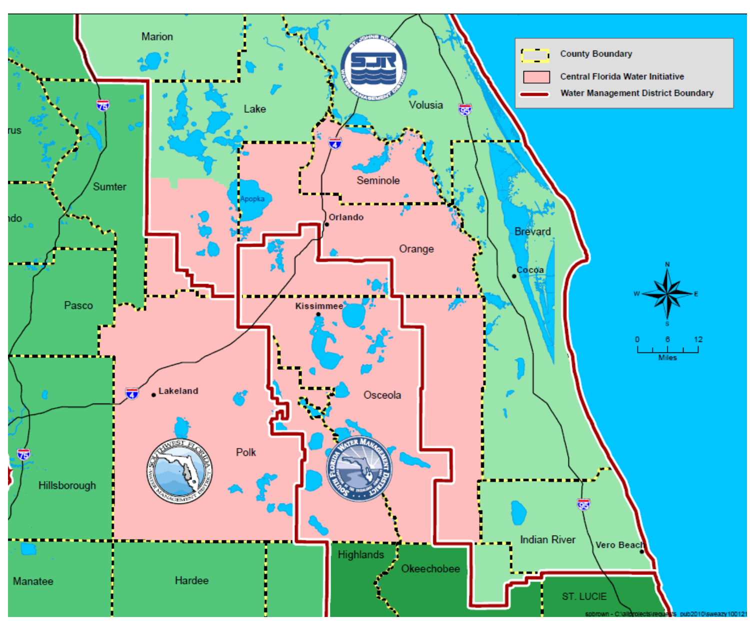

Figure 1. Central Florida Water Initiative Boundary *(source: https://cfwiwater.com/what_is_CFWI)*

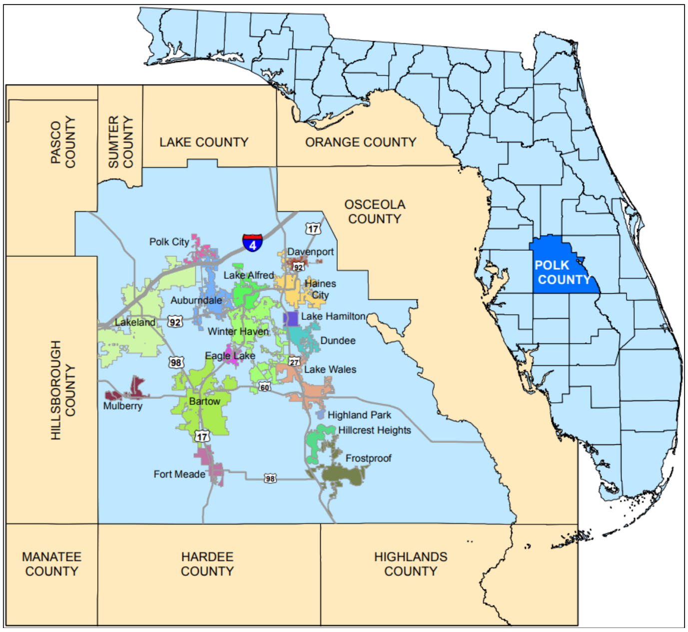

Figure 2. Polk Regional Water Cooperative Member Governments *(source: https://prwcwater.org/documents-old/)*

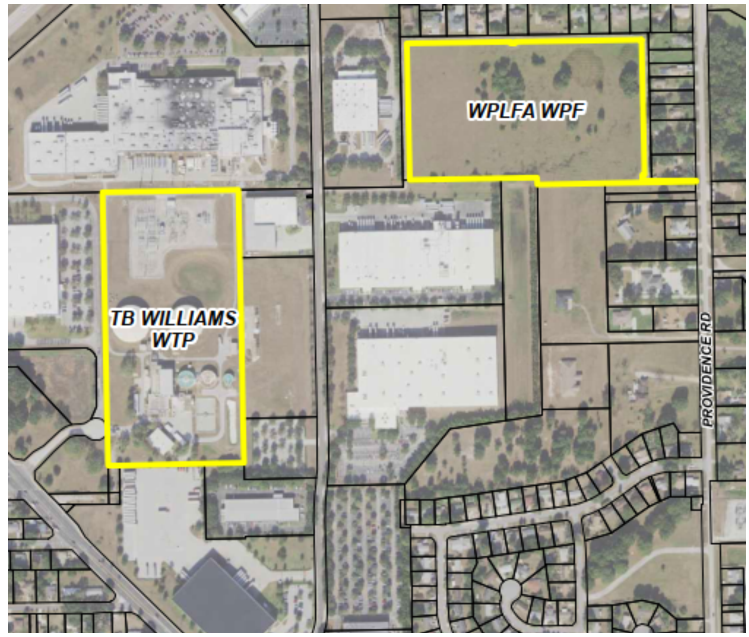

Figure 3. Proximity of the T.B. Williams Water Treatment Plant and the West Polk Lower Floridan Aquifer Water Production Facility's Proposed Site *(source: West Polk Lower Floridan Aquifer Water Production Facility Conceptual Design Report, July 2020)*

the CFWI planning area exceed the estimated sustainable withdrawal limit. As a result, draft rules recently developed by FDEP propose to modify anticipated water availability from the UFA, restricting withdrawals to demonstrated 2025 demands. Alternative water supply (AWS) projects will need to be implemented to satisfy demands beyond 2025 for the remainder of existing permit durations, as well as new permit applications, if the draft rules are implemented.

In 2016, 16 local utilities within Polk County joined forces to form the Polk Regional Water Cooperative (PRWC) in response to the challenges detailed by CFWI. The PRWC was created by an interlocal agreement to foster innovative regional cooperation among local governments of Polk County. This regional cooperation includes developing, storing, and supplying potable water to reduce the potential for adverse environmental effects of excessive water withdrawals. A map of PRWC's member governments is presented in Figure 2.

The PRWC was founded to encourage the development of fully integrated public water supply systems, and its goal is to ensure reliable, sustainable, drought-resistant, and cost-efficient systems that maximize the use of AWS to the most efficient extent practicable. The PRWC has been using funding obtained through SWFWMD's cooperative funding initiative to develop the planning and preliminary design of AWS projects.

Brackish groundwater from the Lower Floridan aquifer (LFA) was identified as a potential key AWS source for public supply. The capital cost to construct a water treatment facility to desalinate LFA water, in addition to the capital cost of installing a transmission system to convey finished water to regional member governments, can represent a barrier to AWS project development. One solution to breaking through this cost barrier is to integrate new AWS facilities with the infrastructure and treatment processes of existing potable water systems.

An example of this innovative concept is demonstrated in the design of the West Polk Lower Floridan Aquifer Water Production Facility (WPLFA WPF), which is designed to provide PRWC's member governments with finished potable water beyond 2025 demands using brackish groundwater from the LFA. More specifically, the WPLFA WPF is proposed to serve PRWC members located in the northwest portion of Polk County. Currently at the conceptual design phase, the WPF is anticipated to have an estimated capacity of 15 mil gal per day (mgd). This capacity can be adjusted as design progresses and as CFWI projections and FDEP regulations develop. Additionally, the design will incorporate phased implementation, allowing for planned expansions as potable water demands increase to mitigate the cost burden to ratepayers.

West Polk Lower Floridan Aquifer Water Production Facility Project Description

Brackish groundwater will be pumped from the LFA and routed to WPLFA WPF for treatment through reverse osmosis (RO) membranes and associated treatment processes, including cartridge filtration, degasification, and disinfection. The WPLFA WPF site is located immediately to the northeast of one of City of Lakeland's existing potable water treatment facilities, the T.B. Williams Water Treatment Plant (TBW WTP), a split lime softening facility. As these two water treatment facilities would be less than a half mi from each other, their proximity invites an opportunity to integrate treatment processes at both facilities. Figure 3 illustrates the relative locations of WPLFA WPF and TBW WTP.

The blending of water presents potential benefits for both treatment facilities. The TBW WTP may reduce or eliminate the need to soften UFA water as RO permeate from the WPLFA WPF will have low hardness, and the WPLFA WPF may reduce or eliminate the need to remineralize the RO permeate if it's blended with raw or finished water from the TBW WTP. Because raw water drawn from the UFA has natural alkalinity and hardness, several process integration alternatives were evaluated to assess the benefits of integration between the proposed AWS project and Lakeland's existing water treatment facility.

Process Integration Alternatives

Through the WPLFA WPF design effort performed to date, six alternatives were developed and compared to determine the most appropriate integration configuration with the TBW WTP. Alternative No. 1 represents the

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baseline alternative in which no integration is arranged with Lakeland's TBW WTP (i.e., the WPLFA WPF is a stand-alone facility). Alternative Nos. 2 through 6 present treatment integration options where raw or treated water from Lakeland's UFA groundwater wellfield is used to blend with treated water from PRWC's WPLFA WPF. These were evaluated based on compatibility of the raw or finished water, impacts to the facilities' well pump hydraulics and/or process treatment, and whether treatment capacity at either facility could manage the combined supply water capacities. Based on this initial analysis, three of the six alternatives were selected for further evaluation regarding footprint, noncost comparison criteria, and cost.

For each alternative, Table 1 includes a brief description, the points of connection between facilities, and the distribution system that would be utilized. Figure 4 illustrates the raw and concentrate piping needed for the WPLFA WPF, regardless of the alternative selected.

Table 1. Process Integration Alternatives Matrix *(source: West Polk Lower Floridan Aquifer Water Production Facility Conceptual Design Report, July 2020)*

Alternative Number	Description	Is There Process Integration Between the Two Facilities	Is Water Transported from: TBW WTP → WP WPF; or WP WPF → TBW WTP	Transferred Water Point of Origin	Transferred Water Destination Point	Distribution System Utilized
1	WPLFA WPF is Operated as a Stand-Alone RO Facility	No	Not Applicable	Not Applicable	Not Applicable	PRWC
2	Raw Water from Lakeland's UFA Wellfield is Conveyed to WPLFA WPF and Blended with RO Permeate Prior to Degasification	Yes	TBW WTP → WPLFA WPF	TBW Raw Water Piping	WPLFA Piping Post-RO and Pre-Degasifier	PRWC
3	Finished Water from TBW WTP is Conveyed to WPLFA WPF and Blended with Degasified RO Permeate	Yes	TBW WTP → WPLFA WPF	TBW Clearwell	WPLFA Clearwell	PRWC
4	RO Permeate from WPLFA WPF is Conveyed to TBW WTP and Blended with Raw Water	Yes	WPLFA WPF → TBW WTP	WPLFA Post-RO Piping	TBW Piping Post-Well Pumps and Pre-Upflow Units	Lakeland
5	Degasified RO Permeate from WPLFA WPF is Conveyed to TBW WTP and Blended with Raw Water	Yes	WPLFA WPF → TBW WTP	WPLFA Clearwell	TBW Piping Post-Well Pumps and Pre-Upflow Units	Lakeland
6	Degasified RO Permeate from WPLFA WPF is Conveyed to TBW WTP and Blended with Lime-Softened Water	Yes	WPLFA WPF → TBW WTP	WPLFA Clearwell	TBW Clearwell	Lakeland

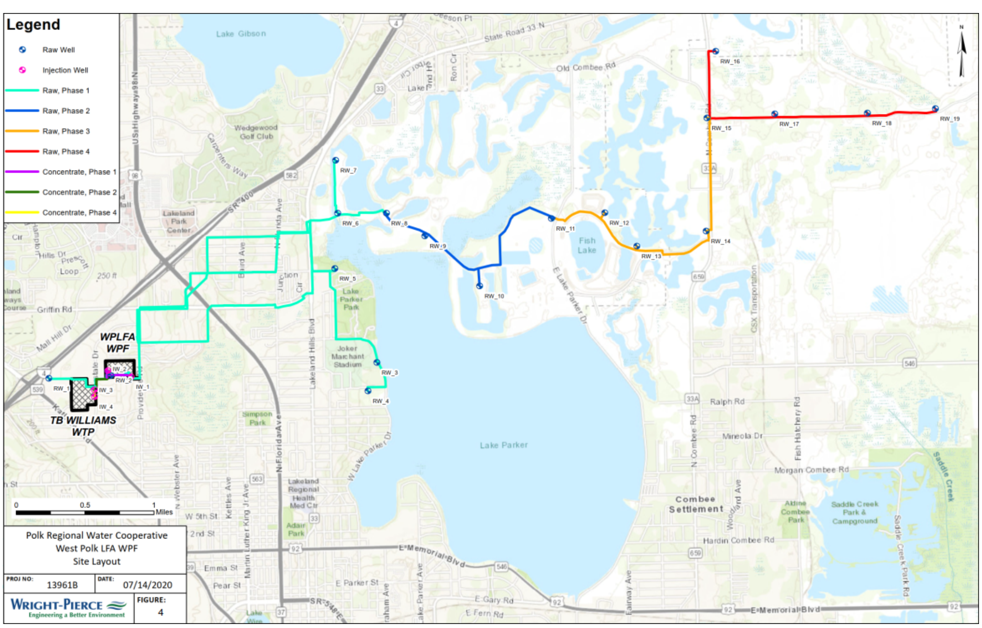

Figure 4. West Polk Lower Floridan Aquifer Water Production Facility Raw and Concentration Piping *(source: ESRI, Wright-Pierce)*

Qualitative Evaluation

Alternative No. 1: West Polk Lower Floridan Aquifer Water Production Facility is Operated as a Stand-Alone Reverse Osmosis Facility

For the evaluated alternatives, RO pretreatment process consisted of sand separation, antiscalant addition, and cartridge filtration. Cartridge filters are included as a final barrier to protect the RO equipment; they are not meant as a traditional particle removal pretreatment step. High-pressure pumps supply the RO system with feed water, and the permeate progresses to the post-treatment processes. The remaining flow stream contains the rejected constituents and forms the waste concentrate to be disposed.

When possible, a pertinent amount of raw water bypass can allow the size of the main treatment process and post-treatment chemicals to be reduced by reintroducing alkalinity and calcium naturally present in the raw water to the RO permeate. After the RO bypass and RO permeate blend, the pH is adjusted using carbonic acid to optimize hydrogen sulfide removal in the degasification system. Effluent from the degasifiers enters the product water clearwell; transfer pumps within the clearwell then convey the degasified product water to onsite ground storage tanks.

Chemical post-treatment includes addition of caustic, carbon dioxide, hypochlorite, and corrosion inhibitor. A finished water pumping building will house low-service and high-service pumps for distribution of finished water. Low-service pumps will convey finished water to the TBW WTP through a newly constructed pipeline; high-service pumps will convey finished water to other PRWC members through a new distribution system constructed, owned, and operated by PRWC. Utilizing two sets of finished water pumps (i.e., low-service and high-service) allows for the most economical distribution of finished water.

Alternative No. 2: Raw Water From Lakeland's Upper Floridan Aquifer Wellfield is Conveyed to the West Polk Lower Floridan Aquifer Water Production Facility and Blended With Reverse Osmosis Permeate Prior to Degasification

Alternative No. 2 offers the opportunity to reduce the amount of remineralization needed in post-treatment, as raw water from the UFA contains natural alkalinity and hardness; however, three notable drawbacks to this process alternative would result:

- The TBW WTP well pumps may need to be upgraded to maintain a constant flowrate to the top of the WPLFA WPF degasifiers. This hydraulic change could affect operations at the TBW WTP.
- Additional carbon dioxide will need to be

added to reduce the pH of the water before degasification, as the blended water will have natural alkalinity from the UFA raw water.

- The addition of UFA raw water to the RO permeate flow would require process operations downstream of blending (i.e., degasifiers, clearwell, ground storage, and low-service pumps) to increase in size to accommodate the additional flow.

Alternative No. 3: Finished Water From the T.B. Williams Water Treatment Plant is Conveyed to the West Polk Lower Floridan Aquifer Water Production Facility and Blended With Degasified Reverse Osmosis Permeate

Alternative No. 3 offers the opportunity to reduce the amount of remineralization needed in post-treatment, as finished water from the TBW WTP will have natural alkalinity and hardness. This reduction in remineralization will be less than that of Alternative No. 2, as finished water at the TBW WTP will have been softened prior to being conveyed to the WPLFA WTP; however, as the transferred water is mixed in the WPLFA WPF clearwell after degasification, the size of the degasifiers and the amount of carbon dioxide needed prior to degasification will be less than that of Alternative No. 2.

Alternative No. 4: Reverse Osmosis Permeate From the West Polk Lower Floridan Aquifer Water Production Facility is Conveyed to the T.B. Williams Water Treatment Plant and Blended With Raw Water

Alternative No. 4 offers the opportunity to reduce or eliminate the need for Lakeland to soften UFA water, as the low calcium and magnesium concentrations of RO permeate would lower the overall hardness of the blended water. Utilizing the TBW WTP's existing clearwell, chemical storage and feed systems, and high-service pumps would result in a significant reduction in capital costs. Utilizing Lakeland's distribution system would also result in capital cost savings and would provide redundancy, as the system is a network of distribution pipelines, rather than a single pipeline that would be constructed to distribute finished water as utilized in Alternative Nos. 1, 2, and 3.

Several items may make this alternative undesirable:

- This scenario would add head to the RO feed pumps at the WPLFA WPF, as they would be utilized to transport water to the TBW WTP.
- The head on Lakeland's existing well pumps would be increased, possibly requiring upgrades. This effect, in addition to the change in resultant blended water quality, could affect TBW WTP's softening process.
- PRWC would incur two costs: a cost for Lakeland to perform post-treatment, and a cost to maintain Lakeland's distribution system.
- Sulfide found naturally in LFA water would not be removed at the WPLFA WPF, and as a result, would require removal at the TBW WTP. This sulfide would be removed by oxidation with chlorine gas and would result in the formation of colloidal sulfur. This could impact finished water turbidity at TBW WTP.

Alternative No. 5: Degasified Reverse Osmosis Permeate From the West Polk Lower Floridan Aquifer Water Production Facility is Conveyed to the T.B. Williams Water Treatment Plant and Blended With Raw Water

Alternative No. 5 is similar to Alternative No. 4, but differs by degasifying RO permeate prior to transporting the water to the TBW WTP for blending. This added process results

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in requiring degasifiers, a clearwell, and transfer pumps, each of which adds a capital cost; however, Alternative No. 5 offers several benefits over Alternative No. 4:

- The RO feed pumps for Alternative No. 5 would have a reduced backpressure, as they would be required to pump water only to the degasifiers, rather than pump directly to the TBW WTP.
- Sulfide would be removed from the LFA water at the WPLFA WPF, preventing turbidity issues associated with colloidal sulfur.
- Alternative No. 5 allows for the option to add ground storage tanks at the WPLFA WPF that will be connected to the transfer pump station. These storage tanks will be used to store treated water if the TBW WTP is unable to receive treated water from the WPLFA WPF for a period of time. This would reduce the downtime of the RO treatment process.

As with Alternative No. 4, the head on Lakeland's existing well pumps would be increased, possibly resulting in the need for upgrades. In addition, the change in resultant blended water quality could affect the TBW WTP lime softening process. Similarly, the PRWC would incur two costs: a cost for Lakeland to perform post-treatment, and a cost to maintain Lakeland's distribution system.

Alternative No. 6: Degasified Reverse Osmosis Permeate From the West Polk Lower Floridan Aquifer Water Production Facility is Conveyed to the T.B. Williams Water Treatment Plant and Blended With Lime-Softened Water

Alternative No. 6 is similar to Alternative No. 5, but differs where degassed permeate from the WPLFA WPF is blended into the TBW WTP process train. In Alternative No. 6, degassed permeate is blended after the UFA raw groundwater is softened. This would allow for added process flexibility for the TBW WTP and would remove the complication of adding head to the TBW WTP well pumps compared to Alternative No. 5. While Alternative No. 6 would add head to the TBW WTP well pumps, it's a minimal amount that is not shown to impact TBW WTP well pump hydraulics.

Elimination of Alternatives Nos. 2, 4, and 5

Process integration Alternatives Nos. 2, 4, and 5 were removed from further qualitative and cost comparisons after an initial review of the process impacts. One common drawback for Alternative Nos. 2, 4, and 5 involved the issue that process integration would impact the TBW WTP's raw water well flow prior to the upflow treatment units, and as a result, could impact the TBW WTP's operations. The potential for impacts to the TBW WTP operations eliminated these alternatives from further consideration. Additionally, Alternative No. 4 would not remove sulfide naturally found in LFA water at the WPLFA WPF and could result in turbidity in the TBW WTP's finished water.

The potential for impacts to the TBW WTP's finished water quality, in addition to the aforementioned impact on well pump hydraulics, made Alternative 4 undesirable. The benefits gained in Alternative No. 5 are also gained in Alternative No. 6, except Alternative No. 6 allows for added process flexibility and removes the downside of affecting TBW WTP's finished water quality. This reasoning led to Alternative No. 5 not being selected as a final configuration option.

Selected Design Alternative

Alternative No. 6 was selected as the most appropriate integration alternative for the WPLFA WPF based on both qualitative and quantitative criteria. In this alternative, LFA water is desalinated and degasified at the WPLFA WPF before being conveyed to the TBW WTP using the WPLFA WPF's transfer pumps. The desalinated water is blended at the TBW WTP with UFA water. The blended, finished water is then transferred to PRWC members utilizing TBW WTP's high-service pumps and City of Lakeland's distribution system.

Notable factors that led to the selection of this alternative include the following:

1. Alternative No. 6 provided the best water quality match to TBW WTP's existing finished water, compared to the other evaluated integration alternatives.
2. The WPLFA WPF finished water will have a reduced need for remineralization in post-treatment since finished water from the TBW WTP will introduce natural alkalinity and hardness upon blending.
3. Corrosion inhibitor can be added at the TBW WTP, and as a result, corrosion inhibitor storage and injection equipment is not needed at the WPLFA WPF.
4. This alternative did not require upsizing of any of the TBW WTP's existing facility processes.
5. Alternative No. 6 does not require a finished water pump station, as it will utilize City of Lakeland's high-service pumps.
6. City of Lakeland's well-developed distribution system will be utilized to distribute water to other PRWC members. This provides an added level of reliability in transporting the water to PRWC members by having a distribution network of pipes, instead of a single transmission line, and significantly reduces the need for new transmission system piping.
7. This alternative allows the WPLFA WPF to be converted to a stand-alone facility in the

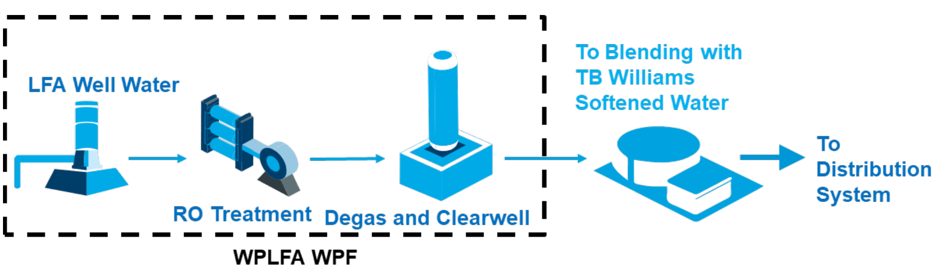

Figure 5. Alternative No. 6 Process Flow Diagram *(source: Wright-Pierce FSAWWA 2020 Fall Conference presentation, December 2020)*

Table 2. Comparison of Probable Capital Costs (2019 dollars) for Alternative Nos. 1, 3, and 6 at Buildout (15 mgd) *(source: West Polk Lower Floridan Aquifer Water Production Facility Conceptual Design Report, July 2020)*

Cost Item	Alternative No. 1 (Stand-alone)	Alternative No. 3 (Blend at WPLFA)	Alternative No. 6 (Blend at TBW)
Water Production Facility[(1)]	**$222,889,000**	**$228,299,000**	**$206,752,000**
Transmission System[(2)]	**$54,373,000**	**$54,373,000**	**$17,374,000**
Total Construction Cost [(3)]	**$277,262,000**	**$282,672,000**	**$224,126,000**

Notes:
(1) Includes costs for the facility, raw and concentrate wells and pipelines and land/easements. Also includes cost contingency, sales tax, contractor general conditions, contractor overhead and profit, engineering, and contract administration.
(2) Includes transmission pipeline and easement costs. Also includes cost markups for contingency, engineering, and construction administration.
(3) The costs presented are provided for comparative analysis. Costs will be refined as the design is further developed.

future if the needs of the PRWC or City of Lakeland change as the two entities grow.

This alternative's approach leads to a streamlined design and a lower capital cost without negatively affecting operations at the TBW WTP or its wellfield. Figure 5 contains a process flow diagram illustrating the integration between the two water treatment facilities for this alternative. The PRWC is currently developing this integrated treatment option at a preliminary design level.

The following section summarizes the methodology for developing conceptual-level cost comparisons used to evaluate Alternative Nos. 1, 3, and 6.

Opinion of Probable Costs Comparison

Preliminary site plans for the three treatment alternatives were developed for the buildout capacity of 15 mgd. The goal was to identify major construction components for the cost estimates. For the three alternatives, the following ancillary systems were included in the development of the project costs: pretreatment with sand separators and cartridge filters, air stripping with degasifiers, a clearwell, transfer pumps, ground storage tanks, and various chemical feed and storage systems for pretreatment or post-treatment.

Alternative Nos. 1 and 3 include a high-service pump station. Other typical facility components will include operation and maintenance (O&M) buildings; other pertinent structures; and electrical, instrumentation, and emergency generator equipment.

The O&M cost estimates included annual chemical use, power consumption, membrane replacement, equipment and well maintenance, distribution system maintenance, labor costs, and costs associated with post-treatment and distribution through Lakeland's TBW WTP and its associated distribution system.

Table 2 includes a conceptual-level capital cost comparison of Alternative Nos. 1, 3, and 6, demonstrating the capital cost savings that can be realized by using existing infrastructure. The O&M costs were also evaluated, but have a direct correlation with usage and did not change the overall outcome of the cost analysis. The system integration option proposed in Alternative No. 6 reduces capital costs by approximately 19 percent, or about $53 million, when compared to development of a stand-alone water treatment facility and transmission system, as proposed in Alternative No. 1. This capital cost deferral can assist with the affordability of AWS projects, particularly for a water supply cooperative that is just beginning to develop its alternative water sources.

Conclusion: Making Alternative Water Supplies More Economically Feasible

The innovative WPLFA WPF design and its integration with the TBW WTP is an example of how existing water infrastructure can be partnered with new AWS projects to obtain more-affordable and environmentally conscious water supplies. As FDEP rules continue to be refined, further technical work on groundwater availability is performed, and utility demands continue to increase, it's likely that many of Florida's utilities will be following in the steps of PRWC to implement AWS projects in the near future. To make AWS projects a reality in this area of Florida, it will take creative solutions to make them more affordable.