ABSTRACT

The City of Aledo is a growing community southwest of Fort Worth, Texas in eastern Parker County. The current population of 2,700 is expected to eclipse 13,000 when all existing City land and extraterritorial jurisdiction (ETJ) reach build out. Presently, the City owns and operates a conventional activated sludge package wastewater treatment plant (WWTP). This 0.35 MGD plant is operating at nearly 90% of its capacity and many of the processes are approaching their design life, needing replacement in the near future. Recently, the City applied for a revised discharge permit with an average daily discharge flow of 0.6 MGD and agreed to a phosphorus discharge limits, ultraviolet disinfection, and odor control facilities. The existing plant will not be able to meet these additional permit requirements. Therefore, modifications and a plant expansion are required.

In 2008, the City of Aledo retained Freese and Nichols, Inc. to assist the City in conducting study, design and construction assistance of the new wastewater treatment facilities to be online by the end of 2012. The goals of the project were:
- Provide treatment facilities capable of meeting current and anticipated TCEQ permit requirements;
- Master plan the existing site to be capable of expansion to meet City’s ultimate need of 1.8 MGD average day flow;
- Attempt to reuse as many of the current facilities as possible to minimize cost and maximize current infrastructure use; and
- Value engineer required infrastructure to be within the Texas Water Development Board’s approved SRF loan value.

Study, design and construction of the Aledo WWTP presented a set of the following unique challenges:
- The existing plant is sited on a small piece of land sandwiched between a bluff as high as 50-ft tall on one side and the 100-year flood plain that engulfs part of the plant site on the other side. Relocation of the WWTP to a new site is not feasible;
- The bluff-side of the plant has experienced significant erosion through the years and soil stabilization is necessary;
- The plant is surrounded by residential properties with luxury houses as close as 20 feet from the City’s property line;
- Existing facilities occupy all usable land needed for construction of new facilities;
- Most of the existing facilities are not compatible with the facilities required to meet design goals and would be difficult to salvage; and
- TCEQ permit requirements such as phosphorus removal, ultraviolet disinfection and odor control mandated investigation of new and advance treatment processes for implementation.

This paper presents innovative solutions developed and currently being implemented by the project team to address the unique set of challenges faced during this challenging project, including:
- Implementation of a soil-nail retaining wall to accomplish soil stabilization and to reclaim previously unusable land for new processes;
- Design of the 3-basin sequencing batch reactor system with chemical feed system and post equalization to meet stringent permit requirements;
- Implementation of Texas’s first installation of the microwave UV system;
- Design of containment and ozone odor treatment facilities to satisfy TCEQ-approved Nuisance Odor Prevention Report and implementation of various noise abatement measures to minimize visibility of the facility to the surrounding residential area;
- Addition of a maintenance and administration building, fine screening, cloth media filtration and plant water system, previously not part of the existing plant;
- Integration of multiple metering and monitoring instruments and supervisory control and data acquisition (SCADA) system for automatic operation and remote monitoring;
- Reuse of existing solids handling facilities in a new process; and
- Implementation of numerous landscaping, drainage, security and accessibility site improvements for current and future expansions.

KEY WORDS

Wastewater Treatment, BNR, Phosphorus Removal, Fine Screens, SBR, Cloth Media Filters, Microwave UV, Ozone Odor Control

BACKGROUND

The City of Aledo is a small community located just south of Interstate 20 on the east side of Parker County (Figure 1). Due to its close proximity to the major population center (City of Fort Worth), and its unique culture and renowned school system, the City of Aledo has experienced nearly 60% growth in the last decade. This growth trend is expected to continue in the near future. The current population of 2,700 is expected to eclipse 13,000 when all existing City land and extraterritorial jurisdiction (ETJ) reach build out.

In the last several decades, the City of Aledo has made a choice to move away from the individual septic systems to a centralized wastewater collection and treatment system. Currently, the City owns and operates a 0.35 MGD package wastewater treatment plant (Figure 2). At present, the average flows into the plant are approaching the design capacity of the existing facility. In order to continue to provide wastewater services to the growing population, the City must expand the existing facility.
In the Summer of 2008, the City of Aledo retained Freese and Nichols, Inc. (FNI), to assist the City in securing finances and performing preliminary design, final design and construction administration services associated with the expansion of the existing WWTP to provide wastewater services for the next 10 to 20 years, and to expand the plant in the future, to serve the City’s ultimate build-out population.
PROJECT CHALLENGES

Due to the age of the existing facility, the changes in the Texas Commission on Environmental Quality (TCEQ) discharge permit, the unique location of the facility and the vision of the City to make the plant expandable to serve the ultimate build-out population, this assignment is a noteworthy engineering challenge.

Facility Challenges

The existing wastewater treatment plant was originally constructed over 20 years ago and has since been modified and expanded several times to take on its present shape. The existing plant is a conventional activated sludge facility composed of above-grade, steel tanks. Current disinfection is accomplished with chlorine gas. No dechlorination is required as part of the existing permit. The solids from the final clarifiers are digested aerobically before they are dewatered using the belt filter press. For the existing wastewater treatment plant’s process flow diagram, reference Figure 3.

In order to expand their existing facility, the City of Aledo applied for a National Pollution Discharge Elimination System (NPDES) permit renewal with TCEQ in 2006. Following permit application review and public hearings, TCEQ issued a draft permit effective upon completion of improvements. In addition to increased flows, the new permit included requirements for phosphorus removal, odor control and ultraviolet disinfection. Table 1 summarizes major differences between the existing and the proposed TCEQ discharge permit for the Aledo WWTP.

Table 1 – Existing and Proposed Permit Major Differences Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Existing Permit</th>
<th>Proposed Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Day Flow (MGD)</td>
<td>0.35</td>
<td>0.6</td>
</tr>
<tr>
<td>Peak 2-Hr Flow (MGD)</td>
<td>1.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Phosphorus Limit (mg/L)</td>
<td>No Limit</td>
<td>1.0</td>
</tr>
<tr>
<td>Disinfection Method</td>
<td>Chlorine Gas</td>
<td>UV</td>
</tr>
<tr>
<td>Odor Control</td>
<td>Not Required</td>
<td>Required</td>
</tr>
</tbody>
</table>
Incorporating new TCEQ requirements into the existing process flow presented significant challenges. Additionally, due to the extended time of service, some of the existing facilities have experienced significant degradation. For example, the corrosion and structural deformation of aeration basins, shown in Figure 4, required replacement.

![Figure 4 – Severe Deflection of the Existing Carbon Steel Aeration Basin](image)

In order to meet the new permit requirements and allow the plant to be expanded in the future, almost all existing treatment facilities required replacement, but must stay in service until new facilities are operational. However, careful consideration of reusing some of the existing facilities was needed for financial reasons.

**Site Challenges**

The City of Aledo owns 4.5 acres of land on which the existing wastewater treatment plant is located. Currently, there are no viable options to relocate the plant or join a regional wastewater treatment system. Therefore, the existing site has to be utilized for the upcoming expansion as well as possible future expansions to handle the City’s ultimate flows.
As indicated in Figure 5, the existing site presented the following challenges for the upcoming plant expansion:

- Approximately 30% of the existing usable land is within the 100 year floodplain. Design of the new facilities would require appropriate hydraulic consideration to ensure that the plant is operational during the flood event. Additionally, coordination with the Floodplain Administrator would be required to allow construction of any facilities within the floodplain.

- An additional 30% of the City-owned land contains challenging elevation changes of steep side slope. At some places, the elevation difference is nearly 50 feet and the side slope is in excess of 45 degrees. Construction within these areas without significant site work would not be feasible.

- The area of steep side slope has experienced significant erosion over the years and poses a significant threat to the luxury residences (Figure 6) at the top of the hill on the south side of the plant property. It is the City’s priority to stabilize the side slope and minimize any further erosion to this area.

- The existing site is not large enough to provide a 150 foot buffer between treatment facilities and the site property line required by TCEQ. Obtaining an easement to the south is not feasible, as most of the land is already developed. In addition to obtaining a variance on the buffer zone requirements from TCEQ, the design will need to take into consideration aesthetics, odor emissions and noise abatement to assure a “good neighbor” policy.

- Though the existing site presents significant challenges and space constraints for the next expansion, it is the City’s desire to master plan the site to allow up to two more future expansions, with the ultimate ability to triple the size of the plant to 1.8 MGD (average day flow).
PROJECT SOLUTIONS

Numerous innovative solutions were developed to address the unique challenges of this project. The selection of process and equipment had to be closely coordinated with the site constraints and site work solutions.

Facility Solutions

In order to address new TCEQ requirements and to efficiently utilize available space and existing facilities, a new process flow diagram was developed for the Aledo WWTP (Figure 7). Because the majority of the existing facilities were in need of replacement, it was decided to decommission and demolish all existing liquid stream process facilities and build new facilities that would allow for easy expansion and to meet the new permit requirements. To complicate matters, all of the existing facilities to be demolished would have to stay in service throughout the construction period and until the new facilities are operational.

The solids handling facilities, however, were still in adequate condition. Through process calculations, it was determined that the sizes of the existing aerobic digesters and the belt filter press were adequate to handle expanded flows of the new process. Therefore, it was decided that the existing belt filter press building would remain as is and the existing aerobic digesters would be converted to the aerobic sludge holding tanks for continued future use.

Other new key components of the WWTP expansion consisted of: odor enclosure and odor scrubbing system for the screens, lift station, and the solids storage areas; new 480V, 3 phase electrical feed and backup generator designed to handle full capacity of the plant; multiple flow and process monitoring instruments controlled by Supervisory Control and Data Acquisition (SCADA) system; plant water system for the belt press wash water and plant hydrant stations; 1,200 square feet multi-use office/maintenance building; and a potable water system for the new building and fire system use. Currently, there is no potable water or fire system service on site.
All major process components are presented in more detail in the following sections.

**Screening Facility**

To protect the downstream lift station and process equipment from large solids, a 1/4 inch fine screen was proposed for the Aledo WWTP. A microstrainer-type screen (Figure 8) was selected because it is a simple piece of equipment that is compact, integrated with conveyor and washer/compactor, and is fully contained with a screenings bagging system to contain odors.
The screen was designed with a pivot system for equipment removal from the channel and ease of maintenance. An overflow bypass channel with a 1-1/2 inch manual bar rack was also provided in case of emergencies and maintenance events. Any consequent expansions would simply require parallel channel construction with similar microstrainer equipment.

**Lift Station**

Because the plant site is so low, gravity flow through the plant is not possible and the incoming wastewater must be lifted to the treatment facilities. The existing duplex lift station in a circular well is inadequate in volume and space to accommodate expansion flow. The proposed lift station has the submersible pump design, sized for 4 bays. The base elbows and discharge piping would be sized to accommodate the largest pump anticipated to be housed in the pump station. This will allow the wet well to be built to handle ultimate flows without the need for structural expansion or the need to shut down the pump station (Figure 9).

**Secondary Treatment**

Secondary treatment is the heart of any wastewater treatment plant and typically occupies more space than any other process. It is critical to select the secondary process that will be capable of meeting the discharge permit requirements as well as be space-efficient.

For the Aledo WWTP expansion, a 3-cell sequencing batch reactor (SBR) system was selected for secondary treatment. “The SBR sequentially selects multiple, individual processes in a single basin, based upon an activated sludge fill and draw wastewater treatment process. Combined with the latest in process and control technology … SBR incorporates equalization, aeration, clarification steps, enabling the treatment of wastewaters exhibiting a wide variation in composition, concentration and flow patterns.”  

1 Ashbrook Simon-Hartley SBR Plus website (http://www.as-h.com/uk/en-gb/sbrplus.aspx)
Major components of the Aledo SBR system include:

- Fine bubble aeration diffuser grid
- 4 positive displacement (PD), variable frequency drive (VFD) blowers – one blower dedicated to each basin with a redundant, swing blower
- 3 submersible waste activated sludge (WAS) pumps (also designed for volume transfer between the basins, and basin draining)
- 3 submersible mixers
- 3 floating decanter assemblies
- Duplex, diaphragm chemical metering pump and storage system for coagulant injection
- Post-secondary equalization basin
- Instrumentation and control system designed to automatically control the SBR process

Some of the Ashbrook Simon-Hartley SBR components are shown in an example installation in Figure 11.

The SBR system was chosen for Aledo WWTP expansion because it is a space-effective process that is capable of nutrient removal and allows for great operational flexibility and adjustments based on incoming wastewater quality and discharge requirements. Additionally, rectangular configuration of the system allows for a more efficient space utilization and future expansion capabilities.
Filtration

Though it is anticipated that SBR effluent will meet the discharge parameters without tertiary filtration, two packaged cloth-media filters (one duty and one stand-by) were designed to provide additional factor of safety. Filtering secondary effluent will assure maximum downstream ultraviolet disinfection system efficiency as well as minimize discharge phosphorus concentration that is often-times trapped in the secondary effluent suspended solids.

Cloth media filters were selected for Aledo WWTP expansion. Cloth media filtration removes solids at the surface of the fabric by physical straining. The cloth is mounted on disks or frames, and water flows from the outside of the filter to the inside of the filter. Cloth media filters achieve similar filtration to granular media filters; however, the surface area per volume is greatly increased as the cloth filters can be arranged such that multiple sides are exposed to the water, whereas the granular media filters are flat and have only a single surface area available for filtration. Additionally, cloth media filters were selected for the Aledo WWTP expansion because they require less backwash water, less driving force (typically 12-18” of water column) and recover faster when filters are overloaded with high total suspended solids concentrations. The filters can also be installed in concrete, fiberglass, stainless steel or carbon steel tanks, limiting in-ground tankage and providing expansion flexibility. An example of a fixed disk cloth media filtration system with automatic backwash is shown in Figure 12.
Disinfection

Per permit requirements of the TCEQ, the Aledo WWTP’s new disinfection system had to be ultraviolet (UV) disinfection. Ultraviolet radiation is a physical disinfection process that does not alter chemical composition of the effluent and the only requirement for operation is electricity. Mercury vapor-filled lamps are excited by electricity to emit ultraviolet radiation. Ultraviolet radiation attacks pathogens by rupturing the microorganisms’ cell walls at high doses or altering microorganisms’ DNA bonds at low doses and preventing pathogen from reproduction, thus deactivating them. For the Aledo WWTP expansion, Severn Trent’s MicroDynamics microwave ultraviolet disinfection system was chosen. Though this technology has been employed in Europe for a decade, it is only now making its appearances in the United States. Aledo will be the first Texas installation of microwave UV.

Microwave UV is based on a different electricity delivery method than conventional, electrode lamp UV systems. Rather than current being passed through an electrode to a filament, as in traditional electrode lamps, microwave energy is passed through an electrodeless lamp to excite the gas inside. This creates the same 254 nm UVc output, and thus the same UV dose, as the traditional UV system. Eliminating the filament allows the lamp to be cycled on and off without impacting the life of the bulb. This is particularly beneficial in an SBR system, where the lamps may only need to be on 50% of the time. The electrodeless lamps also offer short startup time, which is again ideal with an SBR system because the lamps can be turned on shortly before the decant phase and be to full intensity quickly. This makes power consumption much more efficient, with the power delivery to the lamps always accomplishing disinfection rather than just lamp warm up. Other benefits of the microwave UV system is added safety and extended lamp life. Example Severn Trent MicroDynamics UV system is shown in Figure 13.
Odor Control

Though not part of the liquid or solid process stream, odor control is an important component of the Aledo WWTP expansion. It is mandated by the TCEQ and would allow the City to minimize odor impacts of the wastewater treatment on the surrounding properties. The main sources of odors at the Aledo WWTP are the screening structure, lift station and dewatered solids storage area. These areas and facilities were designed with covers and enclosures to contain the odors. Additionally, foul air ventilation and scrubber system was designed to continuously withdraw foul air and treat it before discharging it back into the atmosphere. For the Aledo WWTP expansion, an ozone odor treatment system was selected.

Ozone treatment of foul air is an emerging technology. Ozone can be generated by passing air through an electric field. No chemicals are required for ozone production; only air and an electricity supply. Once ozone is produced, it is a highly reactive compound, and can oxidize the majority of odorous compounds produced at a WWTP, including hydrogen sulfide, organics, and nitrogenous compounds. A carbon filter at the end of the reaction chamber is provided to remove any remaining compounds, including unreacted ozone. A schematic of the operation of an ozone based odor control system is shown in Figure 14.
The ozone treatment process was selected for the Aledo WWTP expansion because it requires a small footprint, no water or chemical demand and low maintenance as compared to conventional biological or chemical scrubber units.

**Site Solutions**

One of the most critical objectives in solving site challenges was to stabilize the south slope of the property. This was critical to minimize further erosion of soils on the plant site that could also cause possible damage to residences located on the top of the hill. Slope stabilization requirement also presented an opportunity to reclaim some land on the City’s property that was previously undevelopable due to severe elevation changes and continuous erosion.

Sloped or angled means of soil retention (such as gabion walls) could be effective, but were not considered because they did not provide the most efficient means of site reclamation. Internally stabilized, vertical, soil nail retention wall was the selected method for the Aledo WWTP expansion. The stability of the wall is created by the frictional resistance developed in the reinforcing nails. The installation process is completed in 5 to 6 foot excavation lifts. After lift excavation, the nail holes are bored into the face of the excavated portion of the soil mass. Next, the steel nails are inserted into the bore hole and the hole is backfilled with pressurized grout. A strip drain is applied to the face of the excavation in between bore holes and a temporary shotcrete face is then applied. The nails are then tied back into the facing elements of the wall through the use of a bearing plate and stud heads. Lastly, a permanent cast-in-place or pre-cast reinforced concrete facing is applied. See Figure 15 for a typical installation sequence of the soil nail lift.

![Figure 15 – Soil Nail Retaining Wall Installation Sequence](image)
The soil nail technique of constructing the retaining wall was chosen for the Aledo WWTP expansion because it was a minimally disruptive, top-to-bottom means of erecting a wall that was not limited in height. Though a subsurface easement had to be obtained in one location, no permanent or temporary construction surface easement was required for installation of the wall, even when the private property line was within inches of the finished wall. Erection of the retaining wall consisted of nearly 400 linear feet of wall (as tall as 50 feet at the highest point) and over 800 soil nails, varying from 35 feet to 50 feet in length (see Figure 16).

The location of the wall was carefully selected to best optimize soil stability, cost effectiveness of the wall and the reclaimed land area. The final location of the wall, as shown in Figure 17, provided for much improved soil stability system on the hill and recovered approximately 25,000 square feet of usable expansion site that is located out of the flood plain.
All the proposed and future facilities, as described in previous sections, were carefully sited to provide the best access for operation and maintenance, as well as to allow for ease of future expansions. The plant was designed to discharge during the 100 year flood and the facilities that were sited within the flood plain received authorization from the active flood plain administrator to be constructed. See Figure 18 for proposed site layout.
Because of the limitations of the site, several special provisions had to be taken into account during the design of the Aledo WWTP expansion.

As required by TCEQ, a 150 foot buffer between treatment structures and property line was not feasible at the existing site. To account for this condition, TCEQ required an approval of the Nuisance Odor Prevention Report that stipulated sources and amounts of odors originated at the WWTP as well as proposed strategies to minimize nuisance odor events. The report was submitted and conditionally approved by TCEQ and the odor control system, described previously, is pending implementation.

In order to minimize equipment noise originating from the plant, all pumps and mixers were designed to be of a submersible type. Positive displacement blowers for the SBR system were specified to be provided with a sound attenuation system capable of dampening operating noise to 75 dB(A), measured in free field 3 feet from unit. This is the equivalent of a vacuum cleaner or a washing machine.

Finally, landscaping was designed to provide a visual barrier between the southern edges of the WWTP, where the residences are located nearest. As part of the designed landscaping improvements, 29 Eastern Red Cedar evergreen trees along with turf reinforcement mats are planned at the top of the soil retaining wall. See Figure 19 for a typical section.

![Diagram](Image)

**Figure 19 –Evergreen Tree Planting Detail**

All aspects of the project were funded by the Texas Water Development Board (TWDB). The construction of the Aledo WWTP expansion was bid on January 27, 2011 for $6,115,000 (approximately $700,000 under budget) and notice to proceed was issued to Gracon Construction Inc., on May 2, 2011. Currently, the construction is nearing the half-way point and is scheduled for final completion on December 15, 2012.