UTILITIES, INC. OF FLORIDA

LUSI SOUTH

LAKE GROVES WTP

DBP REDUCTION TREATMENT ANALYSIS

OCTOBER 2016

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Contents

1 OBJECTIVE

The purpose of this report is to provide Utilities, Inc. of Florida (UIF or Utility), formerly Lake Utility Services, Inc., with technical support and recommendations regarding treatment options that are necessary to achieve compliance with the Stage 2 Disinfection/Disinfection Byproducts Rule (D/DBPR). Per FDEP Consent Order OGC #16-0376, executed on September 12, 2016 regarding violations of Stage 2 D/DBPR, the Utility must be in compliance with the schedule contained therein or in approximately two years. In order to comply with the Consent Order, the Utility must select and implement additional treatment methods that will achieve the potable water quality standards identified in the Stage 2 D/DBPR. Specific disinfection byproducts (DBPs) identified for monitoring in this rule are total trihalomethanes (TTHMs) and halo acetic acids (HAAs) with a regulatory limit of 80 parts per billion (ppb) and 60 ppb over a running annual average, respectively. This report identifies three types of treatment alternatives (not including ozone treatment that was ruled out due to the issues discussed below), the advantages and disadvantages of each alternative, as well as a conceptual level capital and operational cost analysis for each alternative.

2 BACKGROUND

UIF owns and operates the Lake Groves Water Treatment Plant (WTP). The plant is located in south Lake County just west of US Highway 27. The physical address of the Lake Groves WTP is 2425 South US Highway 27, Clermont, FL 34714. The WTP currently has a treatment capacity of 6.0 MGD, and utilizes raw water from two upper Floridan Aquifer wells (LG1 and LG2) and one lower Floridan Aquifer well (LG3). The current average day demand (ADD) from the plant is 2.47 MGD and the maximum daily demand (MDD) produced is 4.2 MGD. For the purpose of this evaluation, the Utility is planning to meet the current demands as well as plan for future growth within the 5-year planning horizon for Utility service areas. This treatment evaluation and its associated cost estimates are based on the planned demands for the Utility service area of 3.0 MGD ADD and 5.25 MGD MDD. As the demand increases beyond the 5-year projected growth, the treatment alternatives can be expanded to the plant buildout capacity of 6.0 MGD. Expansion beyond 3.0 MGD treatment is not included within the analysis of this evaluation; however, the discussion for each alternative includes a brief description for conceptual treatment expansion to the buildout capacity.

The existing treatment process includes chlorination and storage for both the LG1 and LG2 wells. Due to the elevated levels of hydrogen sulfide found in LG3, this well is currently treated utilizing acid feed to lower the pH prior to forced draft aeration followed by chlorination and storage. Since the Stage 2 D/DBPR has been promulgated, the service area has monitored several locations within the distribution system for newly regulated levels of DBPs. Specifically, the DBPs monitored in the Utility's LUSI South service area that are of concern are the TTHMs and HAAs.

The Utility's south Lake County service area is divided into Utility's LUSI North and LUSI South public water systems that are generally divided by Lake Louisa State Park. The D/DBP formation in the two Utility service areas has fluctuated as the systems are thoroughly interconnected. An evaluation of the wells was performed by Environmental Systems Engineering Institute (ESEI) at the University of Central Florida (UCF) to determine the formation potential in each well. This analytical effort was combined with updated hydraulic modeling to simulate the water age in the system. These data were then used to evaluate the most effective way to reduce TTHMs and HAA5s in the combined system. Based on the large permitted capacity of the Lake Groves WTP and its ability to provide a majority of the water to the service area, modifications to the current treatment method were identified as the most effective way to reduce DBP's.

FDEP has issued a Consent Order to UIF in which it directed the Utility to implement the necessary steps to achieve compliance with the Stage 2 D/DBPR. UIF has contracted with Kimley-Horn and Associates, Inc. to evaluate and identify options to attain the regulatory limits stated in the Stage 2 D/DBPR for TTHMs and HAAs. The regulatory limits imposed are a localized running annual average (four most recent quarterly samples) of 80 ppb and 60 ppb, respectively, at each sample site. The first step in resolving the DBP challenge is to identify the source of DBP precursors, which typically relate to the naturally occurring total organic carbon (TOC) in the raw water. As the TOC reacts with the disinfectant (free chlorine) over time, DBPs are formed and transmitted through the distribution system.

3 WELL WATER QUALITY

Kimley-Horn has completed a review of contributors to the DBP challenges within the Utility's North and LUSI South Service Areas through analysis of the eleven (11) raw water wells supplying water to the combined Service Area. The analysis was completed utilizing the services of ESEI at UCF. ESEI evaluated the DBP formation potential of TTHMs and HAAs at each of the eleven (11) raw water wells. The report reflecting the results of the evaluation can be found in **Appendix A**. In general, some of the wells produce Stage 2 compliant water utilizing the existing disinfection treatment prior to distribution.

3.1 TTHM FORMATION POTENTIAL

Based on previous hydraulic modeling of the distribution system, it has been determined that the maximum water age in the distribution system is 100 hours or less under normal operating conditions. Accordingly, all field testing and DBP formation potential curves identified in the ESEI evaluation are based on a 4-day (96 hour) water age. As evaluated in the field and laboratory analyses detailed in the ESEI Report (**Appendix A**), the following wells were at or below the regulatory limit for TTHMs after 96 hours of simulated distribution system contact time with chlorine disinfectant:

- Vistas 1
- Vistas 2
- Anderson Hill 2
- Lake Ridge

Each of the remaining wells produced water that exceeded the TTHM regulatory limit following the 100-hours of simulated distribution system contact time with chlorine disinfectant:

- Lake Groves 1
- Lake Groves 2
- Lake Groves 3
- Vistas 3
- Anderson Hill 1
- Amber Hill
- Oranges/Lake Louisa

The Lake Groves 2 well produced water that slightly exceeded (less than 15%) the TTHM regulatory limit and others significantly exceeded (greater than 15%) the TTHM regulatory limit. For additional consideration in achieving Stage 2 compliance, flow capacities of each well must be taken into account as the total blended flow of all water produced must not exceed the running annual average of 80 ppb TTHMs. As such, blending a smaller capacity, higher DBP producing supply well with a larger capacity, lower DBP producing supply well may result in an average that meets the regulatory limits.

3.2 HAA FORMATION POTENTIAL

Similar to the TTHM formation potential and as evaluated in the field and laboratory analysis detailed in the ESEI Report (**Appendix A**), the following wells were at or below the regulatory limit for HAAs after 96hours of simulated distribution system contact time with chlorine disinfectant:

- Lake Groves 1
- Lake Groves 2
- Lake Groves 3
- Vistas 1
- Vistas 2
- Amber Hill
- Lake Ridge
- Anderson Hill 2

Each of the remaining wells produced water that exceeded the HAA regulatory limit following the 100 hours of simulated distribution system contact time with chlorine disinfectant:

- Vistas 3
- Anderson Hill 1
- Oranges/Lake Louisa

The Anderson Hill 1 well produced water that slightly exceeded (less than 15%) the HAA regulatory limit while others significantly exceeded (greater than 15%) the HAA regulatory limit. For additional consideration, the flow capacities of each well must be taken into account as the blended flow of total water produced must not exceed the running annual average of 60 ppb HAAs when monitored at each of the sampling points within the distribution system. As such, blending a smaller capacity, higher DBP producing supply well with a larger capacity, lower DBP producing supply well may result in an average water quality that meets the regulatory limits.

3.3 FINISHED WATER BLENDING

Previous hydraulic modeling efforts have evaluated blending of the wells listed above to achieve a water quality that meets or exceeds the Stage 2 D/DBPR regulatory limits. Given the capacity of each well and the identified DBP formation potential of the water source, it has been determined that the LUSI North Service Area cannot regularly meet the Stage 2 regulatory limits through blending well output alone. Additional treatment is necessary to achieve the desired regulatory limits on a consistent, long term basis. However, the Lake Groves WTP is capable of pumping a significant volume of water into the Lake Louisa WTP storage tank on a routine basis. Advanced treatment of the Lake Groves water supply will provide enough blending water to the LUSI North Service Area to keep the water within compliance limits.

4 TREATMENT ALTERNATIVES

In order to meet the Stage 2 regulatory limits while still utilizing free chlorine as the disinfectant, additional treatment is required to remove the naturally occurring TOC from the raw water prior to disinfection. Common technologies for achieving the desired TOC reduction include ozone, granular activated carbon (GAC), ion exchange, and membrane treatment. Each of these treatment alternatives are defined at a conceptual level and summarized within this section.

4.1 OZONE

A number of municipalities have turned to ozone for removal of hydrogen sulfide and have noticed a reduction in the DBP formation potential of the ozonated water. The ozone process consists of applying gaseous ozone to the raw water either through an air bubbler system in a reaction chamber or under pressure followed by a contact chamber necessary to dissipate the ozone residual to be destroyed and released to atmosphere. The ozone process is successful by contacting the water supply with a strong oxidant (ozone – O_3) which oxidizes the hydrogen sulfide as well as breaks down TOC into smaller carbon chains to reduce effectively the DBP formation potential. Typical installations include the following components: an ozone generator; liquid oxygen storage and vaporizing system; ozone mixing and injection system; and an ozone residual contact chamber.

Ozone dosage is typically sized based on the oxidant demand in the raw water. Through jar and/or pilot testing, the demand is quantified and a dosage rate is then calculated. Typically, ozone is injected prior to the contact chamber so that all reactions will be driven to completion. Inside the contact chamber, the residual ozone off gasses prior to the treated water being collected and sent to a storage tank. A prospective ozone process diagram of the Lake Groves WTP is shown in **Figure 1** below.

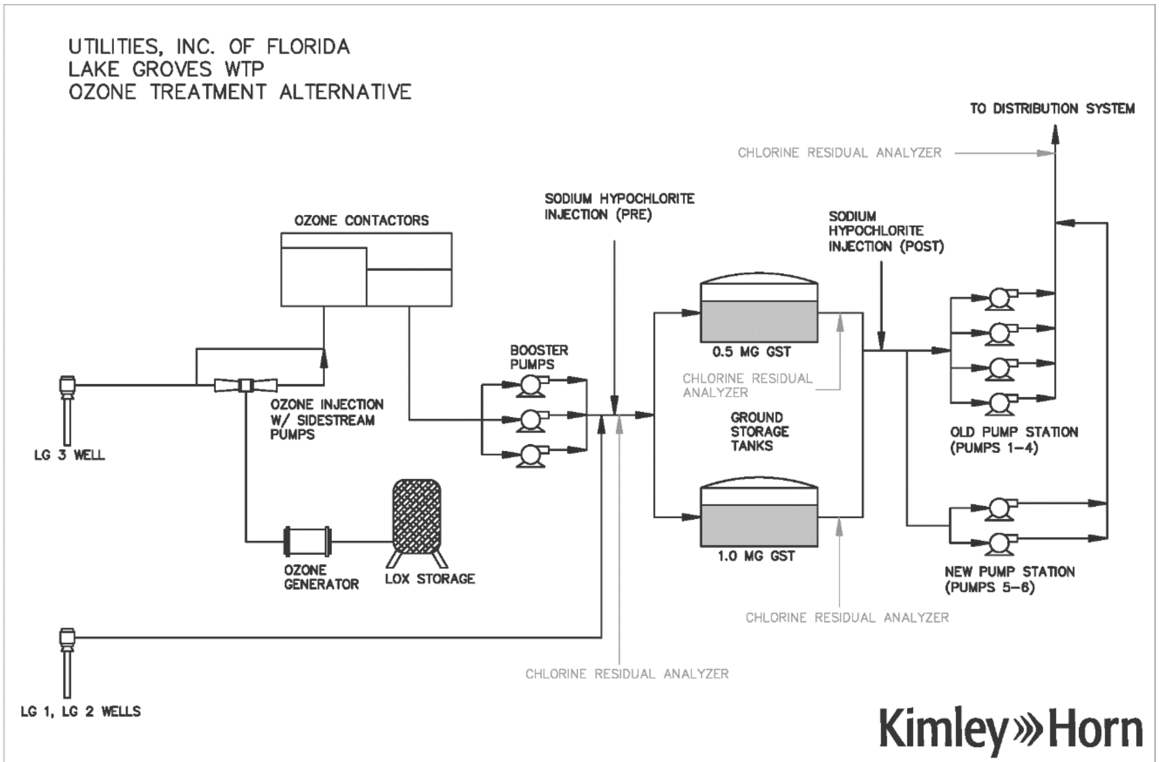

Figure 1. Ozone Process Schematic

While ozone is very effective at removing the hydrogen sulfide commonly found in the Floridan Aquifer, the resulting TOC reduction and subsequent DBP reduction is much less efficient. Previous studies have yielded roughly 15% reduction in the TTHM and HAA formation potential. Given that many of the LUSI North raw water supply wells need additional treatment because they significantly exceed (greater than 15%) the Stage 2 DBP regulatory limits, it was quickly determined that ozone is not sufficient to achieve the Service Areas' compliance with the Stage 2 D/DBPR consistently. Additionally, the Lake Groves facility currently utilizes forced draft aeration, which has been successful in removing the hydrogen sulfide present in the raw water. With no appreciable benefit identified in either TOC reduction or hydrogen sulfide removal, no further investigation has been considered to evaluate ozone treatment for the Lake Groves WTP.

4.2 GRANULAR ACTIVATED CARBON

Granular activated carbon (GAC) has been widely used for removal of naturally occurring TOC and a variety of other contaminants found in Florida groundwater. Specifically, several central Florida utilities have implemented GAC to reduce their DBPs after the promulgation of the Stage 2 D/DBPR. GAC is very effective at removing TOC and subsequent DBPs formed through sodium hypochlorite disinfection.

The GAC treatment process consists of pressurized vessels containing GAC, a number of valve and fluid flow control devices, pressure monitoring devices, and a backwash system. The GAC process entails passing water through fixed beds of high surface area carbon granules. Each granule is approximately one millimeter (1 mm) in diameter. The carbon granules adsorb dissolved organic carbon (DOC) onto the carbon granule's surface and remove it from solution. A prospective GAC process diagram is shown in **Figure 2** below.

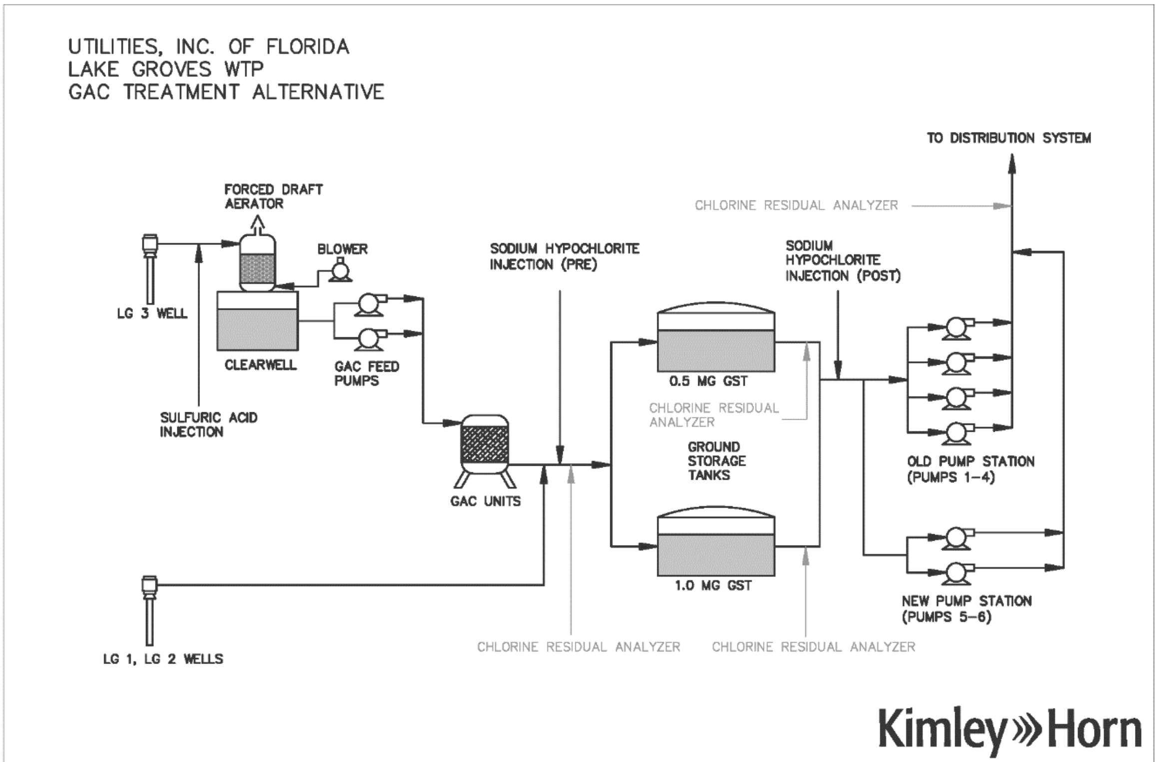

Figure 2. GAC Process Schematic

GAC treatment is typically sized based on the hydraulic loading rate per surface area (GPM/ft^2) as well as the raw water contact time with the carbon while inside the pressurized vessel, termed as empty bed contact time (EBCT). Typical hydraulic loading rates for GAC are 3.0 GPM/ft^2. Typical EBCTs for GAC treatment designed to remove TOC range from 10 to 20 minutes for effective treatment at maximum day demand (MDD). Using recent evaluations of GAC applications at other utility sites and their respective loading rates, this report is based on 3.0 GPM/ft^2 hydraulic loading rate and 16 minutes of EBCT.

As the adsorption of TOC onto the GAC media occurs within the contact vessel, the GAC media begins to become saturated with contaminants reducing the availability of adsorption locations within each granule. The saturation of the GAC results in a steady increase in TOC breakthrough, or passing TOC through the GAC vessel. These systems are designed to tolerate a portion of TOC breakthrough as the GAC becomes spent. Once the breakthrough occurs, close monitoring of the treated water is necessary to ensure compliance with the Stage 2 D/DBP Rule. As breakthrough occurs and the GAC media becomes unable to remove the TOC, the GAC media must be regenerated to return it to its useful purpose of removing TOC. Typically, regeneration is accomplished by unloading the carbon from the pressure vessel, hauling it to the nearest regeneration site and removing the TOC through a high temperature regeneration process. Once the carbon is regenerated, it can be hauled back to the WTP for vessel reloading and transition back to operation. Utilities typically procure an extra load of carbon to be swapped out while each load is being regenerated. For example, if six vessels are in operation, a seventh vessel load of carbon will be procured and stored at the regeneration facility until a regeneration is required. For the purposes of this evaluation, a regeneration frequency is calculated based on the estimated consumption of GAC in pounds per 1,000 gallons treated. Similar systems have been tested and designed utilizing 0.75 pounds of GAC per 1,000 gallons treated.

Table 4-1. GAC Conceptual Design Parameters

Criteria	Specification
Treatment Flow ADD (MGD)	3.00
Pounds GAC per 1,000 Gallons Treated (lbs/1,000 gal.)	0.75
No. of Vessels	6
Vessel Diameter (ft)	12
Vessel Height (ft)	24.75
No. of Vessels in Service	6
Empty Bed Contact Time, EBCT ADD (min.)	28.3
Empty Bed Contact Time, EBCT MDD (min.)	16.2
Run Time per Unit (days)	109
Hydraulic Loading Rate ADD (GPM/ft2)	3.0
Unit Hydraulic Loading Rate ADD (GPD)	489,600
Individual Unit Regeneration Frequency at ADD (days)	18

Table 4-1 represents planned capacity for the current and 5-year planning horizon. Beyond 3.0 MGD capacity, the GAC treatment alternative can be expanded to meet future demands through the addition of GAC vessels. At the design flow rate, each additional vessel can increase the plant's capacity by 0.5 MGD. The future capacity increases up to 6.0 MGD will be addressed by expanding the number of vessels and extending the piping manifolds to the new vessels.

The GAC units will require backwashing to rinse the freshly loaded new or regenerated GAC media, and periodically thereafter when the differential pressure across the GAC units exceeds the design setpoint. The backwash system incorporates a backwash pump, storage tank and disposal to an onsite wastewater collection system. Backwash flow rates for the GAC are 15 GPM/ft^2 or 1,700 GPM for 30 minutes duration with a 12-foot diameter vessel. Following the backwash, a rinse is required to remove any fines or remaining debris at 3 GPM/ft^2 or 340 GPM for a duration of 10 minutes. Total flows utilized in the backwash process are shown in **Table 4-2** below:

Table 4-2. Backwash Criteria

Cycle	Flow Rate (GPM)	Total Consumption (Gallons)
Backwash Cycle	1,700 GPM	51,000 Gallons
Rinse Cycle	340 GPM	3,400 Gallons

The anticipated backwash frequency can vary based on the constituents found in the raw feed water. Similar systems are backwashing each vessel once per week. Utilizing six vessels, the quantity of waste stream water pumped to the influent of the adjacent Lake Groves Wastewater Treatment Plant through the backwashing and rinse cycles totals over 326,000 gallons per week or an average of 46,500 gpd. Given the relatively large flow rate over the backwash cycle and the potential to surge the wastewater system, it would be necessary to provide a backwash waste storage tank to store and slowly repump the waste stream to the wastewater treatment headworks.

Given the general description of the GAC process and the components listed above, the advantages and disadvantages are listed below:

Advantages

- No additional hazardous chemicals required for treatment
- GAC is very efficient in removing TOC
- GAC can be designed for full or partial removal of TOC
- GAC can be regenerated which minimizes the operational costs following the initial supply
- Capital cost for the treatment installation is comparable to other treatment technologies
- Offers flexibility for future expansion by modular addition of GAC vessels

Disadvantages

- GAC is consumed by hydrogen sulfide thus requiring the raw water to be aerated through the existing forced draft aerators, then repumped through the GAC treatment vessels
- Regeneration frequency is anticipated to be one vessel per 18 days or all six vessels 3.5 times per year at ADD
- Regeneration costs are subject to escalation by the consumer price index (CPI) which can fluctuate with the varying cost of other commodities such as fuel and carbon supply/demand.
- Large loading of backwash/rinse flow disposal into the WWTP (approximately 326,000 gallons per week)
- Operational cost for the GAC system is higher than other alternatives which subjects the Utility to additional, and more frequent rate increases to account for the reoccurring operating expenses
- Regeneration costs and schedules are dependent upon an outside entity to remove, regenerate, store, and return the GAC to the facility in a timely and cost effective manner.

4.2.1 CONCEPTUAL LEVEL ENGINEER'S OPINION OF PROBABLE COST

Estimated operating costs for the various treatment levels are presented in **Table 4-3** for GAC treatment. Non-labor operating costs are mainly composed of the cost of GAC regeneration. Operating costs are estimated based on average annual design flow conditions. The large contributors to the operating expenses for GAC center on the supply and regeneration of the GAC media, its transport to and from a regeneration facility, and its steady replacement through each regeneration cycle. GAC regeneration costs are estimated using $1.25 per pound of GAC and a GAC consumption rate of 0.75 pounds per 1,000 gallons treated prior to breakthrough. Backwash disposal costs, labor costs, and other existing operating costs are not included in this estimate. Overall, total operating costs are estimated to be $0.94 per 1,000 gallons produced for the respective treatment level considered.

Table 4-3. Conceptual Level Annual GAC Operational Cost Estimate

ADD Capacity (MGD)	MDD Capacity (MGD)	Operating Costs ($ per 1,000 gallon produced)	Estimated Annual Operating Cost (3.00 MGD treated per day)
3.00	5.25	$0.94	$1,029,300

The conceptual levels of capital costs estimated for GAC treatment are shown in **Table 4-4**. The estimated costs are based on treating the average day demand flow rate of 3.00 MGD. The cost shown includes the GAC treatment systems, as well as the ancillary backwash systems and controls needed for full operation of the GAC treatment system. **Table 4-4** below, provides a summary of the estimated costs for the GAC treatment alternative.

Table 4-4. Conceptual Level GAC Capital Cost Estimate

Item	Size/Units	Quantity	Unit/Material Cost	Total Cost
General Requirements	L.S.	1	$ 412,500	$ 412,500
Site Civil	L.S.	1	$ 137,500	$ 137,500
Site Mechanical	L.S.	1	$ 269,500	$ 269,500
Structural & Architectural	L.S.	1	$ 165,000	$ 165,000
Electrical Service	L.S.	1	$ 330,000	$ 330,000
Process				
Granular Activated Carbon	MGD-ADD	3.00	$ 1.52	$ 4,554,000
Plant and Process Electrical	L.S.	1	$ 275,000	$ 275,000
Instrumentation & Controls	L.S.	1	$ 302,500	$ 302,500
Total Construction Cost				$ 6,446,000
Engineering Design	% of Const.	8%	$ 515,680	$ 515,680
Engineering Construction	% of Const.	1%	$ 64,460	$ 64,460
Total Construction Cost				$ 7,026,140

4.3 ION EXCHANGE

The ion exchange process incorporates an exchange of one desired ion for another problematic ion in solution in the raw water using a carrier media called the ion exchange resin. The resin is charged with a weak bonded ion through its generation process that is easily exchanged for a much stronger bond with the problematic ion in the raw water. In the LUSI South service area, hydrogen sulfide and TOC found in the raw water are the problematic constituents in the raw water. Effective removal of the TOC in the raw water will reduce the DBPs formed in the distribution system and ultimately achieve compliance with the Stage 2 D/DBPR regulations.

Additionally, ion exchange has been found to remove hydrogen sulfide in conjunction with TOC. The Utility can expect to see a portion of the hydrogen sulfide removed through the ion exchange process. However, the removal efficiency is not anticipated to meet the guidelines provided by FDEP and would require the treated water to be repumped through the existing forced draft aeration units after ion-exchange treatment. A prospective ion exchange process diagram is shown in **Figure 3** below.

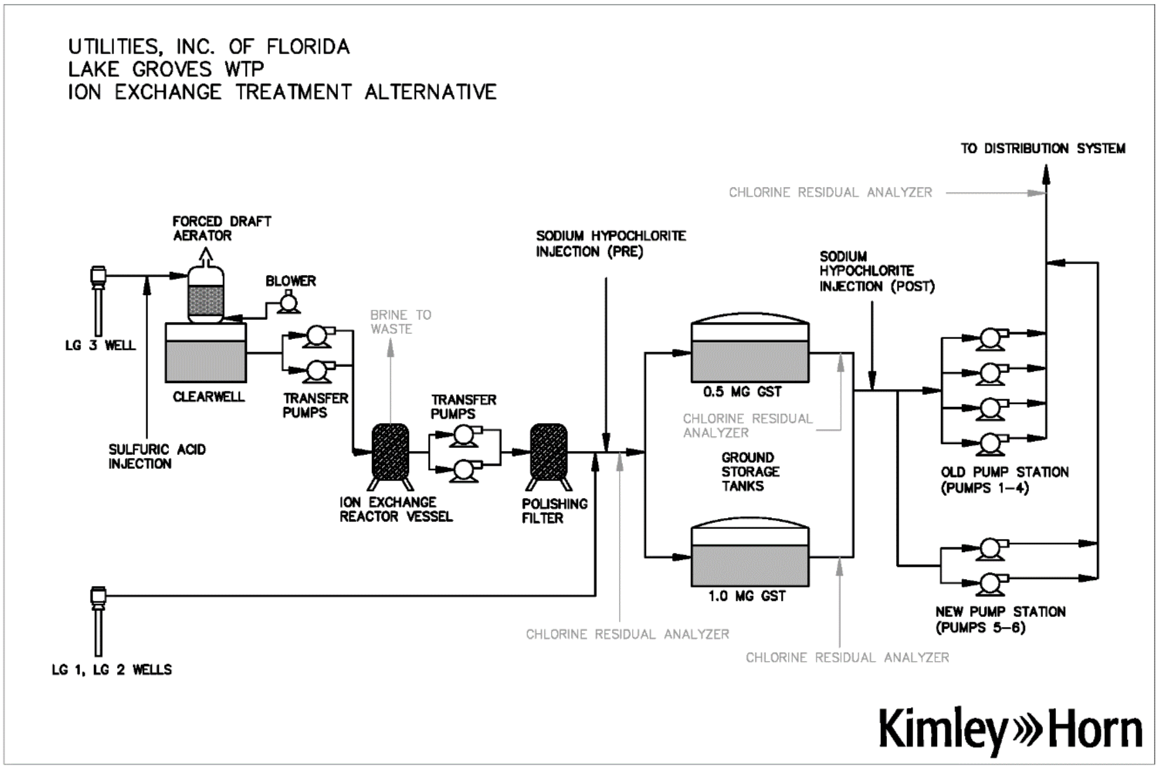

Figure 3. Ion Exchange Process Schematic

Sizing of the ion exchange system is critical to quantify the capital and operational undertaking of construction and operation of this treatment process. Generally, the treatment is sized based on the bed volume design. Specifically, a 1,000-bed volume criterion means that for every 1,000 gallons of water treated with one gallon of resin, the resin is regenerated. As such, a lower bed volume results in better TOC removal but is offset by frequent regeneration of the resin and higher operating costs.

For the combined Service Area, 1,000-bed volume treatment is estimated to be sufficient to achieve compliance with the Stage 2 D/DBPR regulatory limits for TTHMs and HAAs. As such, the ion exchange treatment process will consist of raw water being pumped directly to the existing forced draft aerators for removal of the hydrogen sulfide to limit the additional hydrogen sulfide loading on the ion exchange system. Following aeration, the water will be re-pumped to the ion exchange reactor. A flow splitting channel will be used to distribute the raw water between the individual reactor cells of the ion exchange structure. The reactor will be divided into multiple sections to achieve the effective transfer of ions and the cells will be open to atmosphere with aluminum or stainless steel covers. Following the reactor, the water will be collected and repumped through a set of polishing filters to capture any resin that escapes the reactor basins. The aerated, treated and filtered water will then be transmitted to the ground storage tanks for disinfection and supply.

Ancillary systems to the ion exchange process that are outside of the primary process treatment include: a resin storage facility; loading and transmission system; regeneration system; brine tank and brine pumping system; and a brine disposal transfer and unloading system. These systems require significant automation and operator involvement to maintain steady operation of the ion exchange process.

Given the general description of the ion exchange process and the components listed above, the advantages and disadvantages are listed below:

Advantages

- Partial removal (60% to 70%) of the TOC
- Partial removal (75% to 80%) of the hydrogen sulfide
- Requires low operating pressures
- No hazardous chemicals required for treatment

Disadvantages

- Significantly less TOC removal compared to the alternatives evaluated
- Potential to lose resin and thus require the regular purchase of new resin increasing operating expenses and triggering subsequent rate increases
- Maintenance is operator intensive with several mechanical transfer processes requiring frequent attention
- Brine disposal includes generation of a chloride-loaded waste stream
- Requires post-filtration following ion exchange process
- Requires significant facility improvements for future expansion
- Requires the water to be repumped twice through the process resulting in additional operating expense related to additional maintenance, power and equipment replacement
- Dependent upon ion exchange resin supply and industry demand
- Highest capital cost for the system's construction and ancillary systems' installation
- Medium operational cost for treatment compared to the alternatives evaluated
- Requires elevated skill set by the operating staff to maintain peak performance of the treatment process

4.3.1 CONCEPTUAL LEVEL ENGINEER'S OPINION OF PROBABLE COST

Non-labor operating costs are mainly composed of ion exchange resin replacement, regeneration cost and brine disposal cost. Operating costs are estimated based on average annual design flow conditions. Ion exchange resin replacement and regeneration with sodium chloride is estimated at $0.19 per 1,000 gallons of treated average flow. Brine disposal cost is estimated at $0.11 per 1,000 gallons of ion exchange treated flow. Both the resin supply and brine disposal costs are subject to CPI cost increases and could lead to increased operating expenses. Labor costs, power costs and other existing operating costs are not included in this estimate. The conceptual level operational costs estimates for the ion exchange system are shown in **Table 4-5** below.

Table 4-5. Conceptual Level Annual Ion Exchange Operational Cost Estimate

ADD Capacity (MGD)	MDD Capacity (MGD)	Operating Costs ($ per 1,000 gallon produced)	Estimated Annual Operating Cost (2.47 MGD treated per day)
3.00	5.25	$0.30	$328,500

The conceptual level estimates of capital costs for ion exchange treatment construction are shown in **Table 4-6**. The estimated costs are based on treating the average day demand flow rate of 3.00 MGD. The cost shown includes the ion exchange treatment systems as well as the ancillary resin regeneration system, brine storage and transfer systems, and resin storage and system controls needed for full operation of the ion exchange treatment system. **Table 4-6** below provides a summary of the estimated costs for the ion exchange treatment alternative.

Table 4-6. Conceptual Level Ion Exchange Capital Cost Estimate

Item	Size/Units	Quantity	Unit/Material Cost	Total Cost
General Requirements	L.S.	1	$ 550,000	$ 550,000
Site Civil	L.S.	1	$ 137,500	$ 137,500
Site Mechanical	L.S.	1	$ 247,500	$ 247,500
Structural & Architectural	L.S.	1	$ 275,000	$ 275,000
Electrical Service	L.S.	1	$ 374,000	$ 374,000
Process				
Ion Exchange	MGD-ADD	3.00	$ 2.70	$ 8,085,000
Plant and Process Electrical	L.S.	1	$ 715,000	$ 715,000
Instrumentation & Controls	L.S.	1	$ 302,500	$ 302,500
Total Construction Cost				$ 10,686,500
Engineering Design	% of Const.	8%	$ 854,920	$ 854,920
Engineering Construction	% of Const.	1%	$ 106,865	$ 106,865
Total Construction Cost				$ 11,648,285

Table 4-6 represents planned capacity for the current and 5-year planning horizon. Beyond 3.0 MGD capacity, the ion exchange treatment alternative can be expanded to meet future demands through a mirroring of the treatment units. Due to the configuration of the ion exchange system, its flow rates through the reactor beds and regeneration frequencies, a significant level of effort is necessary to expand the ion exchange process. The future capacity increases up to 6.0 MGD will be addressed by doubling the structures and processes included within the cost estimate shown in **Table 4-6.**

4.4 MEMBRANE TREATMENT

Membrane treatment has traditionally been used in Florida for chloride removal using brackish and seawater water supplies. Additional uses include softening of raw water supplies with elevated hardness levels which also results in TOC removal. Either softening or higher rejection membranes can be used to achieve compliance with Stage 2 D/DBPR. For the purposes of this analysis, the higher rejection membranes are considered to provide the most conservative approach. Given the required water quality objectives set by FDEP and the Utility, membrane treatment provides an excellent method of removing TOC and the resulting DBPs.

Membrane systems are composed of raw water pre-filtration using cartridge filters followed by a pressurized feed to the membrane elements. The product water, termed the permeate, is collected and sent on for stabilization, disinfection and storage. The reject water, termed the concentrate, is collected and sent to disposal. Since the raw water is relatively low in chlorides, the concentrate stream can most likely be diverted directly to the reclaimed water treatment process downstream of the reclaimed water filters and thus effectively augment the otherwise limited reclaimed water supply. Because the membrane treatment process is so successful in removing unwanted constituents from the source water, membrane treated water can be mixed with non-membrane treated water to produce a blended water that will be compliant with Stage 2 D/DBPR regulations.

The membrane system estimated for this process improvement will be designed to remove 99.7-percent of the TOC from the fraction of the raw water treated through membrane elements. Under normal operation, the membrane treated stream can be trimmed to a portion of the Lake Groves Well 3 flow in order to reduce capital and operating expenses. The anticipated plant would include two membrane trains with each train utilizing a 2:1 membrane array. The pressure vessel arrangement will yield 24 vessels in the first stage, 12 vessels in the second stage. The product recovery will be 85% to 90% of the feed water flow rate producing approximately 1,500,000 GPD of permeate. The remaining raw water will be blended prior to forced draft aeration to remove the hydrogen sulfide as in the current operation. Following aeration, the treated water will be disinfected, stored and pumped out for potable use.

The concentrate stream will be a steady stream of rejected water that can be discharged directly into the reclaimed system following chlorination. Given the estimated 85% recovery (a conservative estimate subject to the results of pilot testing), the concentrate flow rate will be 265,000 GPD per train in operation. With the additional pressure available in the concentrate stream, the concentrate can be transmitted to the reclaimed system with no additional pumping required. The concentrate pressure coming off the membrane trains will be sufficient to push the concentrate to either the reclaimed storage tank, chlorine contact chamber, or the onsite rapid infiltration basins without constructing additional storage or having to repump. A prospective membrane process diagram is shown in **Figure 4** below.

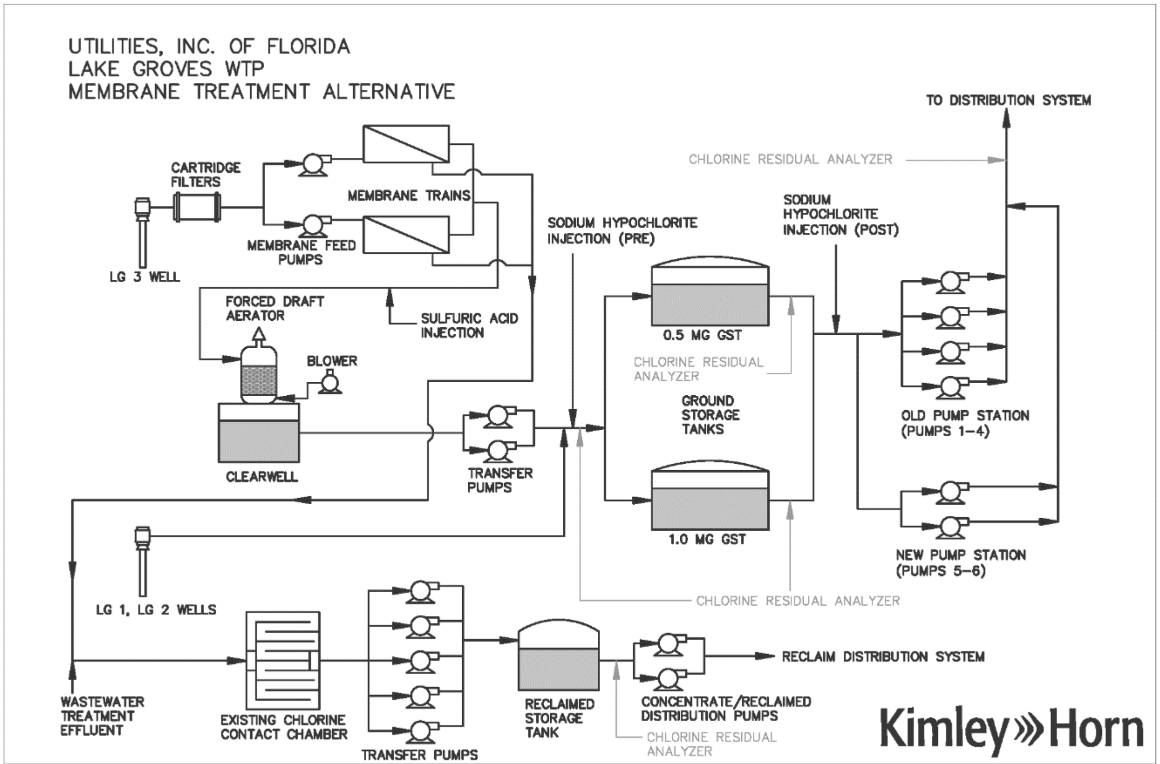

Figure 4. Membrane Process Schematic

Ancillary systems associated with membrane treatment include a chemical injection system for anti-scalant pretreatment dosing of the membrane feed and a cleaning system that will be utilized on a semi-annual basis as the membrane elements begin to foul.

Given the general description of the membrane treatment process and the components listed above, the advantages and disadvantages are listed below:

<u>Advantages</u>

- Near complete removal (99%) of the TOC which enables the maximum blending of other lesser water quality wells
- Continuous operation of treatment production
- No additional hazardous chemicals required for treatment
- Reduction in the quantity of sulfuric acid injection and handling
- Automated process controls and online process analysis
- Concentrate can be used to augment the reclaimed water supply and thus avoid capital cost of concentrate disposal through deep well injection or other means
- Increases revenue generated from additional reclaimed water sales
- Lowest operating cost of the alternatives analyzed
- Less operational complexity compared to the alternatives analyzed
- Provides a consistent water quality throughout the membrane life
- Less likely to generate customer complaints associated with aesthetics (taste, color, feel)

- May qualify for cost share funding by SJRWMD reflecting alternate water supply development
- Maximizes the use of water resources compared to the other alternatives
- Offers flexibility for future expansion with consistent treatment of lower Floridan aquifer wells
- Provides the lowest operational expenses which may provide the Utility with an opportunity to delay future rate increases
- Provides the lowest net present value and lifecycle costs for the Utility

Disadvantages

- Concentrate disposal is required
- Second lowest capital cost for the system's construction and ancillary systems' installation
- Requires membrane replacement every 5-12 years
- Largest power consumption alternative analyzed

4.4.1 CONCEPTUAL LEVEL ENGINEER'S OPINION OF PROBABLE COST

Traditionally, membrane operational costs and concentrate disposal have been the prohibiting factor in integrating membrane treatment. Since the Lake Groves WTP is co-located with the wastewater treatment plant, no additional expenses beyond disinfection are anticipated for the concentrate disposal. Given that the anticipated feed pressures for this raw water quality are expected to be less than 100 psi, the non-labor operating costs are much more comparable to, if not less expensive, than other treatment technologies. For this operating expense analysis, we have calculated the power consumption using 100 psi as the feed pressure and the remaining concentrate pressure to transport the concentrate to the reclaimed system.

The non-labor operating costs are mainly composed of energy (feed pumping) cost, membrane replacement cost (5-year replacement), and concentrate disposal cost (direct feed into the reclaimed system). The conceptual level operating costs are estimated based on average annual design flow conditions. Membrane feed power costs are estimated using $0.12 per KWH and 100 psi net feed pressure, which results in a cost of $0.15 per 1,000 gallons of membrane permeate produced. Concentrate disposal cost is not anticipated due to the close proximity of the reclaimed water system. Membrane replacement cost is estimated at $0.04 per 1,000 gallons of permeate produced. Labor costs, additional chemical costs and other existing operating costs are not included in this conceptual level cost estimate.

Table 4-7. Conceptual Level Annual Membrane Operational Cost

ADD Capacity (MGD)	MDD Capacity (MGD)	Operating Costs ($ per 1,000 gallon produced)	Estimated Annual Operating Cost (3.0 MGD treated per day)
3.00	5.25	$0.19	$208,050

The conceptual level estimate of capital costs for membrane treatment system construction is shown in **Table 4-8**. The estimated costs are based on producing the average day demand flow rate of 3.00 MGD. The cost shown includes the membrane treatment systems, as well as the ancillary cleaning system, concentrate storage and disposal systems. **Table 4-8** below, provides a summary of the estimated costs for membrane treatment alternative.

Table 4-8. Conceptual Level Membrane Capital Cost

Item	Size/Units	Quantity	Unit/Material Cost	Total Cost
General Requirements	L.S.	1	$ 550,000	$ 550,000
Site Civil	L.S.	1	$ 137,500	$ 137,500
Site Mechanical	L.S.	1	$ 269,500	$ 269,500
Structural & Architectural	L.S.	1	$ 165,000	$ 165,000
Electrical Service	L.S.	1	$ 330,000	$ 330,000
Process				
Membrane Treatment	MGD-ADD	3.00	$ 2.31	$ 6,930,000
Plant and Process Electrical	L.S.	1	$ 385,000	$ 385,000
Instrumentation & Controls	L.S.	1	$ 302,500	$ 302,500
Total Construction Cost				$ 9,069,500
Engineering Design	% of Const.	8%	$ 725,560	$ 725,560
Engineering Construction	% of Const.	1%	$ 90,695	$ 90,695
Total Construction Cost				$ 9,885,755

Table 4-8 represents planned capacity for the current and 5-year planning horizon. Beyond 3.0 MGD capacity, the membrane treatment alternative can be expanded to meet future demands through a modular expansion in the number of membrane trains. Either option for expansion up to 6.0 MGD will be considered in the initial design to promote a quick and easy expansion when the demands approach 3.0 MGD.

5 SUMMARY AND RECOMMENDATIONS

Several treatment processes were evaluated to determine the best fit for the Lake Groves Water Treatment Plant. The primary concern for this evaluation focused on DBP reduction in order to achieve compliance with the Stage 2 D/DBPR and the FDEP-issued Consent Order within the timeframe contained therein.

5.1 REVIEW OF TREATMENT ALTERNATIVES

Four alternative treatment methods were evaluated using previous experience and current water quality parameters using the existing Lake Groves Well 3 as the primary water source. Ozone treatment was eliminated from further consideration due to the minimal water quality improvement anticipated using this treatment technology. The remaining three alternatives provided significant water quality improvement based on their projected performance. Each was compared for operating and capital cost as well as their respective net present value as shown in **Table 5-1** below. The combination of capital and operating costs are plotted in **Figure 6** to project the annual expense over the first 20 years of operation.

Table 5-1. Capital, Operating and NPV Cost Summary

Treatment Alternative	Capital Cost	Annual Operating Cost	20-Year NPV: Capital and Operating Cost (1.5% Discount Rate)
Ion Exchange	$ 11,648,285	$ 328,500	$ 18,121,191
GAC	$ 7,026,140	$ 1,029,300	$ 27,307,913
Membranes	$ 9,885,755	$ 208,050	$ 13,985,262

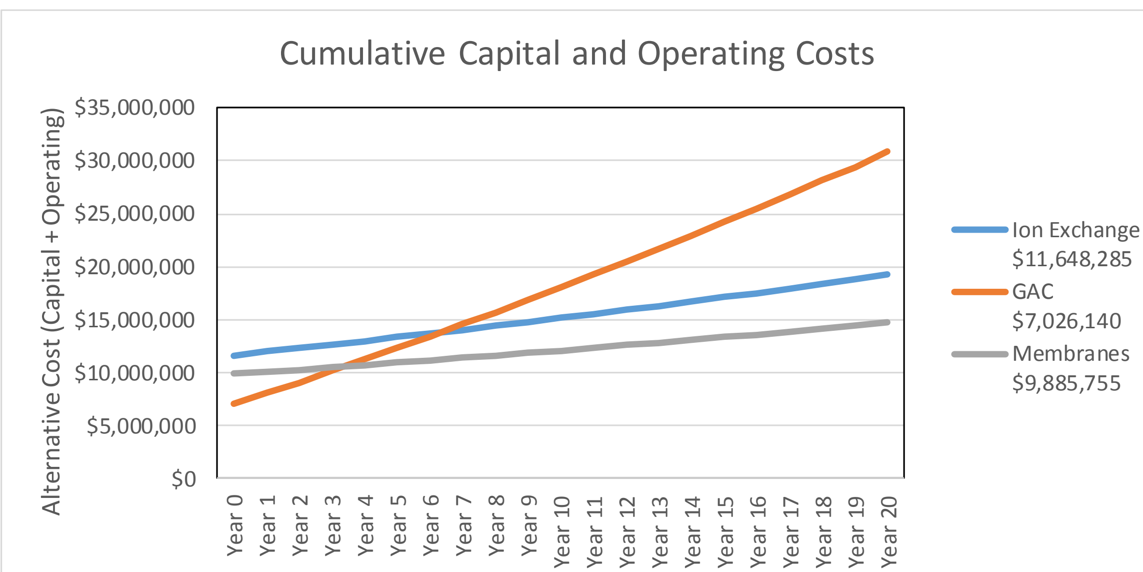

Figure 5. Capital and Operating Cost 20-Year Projection (1.5% Discount Rate)

5.2 RECOMMENDATIONS

The three treatment alternatives considered for the Utility's Lake Groves WTP are each projected to meet the TOC removal required to achieve compliance with the Stage 2 D/DBPR. The recommendations have been based on the ability to achieve treatment compliance for the Utility Service Areas as well as capital expense and operational expense. Further review for consideration of each alternative in their respective secondary benefits such as complexity of operations; reliability of treatment; ease of future expansion; consistency in operation and treatment quality; safety for operations staff and the community; and the skillsets needed to maintain optimal operation of the treatment process. After reviewing these categories for each alternative, this section provides a discussion of the treatment alternative selection that is recommend for proceeding at Utilities, Inc. of Florida's Lake Groves WTP.

5.2.1 TREATMENT SELECTION

Based on the combination of capital and operating costs, it is recommended that the Utility pursue the membrane treatment alternative for this facility. The membrane treatment alternative provides the median capital cost for the three alternatives and the most effective, consistent method of TOC removal for the lower Floridan aquifer water supply. Further, the annual operating expenses for membrane treatment are significantly less than the GAC and slightly less than the ion exchange alternatives. Over the course of the first four years of service, the operational expense savings will begin to exceed the capital cost savings associated with GAC. Through the next 16 years, the operating expenses continue to reveal that membrane treatment is the most cost-effective, sustainable solution for the Utility and its customers. The long-term economic differential is graphically depicted in **Figure 5** and numerically with the net present value shown in **Table 5-1**.

5.2.2 SECONDARY BENEFITS

In conjunction with the financial considerations of the treatment alternative selection, the secondary benefits of each alternative was reviewed to support the final recommendations for this facility.

<u>Complexity of Operations:</u> Operation of the membrane treatment system offers similar flexibility to the other alternatives in that the flow production can be increased or decreased by selecting the desired flow rate and number of treatment trains in operation. With only a few control points for each membrane train and full automation of those components, the complexity of the operation becomes easily manageable by the Utility's operations staff.

<u>Consistent Operation and Water Quality:</u> The membrane process will consistently produce high quality water with very little deviation in either the laboratory or customer perceived water quality aesthetics. Due to the constant operation of the membrane trains, flow rates and chemical injections are also stable through the day-to-day operations of the facility. Regular change outs of filtration media and backwash cycling associated with GAC and ion exchange can lead to challenging flow pacing for chemical pumping systems attempting to disinfect the finished water from those systems. Given the automated nature of the membrane process, its process control points, and modularity in train design, the membrane treatment alternative offers a reliable treatment process for the operations staff.

<u>Reliability of Treatment and Ease of Future Expansion:</u> Membrane treatment offers reliable treatment process for the current Lake Groves WTP and future expansions pulling water from the lower Floridan aquifer. Future well and capacity expansions can be achieved by adding modularized treatment trains to the process facility up to the buildout capacity. The process building should be designed to accommodate

any anticipated expansion within the next 10 years within the initial structure and additional expansion can be easily co-located to share common conveyance and treatment components where convenient.

Safety for Operations Staff and the Community: Sulfuric acid will most likely be required to reduce the permeate pH prior to the forced draft aerator's removal of the hydrogen sulfide. However, unlike the GAC and ion exchange processes, hydrogen sulfide removal will occur after membrane treatment, which will remove much of the buffering capacity in the sulfide-laden water. The resulting acid consumption will be dramatically reduced requiring less frequent deliveries, less operator handling and reduced safety hazards for the operations staff. Further, the frequent semi-truck and trailer delivery loads of regenerated GAC or ion exchange resin, sulfuric acid and other process related chemicals pose a safety risk to the surrounding community. These transportation risks will be minimized with membrane treatment. The only additional chemical necessary for membrane treatment will be anti-scalant, which is non-hazardous and requires only a few deliveries per year.

Operator and Maintenance Skillsets: The membrane treatment process utilizes traditional pumping, instrumentation and valve equipment for controls and operation. As such, standard level maintenance technician skillsets are sufficient for routine maintenance of the treatment equipment. From an operations standpoint, the integration of membrane treatment can be carefully monitored and alarmed using the automated control system. Alarms and warnings can notify the operators if a process issue arises and where to intervene with the membrane system. With the proprietary mixing chambers and beds utilized in ion exchange, the operations staff will have greater difficulty effectively and timely troubleshooting the process and control system with any certainty. The ability to operate the membrane treatment process in a consistent, reproducible manner offers the most reliable and reasonable operation paradigm for the Utility's staff.

Given the overall evaluation of each technology, membrane treatment offers the best fit for the Lake Groves WTP. Not only are the financial impacts of the membrane treatment process more beneficial to the Utility and its customers, but the secondary benefits of the treatment process present the best all-around solution for the operations staff and the community.