CLEAR LAKE SANITARY DISTRICT IS FIRST IN IOWA TO PROVIDE REUSE WATER FOR POWER PLANT

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Abstract

Clear Lake Sanitary District (CLSD) was originally built in the early 1950s and utilized a trickling filter system for wastewater treatment. By 1988, the plant was in need of a major renovation to update older technology and meet the demands of a growing population. This $23 million project began in 1995 and was implemented in several phases over the course of six years. Renovations included construction of a new 4-basin AquaSBR® secondary treatment system, two storm flow equalization basins providing a total retention of 8 million gallons, renovations of eight lift stations, and 8.5 miles of new force mains. The 4-basin AquaSBR® system was retrofitted into the plant's existing trickling filter system and provides a design average daily flow of 5.7 MGD and peak flow capability of 8.2 MGD, which is essential during the area's busy tourist season.

Shortly after the renovation projects were completed, CLSD entered into an agreement with a nearby Alliant Energy power generation plant to supply treated wastewater for reuse in their cooling process. This would be the first water reuse application of its kind in the state of Iowa. In order to meet the new reuse guidelines that accompanied the agreement, CLSD added a tertiary treatment system to provide filtration and disinfection of the effluent. Alliant paid for the tertiary system, which included a 210,000 gallon effluent equalization basin and a new Tertiary Treatment Building that houses (3) 6-disk AquaDisk® cloth media filters and an ultraviolet disinfection system. The cloth media filters provide a maximum hydraulic capacity of over 9.0 MGD with all three filters in operation.

After being received by Alliant Energy, the reuse water is further disinfected using chlorination and blended with groundwater at a ratio of 3 parts groundwater to 2 parts effluent. 80% of the water is evaporated in the cooling process, with the remaining 20% returned to Clear Lake for discharge or treatment. Inline probes monitor the cooling water supply, cooling water return and plant effluent to detect chlorine, conductivity, turbidity, pH, temperature, and line pressure. Sodium Bisulfate is automatically added for dechlorination of the cooling water return as needed. The inline monitoring allows automatic diversion of the cooling water return flow to the storm flow equalization basin should the probe detect values that exceed permit limits.

CLSD has been providing reuse water to the power plant since December of 2003. The AquaSBR® and AquaDisk® filter system consistently achieves BOD_5 and TSS levels less than 5.0 mg/l and effluent NH_3-N and NO_3-N values of less than 0.1 and 3.0 mg/l, respectively.

CLSD History

CLSD Formation and the First Treatment System

Clear Lake Sanitary District was formed in 1950 due to failing septic systems in the City of Clear Lake and other communities surrounding Clear Lake. The lake is a natural 3,600 acre lake, and serves as a destination for many Iowa citizens, as evidenced by current PE equivalents 10,000 in winter to 25,000 in summer. Contamination of these highly recreational waters from the failing septic systems threatened to close the lake to the activities enjoyed by so many. With the formation of CLSD in 1950, a network of piping was installed to collect wastewater from communities surrounding the lake and convey it to a new trickling filter plant. In its early years, while serving the immediate communities surrounding the lake, the trickling filter system achieved effluent objectives of 20 mg/l BOD_5 and 30 mg/l TSS. However, additional areas were annexed by CLSD from 1972 through 1986. As new areas were brought online, the ability of the existing trickling filter system to meet the performance objectives became increasingly difficult. This was compounded by the high amount of inflow and infiltration (I&I) associated with the high water table and the length of pipe needed to convey wastewater around the perimeter of the lake. Trickling filter bypasses, and NPDES permit violations, became increasingly more common as the years passed and more flow was sent through the system. Ultimately, this led to the issuance of an Administrative Order by the Iowa Department of Natural Resources in 1988 and a potential lawsuit if the District did not respond. CLSD took steps to alleviate some of the I&I, but the leaks in the piping system were too extensive and costly to repair them all.

A New Treatment System

Although CLSD could have opted to try and fix all of the leaky pipes and hope the problems would go away, an alternate solution proved to be the best option: upgrade the treatment facility. To ensure reliable treatment with limited or preferably no plant bypasses, and to provide the ability to handle future additional flows, a complete overhaul of the system was envisioned. In addition, CLSD recognized that future limitations on wastewater constituents such as Nitrogen and Phosphorus were inevitable and planning for them now would pay dividends in the end. Several secondary treatment processes were considered for the upgrade. Primary factors considered in the selection were the ability to handle the seasonal variations of organic loads, process the high amount of I&I, and be easily modified when needed to provide total Nitrogen and Phosphorus removal. Considering these factors, the CLSD Board elected to upgrade the facility to utilize Sequencing Batch Reactor (SBR) technology with the AquaSBR® system by Aqua-Aerobic Systems, Inc. The project began construction in 1995 and also included upgrading eight (8) lift stations, directional drilling a 6,020 feet 18 inch diameter force main pipe 30 ft below the bottom of Clear Lake (setting a record at the time), and installing two (2) new storm water equalization basins with 8 million gallons of storage.

The SBR system was a retrofit to the existing trickling filter basins, providing a four basin SBR system with an average daily dry weather flow capacity of 5.7 MGD, and a peak flow capacity of 8.2 MGD. Wastewater passes through a screening and grit removal system prior to entering the SBR system. The SBR system operates on a Fill and Draw principle, with two (2) reactors filling at the same time. After a pre-set time duration, flow is transitioned to the other two (2) reactors. All reaction steps, as well as clarification and supernatant withdrawal, occur directly within the four (4) reactor basins, without the need for separate anoxic/anaerobic reactors or clarifiers. The reactors perform all operations in a series of five (5) distinct steps.

AquaSBR® Fill Phases
Mixed Fill – Influent enters the AquaSBR® reactor. Complete mix of the reactor contents is achieved by a mechanical down-draft mixer, without the use of aeration. This phase assists in control of filamentous organisms and biomass conditioning, and allows for optimization of biological phosphorus removal.
React Fill – Influent flow continues to enter the reactor under mixed and aerated conditions. Aeration is operated intermittently to provide alternating aerobic and anoxic conditions. This allows each reactor to achieve complete nitrification and denitrification within each cycle. The separation of aeration and mixing also allows conservation of energy by aerating only as much as needed to meet the actual oxygen demand, without compromising the complete mixing of the system.

AquaSBR® Non-Fill Phases
React – Influent flow is terminated, while mixing and aeration continue. Intermittent operation of the aeration system may continue to complete the nitrification/denitrification process, or to conserve energy.
Settle – Mixing and aeration cease. Solids/Liquid separation takes place under perfectly quiescent conditions.
Decant/Sludge Waste – The mixer and aeration system remain off and, at this time, the decantable volume is removed by means of subsurface withdrawal. The reactor is immediately ready to receive the next batch of raw influent. A small amount of sludge is wasted each cycle.

Plant upgrades were completed in 2001, and the decision to convert to an effective new treatment system rather than to simply repair the existing leaking pipes and failing trickling filter system would soon prove beneficial in a way CLSD could not have envisioned.

The Contract

Alliant Energy Selects CLSD Location
In late 2001, Alliant Energy was investigating potential sites for a new natural gas-fired power plant in Iowa. The decision was narrowed to 2 potential sites, one of them located approximately 6 miles from the CLSD treatment facility. One critical issue faced by Alliant Energy that would be instrumental in the final decision would be the availability of clean water. For its cooling tower needs, Alliant Energy would require approximately 3,400 gallons per minute. However, the Iowa DNR would allow only 2,000 gallons per minute to be withdrawn from the only practical source of fresh water available, the Jordan Aquifer. This left 1,400 gallons per minute of additional cooling water needs to be supplied from another source. Alliant first approached CLSD in January, 2002 with the idea of reusing the effluent from the district's wastewater treatment facility to supplement their cooling tower water needs. The fit could not have been more ideal. Actual average daily effluent flow from the CLSD treatment facility was approximately 2.0 millions gallons per day (approximately 1,400 gallons per minute). In addition, the right of way obtained to connect two major natural gas pipelines to the power plant ran within less than one mile of the CLSD property. This would ease right-of-way issues in running new reuse water piping the 6 miles needed between the treatment facility and the power plant. Finally, with the new treatment system improvements recently completed, only minor modifications to the wastewater plant would be needed to provide the reuse water quality needed to meet Alliant Energy's needs. Were it not for the plant improvements already completed in 2001, including the implementation of the SBR process, CLSD likely would not have been a candidate for supplying the supplemental cooling water needs for Alliant Energy.

The final decision was made by Alliant Energy in May 2002 to locate the new Interstate Power and Light (IPL) facility at the Clear Lake area location. In the remainder of 2002, CLSD and Alliant Energy negotiated a contract for the supply of the reuse water. This process also involved work with the Iowa DNR to establish the reuse water criteria, as the state currently has no existing criteria. The criteria established would be instrumental in determining what additional treatment processes would be required at the CLSD treatment facility. The following table summarizes the key reuse water quality criteria established:

Table 1: CLSD Reuse water criteria

Reuse Quality Parameter	Reuse Limit
BOD_5	5.0 mg/l
TSS	5.0 mg/l
NH_3-N	2.0 mg/l
E. Coli	126 CFU/100 mg/l

New Tertiary Treatment System

The newly established reuse criteria would require the addition of tertiary filtration and disinfection at the facility. Cloth media filtration, a technology which filters the secondary effluent through a pile cloth media supported on vertical disk segments (see Figures 1 and 2) was selected as the preferred tertiary filter technology.

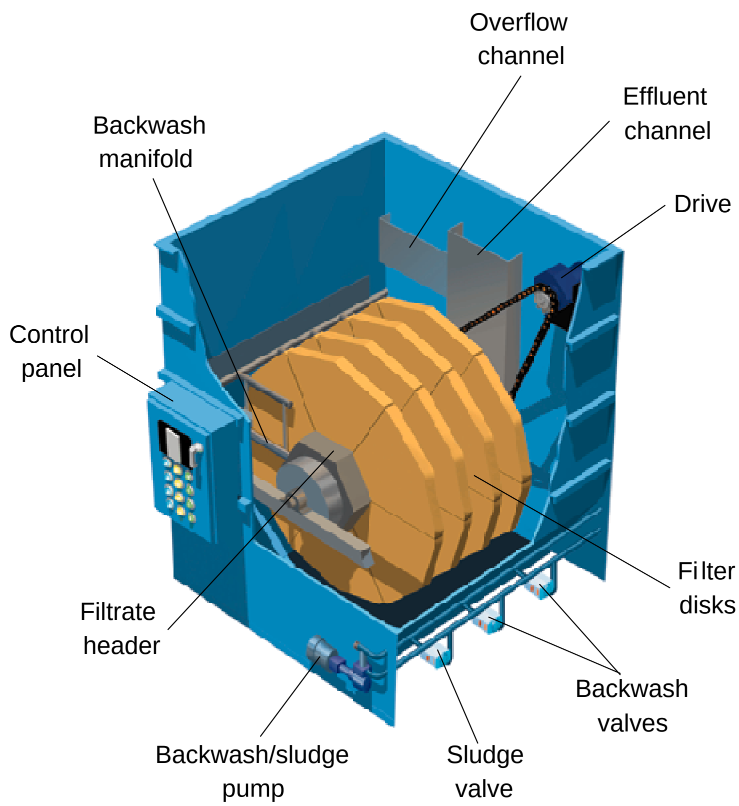

Figure 1. Aqua-Aerobic Systems, Inc. Cloth Media AquaDisk® Filter

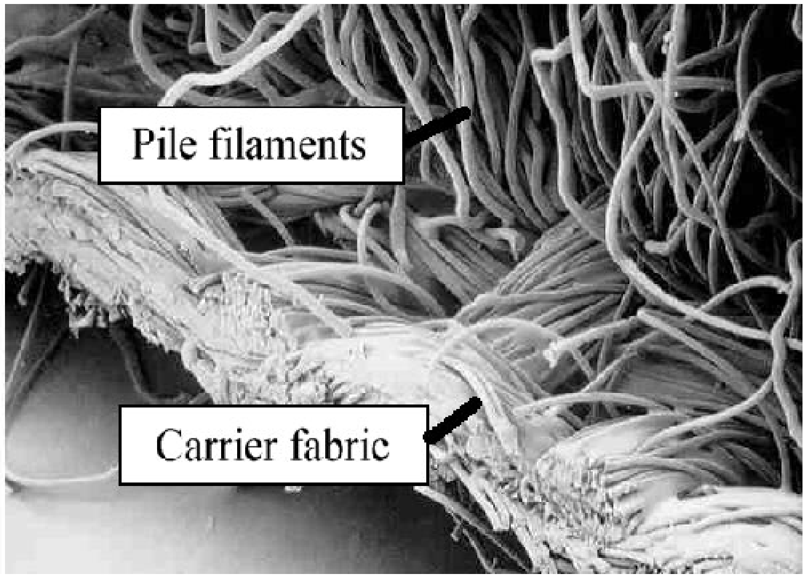

Figure 2. Microscopic View of Cloth Media

Cloth media filtration was selected in large part due to its established successful history in reuse applications in many other states (see Table 2).

Table 2. Sample of States Using Cloth Media for Reuse

State	Turbidity Limit (NTU)	TSS Limit (mg/l)
California	= 2	= 5
Florida	2.0 to 3.0	= 5
Georgia	= 3	= 5
Virginia	= 5	= 10

A total of three (3) 6-disk AquaDisk® Cloth Media Filters were selected, providing a total peak flow capacity of 9.4 million gallons per day. To equalize the batch discharges from the SBR system, a new 210,000 gallon post-equalization basin was installed ahead of the tertiary filters system. Finally, although the state of Iowa did not require effluent disinfection at the time and the cooling water feed would be chlorinated at IPL, future disinfection requirements for CLSD's NPDES permit are very likely inevitable in the coming years. In recognition of this, and to minimize the chlorine requirements at IPL, ultraviolet (UV) disinfection was selected to follow the filtration step. The ultraviolet disinfection system operates with automatic UV bulb intensity adjustment based on UV transmittance measurement. This operating strategy allows CLSD to minimize energy consumption by the UV system while maintaining superior levels of disinfection. This operating strategy is particularly optimized by the use of the AquaDisk® Cloth Media Filters before the disinfection process. As has been demonstrated in prior performance tests, the ability of the Cloth Media to maintain high quality TSS effluent with minimized effluent particle sizes substantially improves the performance and reliability of the UV disinfection system.[1]

An additional issue faced by Alliant Energy involved the disposal of the water from the cooling towers. 80% of the supply water to the cooling towers is evaporated in the process, leaving approximately 680 gallons per minute of evaporate water be disposed of. Due to the evaporation process, all constituents in the wastewater are concentrated, making the evaporate water high in certain contaminant levels, particularly Total Dissolved Solids, Turbidity and Chlorine. Chlorine is added to the reuse water at the IPL facility to prevent bio-growth within the cooling towers. Through the contract negotiations, it was agreed that IPL would send the reject water back to the CLSD treatment system. Additional monitoring equipment is required to continuously determine if the reject water received by CLSD is of sufficient quality to blend with final effluent sent to the plant outfall, or require additional treatment. Automatic sodium bisulfate addition for dechlorination is also incorporated into the reject water receiving system.

Final Contract Details

With the reuse criteria established and the tertiary treatment system requirements identified, final contract negotiations were undertaken in early 2003. The agreement was accepted by all parties and signed in July of 2003, and is in effect for twenty-five (25) years. As set forth in the agreement, the new tertiary treatment system would be purchased and owned by Alliant Energy. The tertiary treatment system would be located at the CLSD facility, with CLSD contracted to operate and maintain the equipment. The contract also governs the supply requirements for the reuse water, which essentially give IPL rights to the first 2,100 GPM of effluent from the tertiary treatment system. CLSD must monitor and report the cooling water supply quality, separately from their NPDES permitting, and is required to take the cooling tower reject water from IPL.

Treatment System Performance

The tertiary treatment system went online in January of 2004 and began supplying cooling water to IPL shortly thereafter. Following is a summary of key parameters for 2005.

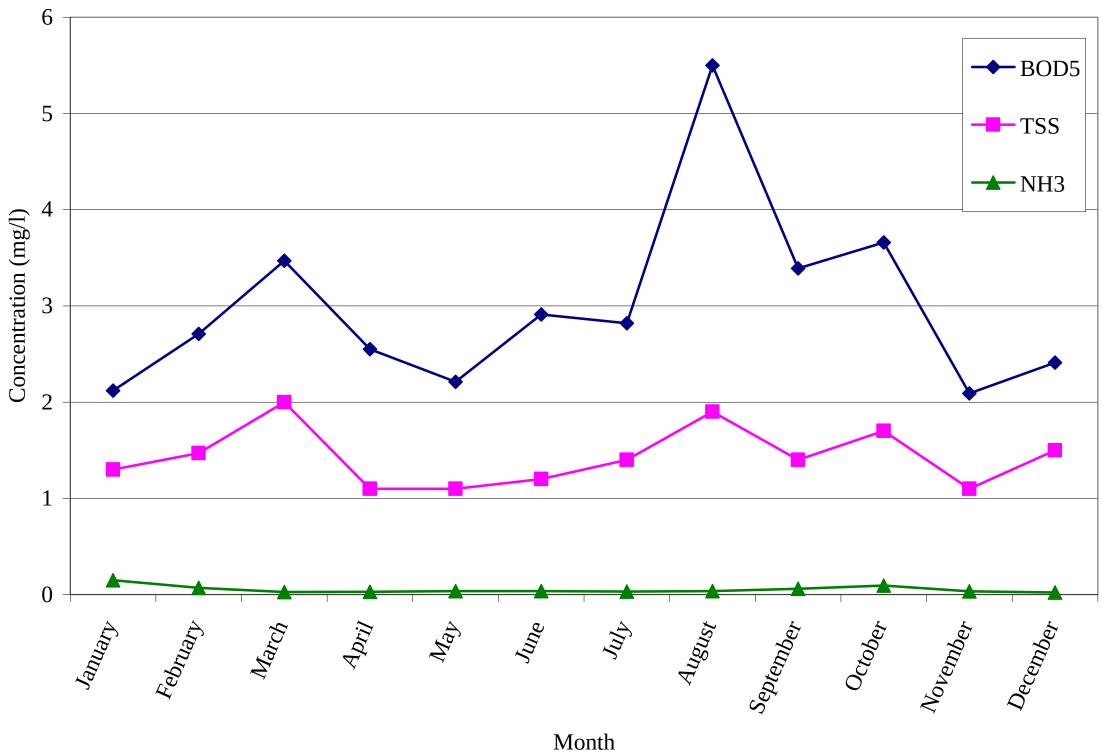

Figure 3. 2005 Cooling Water Supply Concentrations

Although many additional parameters are monitored and reported, such as Ca, Na, Mg, K, Fe, Zn, Cr, FOG, Chloride and Sulfate, the primary constituents controlled by the operation of the secondary SBR system and subsequent Cloth Media Filter system are shown in Figure 3. It is noted that, with one small exception in August, all parameters are well within the required reuse limitations set forth in the agreement. During August 2005, the plant was forced to take two (2) SBR tanks offline during the peak flow season to repair damage to the SBR structure. Once repaired, however, the tanks were easily brought back into service to provide the full treatment capabilities.

As previously noted, final effluent from CLSD is a blend of any tertiary effluent that is not sent to IPL and all cooling water return water from IPL. Following is a summary of the final effluent values at the CLSD outfall for 2005.

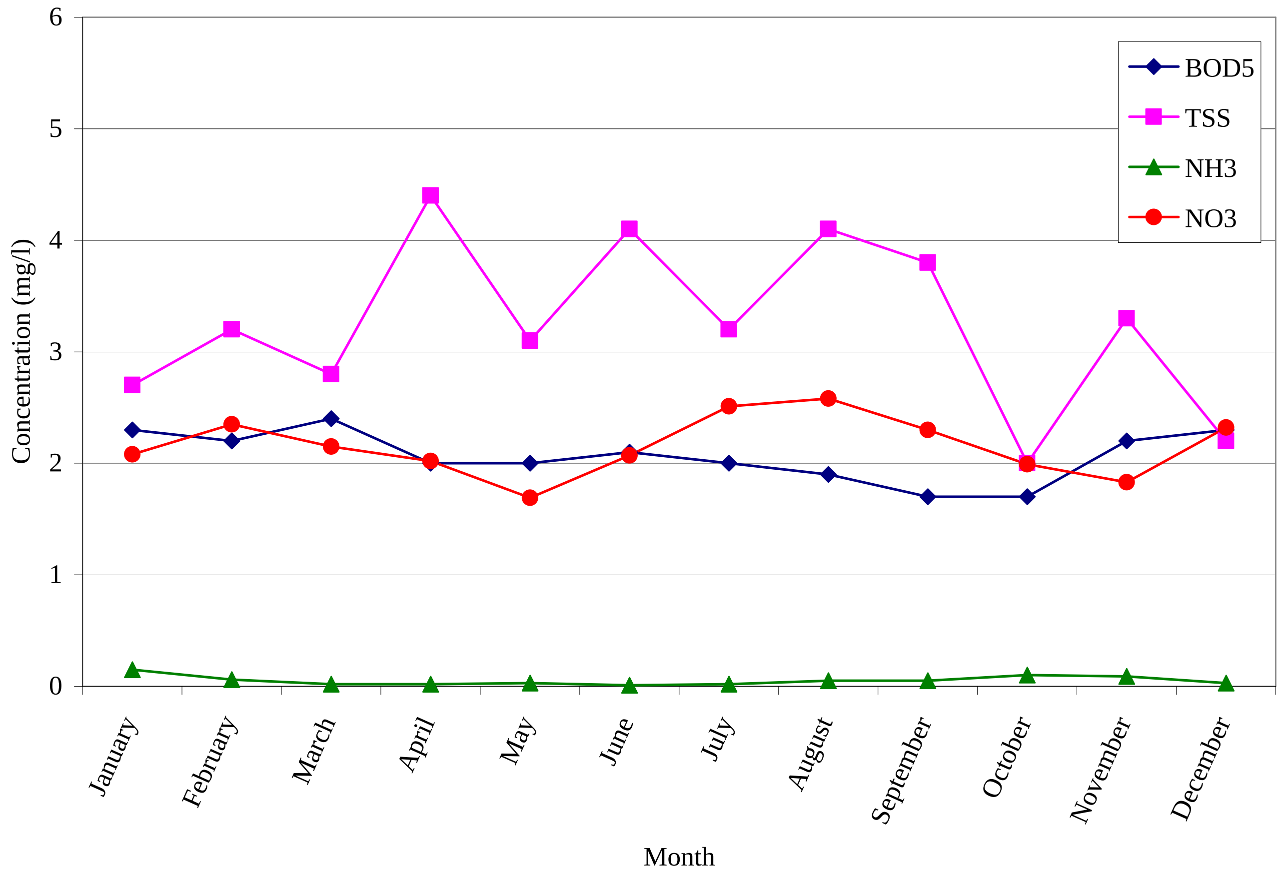

Figure 4. 2005 CLSD Final Effluent Concentrations

Final effluent values are well within the NPDES permitted values of 25 mg/l BOD_5, 30 mg/l TSS, and 2.1 mg/l NH_3-N. Even the effluent Nitrate (NO_3-N) is reduced to extremely low levels, though neither the reuse agreement nor the NPDES permit require it. This is directly attributable to the ability to vary the reactor environment between aerobic and anoxic condition in the SBR system at any time, while maintaining completely mixed conditions.

Challenges Faced

Although the treatment system has performed exceptionally well and supplied reuse quality water for over two (2) years to the IPL facility, there have been some unforeseen challenges faced along the way. The most obvious of these was noticed in 2005. The water contained within the Jordan Aquifer is generally high in dissolved Iron (Fe). As 60% of the total cooling water used is taken from the aquifer, and 80% of this is evaporated, Fe concentrations are further increased. With 6.5 miles of pipeline between CLSD and IPL, travel velocities within the cooling water return piping are at times very low. Under these conditions, a significant amount of Fe began to precipitate within the pipeline, leading to high TSS levels in the cooling water return when velocities within the pipe exceeded 3 ft/sec. While these levels were significant enough to potentially increase the final effluent TSS concentrations, routing the cooling water return back through the entire treatment process did not seem warranted. To address the issue, CLSD wisely decided to modify the piping and valving options for the cooling water return and the filter influent. The additional option of completely segregating one of the 6-disk filters to directly filter only the cooling water return was added, leaving the other two (2) filters to treat the equalized SBR effluent flow. By segregating the filters in this way, CLSD is able to avoid recycling of cooling water return through the SBR reactors and still remove the Fe related TSS. Although the two (2) remaining filters are now routinely loaded near their peak flow capacity, this operating strategy has proven very successful in allowing CLSD to meet all objectives.

Future for CLSD

The contract between CLSD and Alliant Energy's IPL natural gas facility extends until the year 2028. During that time, the reuse water volume available to IPL will only increase as the communities around Clear Lake continue to expand, ultimately reducing the strain on the Jordan Aquifer. CLSD is also currently considering annexing another area that includes 3,000 PE. Future NPDES permit limits on total Phosphorus and potentially total Nitrogen are also inevitable, and well within the foreseeable future. From the decision to upgrade the facility to flexible SBR technology, to the addition of the tertiary treatment system needed to provide reuse quality water to Alliant Energy's IPL facility, CLSD has placed itself in a position to effectively address all future challenges that may come its way.

References

1. Perry, John et al (2003) "The Use of Cloth Media Filtration Enhances UV Disinfection Through Particle Size Reduction", City of San Bernardino Municipal Water Dept. RIX Facility, San Bernardino, CA.