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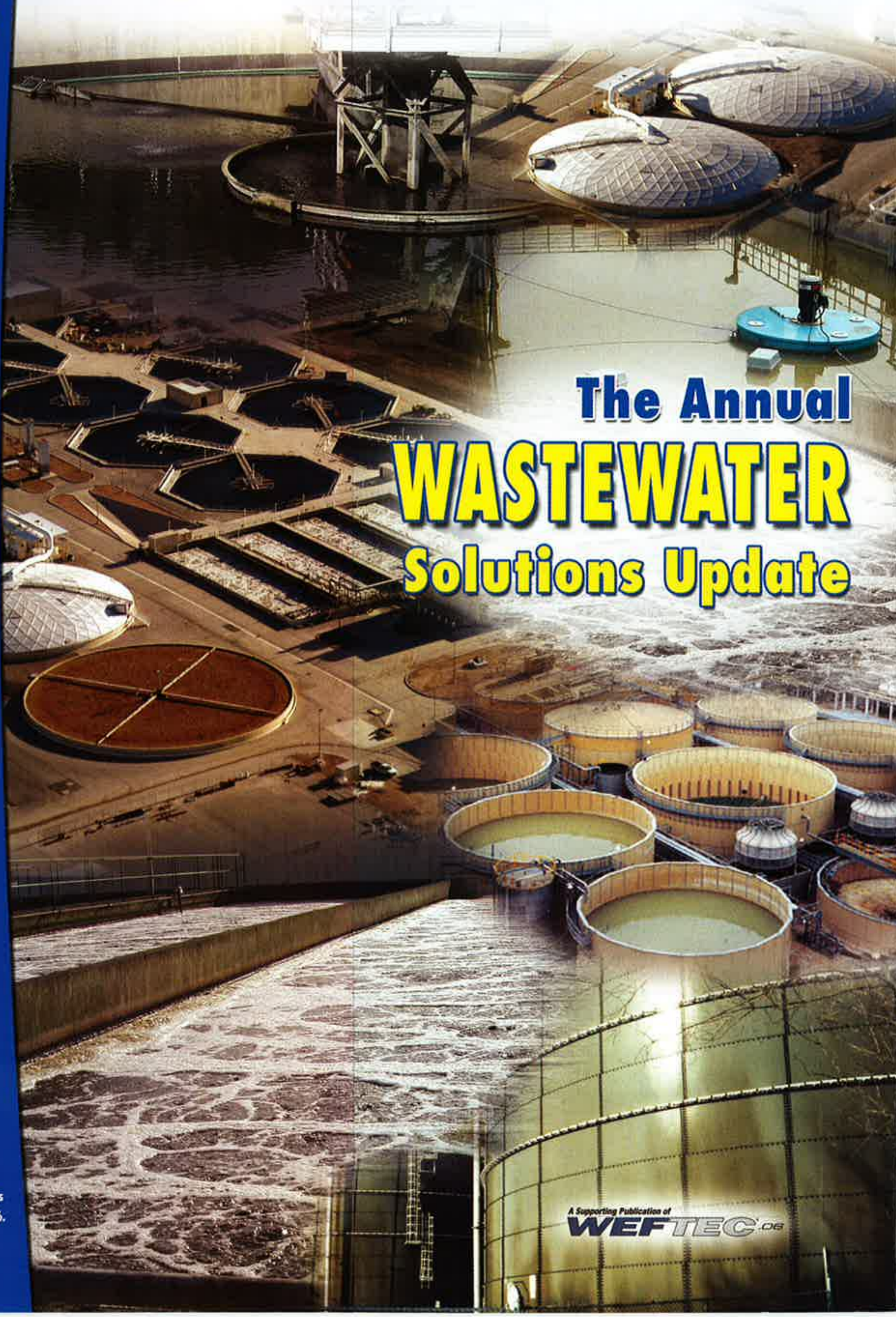

The Annual WASTEWATER Solutions Update

A Supporting Publication of WEFTEC.06

Get More For Less: Cost-Effective Solutions For Lagoon Conversions

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As federal and state regulatory agencies continue enforcing more stringent nutrient removal policies and increasing the plant capacity of wastewater systems becomes essential, the cost of maintaining a productive wastewater system skyrockets. While pricey, meeting the new goals set by the municipalities and industries is an unavoidable necessity. But, there is an alternative to starting from scratch. "Lagoon Conversions," better known as lagoon upgrades, are the cost-effective means to modifying existing wastewater systems in order to accomplish the growing demands on the wastewater systems.

Tackling new regulations dealing with lower biological oxygen demand (BOD), total suspended solids (TSS), and ammonia levels is incredibly expensive. Managing those regulations as well biological nutrient removal (BNR) while controlling the cost of new designs, plant modifications, and new plant construction is incredibly challenging. Historically, when faced with these stringent effluent limits and/or increases in plant influent flows or loadings, engineers have redesigned an entirely new plant to ensure compliance with the effluent requirements.

Fortunately, reengineering a wholly new plant is not the only solution. Instead, upgrading existing lagoon systems by preserving and using as much of the existing system and equipment as possible is a feasible alternative.

Lagoons are intentionally designed to be easy to operate and maintain and to produce effluent capable of achieving conventional secondary treatment. However, as environmental standards become more stringent and populations grow, communities must increase the capacity and efficiency of their treatment facilities.

Upgrading Lagoons To Improve Treatment Efficiency And Increase Treatment Capability

The following case studies demonstrate examples of the range of possibilities for lagoon conversions, including an energy savings equipment renovation, an activated sludge upgrade, and an in-lagoon fixed-film media system conversion.

Astoria, OR — Updating Technology To Save Electricity Costs

In 2002, the city of Astoria, OR wanted to use a grant from the Energy Trust of Oregon, Inc. to upgrade the aerators in its existing lagoons. The wastewater lagoons and aerators were 25 years old at the time of the upgrade. The existing equipment consisted of 10 40-HP surface splasher-type mechanical aerators. The 40-HP motors operated continuously, using approximately 920,000 kilowatt (kW) hours of electricity each year.

Through the assistance from the Energy Trust of Oregon, the city conducted an energy efficiency study in conjunction with Pacific Power and identified an energy-saving strategy for the mechanical aeration equipment. This strategy consisted of investment in new modern and efficient technology that, once implemented, would result in a reduction in electrical consumption at the plant.

Flow at Astoria averaged 3.0 MGD. The influent loading coming into the plant averaged 125 mg/l BOD5 and 25 mg/l ammonia in the summer. Effluent goals were 20 mg/l BOD5 and 1 mg/l ammonia. The plant layout consisted of three earthen lagoons in series — a primary, secondary, and polishing lagoon. The existing aerators were installed in the primary and secondary lagoons. The primary lagoon had an area of 6.8 acres with a depth of 9 feet, and the secondary lagoon had an area of 5.8 acres, also with a depth of 9 feet.

The city decided to add new float-mounted process aerator/mixers, which combine powerful propeller-driven mixing with regenerative blower-fed air injection below the water surface. The aerator/mixers greatly increase dissolved oxygen content throughout the depth of the basin and minimize water cooling during the colder months of the year that can negatively impact the process kinetics. These units provided a substantial increase in treatment efficiency compared with the original splasher-type aerators that provide aeration only at the surface of the water and produce only localized mixing. The process aerator/mixers are dual-function units that allow for the air to be turned on or off independent of the mixing.

The facility added five 20-HP process aerators to the first lagoon and five 15-HP process aerators to the second lagoon. The old equipment was phased out from the lagoons during installation.

The new aeration equipment in both the primary and secondary lagoons was sized for a facultative mix. In conjunction with the new Aire-O_2 Triton process aerators, the equipment supplier, Aeration Industries International, Inc., also developed a complete controls package to regulate the operation of the process aerators. Dissolved oxygen (DO) meters were installed in the lagoons to continuously monitor the DO concentration at specific points in the basin. A controls strategy was developed to automatically turn the blowers on the aerators on and off when DO concentrations reached specified values. In this manner, mixing was maintained in the basin while conserving energy by shutting down the blowers.

Implementation of the new equipment and the controls package resulted in a savings of about 547,000 kW per year, which is nearly a 60% decrease in power consumption. This equates to nearly $23,000 in annual energy savings at Astoria's wastewater treatment facility. Furthermore, dissolved oxygen levels in the lagoons have increased as a result of the new equipment, therefore improving the overall process performance and quality of the effluent.

Fabrica de Papel, Mexico — Upgrading An Industrial Lagoon To Activated Sludge

Fabrica de Papel is a paper manufacturer located in Mexico. The wastewater treatment process at the plant consisted of a 121-foot-by-335-foot lagoon divided into three sections. The influent entered on the east side of the basin into aeration cell #1 with a hydraulic volume of 21,237 gallons. A total of six 10-HP aspirator aerators were installed in this cell. Flow progressed under a baffle wall to aeration cell #2 with a hydraulic volume of 12,754 gallons. A total of three 10-HP aspirator aerators were installed in this cell. Finally, flow moved into a polishing cell with a hydraulic volume of 22,225 gallons. Two 5-HP aspirator aerators were installed in this cell. The effluent was then disinfected with chlorine in a chlorine contact tank (CCT) prior to discharge.

Influent flow to the wastewater plant was 555 gpm or 800,000 gpd. Influent quality can be summarized as follows:

- BOD = 500 mg/l
- COD = 1,100 mg/l
- TSS = 450 mg/l
- Temp = 30 to 40 degrees C

The effluent goal for the plant discharge was BOD <= 60 mg/l and COD <= 200 mg/l. With the level of loading coming into the treatment plant, there was not enough hydraulic retention time or oxygen and mixing to properly treat the BOD in the existing lagoon design to meet the effluent goals.

To address this deficiency, the treatment plant's basic lagoon system was upgraded to an activated sludge process. .The new lagoon upgrade was capable of handling flows up to 1,000 gpm. The area to the west of the existing treatment lagoon contained another earthen lagoon that was not in use. The plant decided to segregate about 40% of this earthen lagoon for construction of a secondary clarifier and an aerobic digester. The plant installed a 66-foot diameter secondary clarifier to reduce the suspended solids levels after the aeration cells and to allow for solids recycle. An aerobic digester was added in the area available between the lagoon and the clarifier to receive the excess settled sludge from the clarifier and reduce the waste solids' volume through further aerobic digestion. Clarifier influent was piped from the polishing cell. Clarifier effluent was piped to the chlorine contact chamber for disinfection prior to discharge. A sump was installed next to the clarifier along with two 500-gpm submersible pumps for the clarifier blowdown to remove the thickened sludge and return it either to aeration cell #1 or to the aerobic digester. Digested solids were periodically pumped out of the aerobic digester and dewatered by means of a sludge press.

The aeration equipment was rearranged and supplemented with new Aire-O_2 Triton process aerator/mixers and Aire-O_2 Turbo surface aerators to increase the mixing and oxygen transfer efficiency in the lagoon. The new aerator layout provided for a tapered mix/tapered air design providing about 2/3 the HP/volume in aeration cell #2 and the polishing cell vs. aeration cell #1. Also, the three existing 10-HP Aire-O_2 aspirator aerators in aeration cell #2 were moved to the aerobic digester.

Lagoons typically take up large amounts of land area. Depending on the layout of the lagoon and the process restrictions, this affords many opportunities for berming off sections of the lagoon to install activated sludge processes within the limits of the existing plant as was done at Fabrica de Papel.

In-Lagoon Nitrification Using Fixed-Film Media

Ammonia limits for the discharge of wastewater are becoming more stringent in many parts of the United States. Many lagoons achieve full or near full nitrification during the warmer months of the year. While nitrification processes in lagoon systems are understood fairly well, achieving full nitrification throughout the year is often difficult in lagoons due to low basin temperatures in the winter months and seasonal fluctuations in flow rates.

There are a variety of valid process modifications for removing ammonia that have been developed for lagoon treatment systems over the past 20 years, including adding lagoon storage volume, converting to SBR operation, and conversion to activated sludge technology. All of these solutions, however, are often prohibitively expensive to implement. One of the most promising recent modifications involves the installation of biomass carrier elements directly in the existing lagoon. These carrier elements can take a variety of forms, from plastic polyethylene wheels or saddles to polypropylene rope or mesh to suspended polyethylene or textile sheets. The carrier elements all have several things in common: They are nonbiodegradable, they are nontoxic, and they have a high effective surface area that facilitates the establishment and growth of nitrifiers, and often denitrifiers, on the surface of the media.

Of particular applicability to existing lagoons is the new Aire-O_2 Bio-ffilm fixed-film media process, offered by Aeration Industries International, Inc., involving installation of engineered suspended geotextile sheets. The sheets are free-floating, using buoyant floatation collars, and hang vertically in the water column. They can be installed easily with no special construction and no plant downtime. Arrays of the sheets of media are paired with Triton process aerators or aspirator aerators to create treatment modules, which are sized based on the treatment requirements. The aerators are sized and oriented relative to the media arrangement to provide the proper amounts of mixing and aeration for solids suspension, nutrient transfer, and oxygen diffusion. The aerators also maximize treatment kinetics by maintaining higher basin temperatures in cold weather.

In fixed-film processes, biomass builds up on the media with the surface layer being aerobic and consisting largely of nitrifiers. Given the right carrier element structure, the biomass can reach a thickness where the deeper section of the biomass is anaerobic, thereby leading to the growth of denitrifiers and providing the added benefit of simultaneous nitrification/denitrification. In the case of the Bio-ffilm process, as the biomass grows over time, turbulence in the basin due to aeration and mixing produced by the aerators causes the media to naturally move and flex so it routinely sheds the excess biomass, thereby continuously renewing the biomass. The sloughed biomass easily settles out and is further digested in the process.

Most nitrifiers and denitrifiers are not free-swimming organisms, but grow and multiply through attached growth mechanisms. Having a dense population of these microorganisms facilitated by the Bio-ffilm media is an efficient method for breaking down ammonia and nitrates and is an effective method for cold weather nitrification. Studies have demonstrated nearly full nitrification down to basin temperatures of 2 to 3 degrees Celsius.

A dense community of these microorganisms makes them more resistant to shock loadings and temperature extremes and allows for quick recovery of the biomass in extreme circumstances. Moreover, by increasing the biological concentration (mass or M) in a lagoon using the fixed film for a given loading (food or F), the F/M ratios are lowered, providing for a more stable system, allowing for the possibility of applying higher loadings to the process, and preventing biological process washouts due to seasonal hydraulic swings.

Lagoons can be divided into discrete cells using floating baffle walls to further optimize process treatment, if required. Typically, this involves segregating the BOD removal, nitrification, and settling processes. In-lagoon fixed-film media processes are ideal for existing lagoon systems, both industrial and municipal, where the facility wants to maintain the simplicity of operation of the lagoon treatment system but needs to improve the treatment efficiency of the process.

Conclusion

Lagoon conversions will be of major importance in the future because of the large number of lagoon systems throughout the United States, the increasing concerns about environmental pollution, and the population growth. As regulations become stricter and funding remains limited, using and upgrading existing lagoon processes will be an attractive and easy solution to a complex problem.

About The Author

Shawn Brown is the systems product manager at Aeration Industries International, Inc. He has worked as an engineer in the OEM sector of the water and wastewater industry for 12 years and holds a B.S. in Chemical Engineering from Virginia Tech.