



In 2014 the Stickney WRP had an average flow of 728 million gal per day

Recovering Resources

By Allison Fore

Illinois plant employs enhanced biological phosphorus removal & recovery

Phosphorus is a valuable and non-renewable resource that is critical to maintaining and expanding agricultural production at the levels needed to sustain the world's growing population, and the Metropolitan Water Reclamation District of Greater Chicago (MWRD) is working to enhance its removal and recovery at the Stickney Water Reclamation Plant (WRP) in Cicero, Ill.

The Illinois Environmental Protection Agency (IEPA) recently issued a renewed National Pollutant Discharge Elimination System (NPDES) permit for the Stickney WRP with an effluent limit for total phosphorus of 1 mg/L as a monthly average starting in 2019. This permit recognizes the MWRD's phosphorus recovery initiative, and the Stickney WRP is working to meet the target through a unique enhanced biological phosphorus removal (EBPR) process that has been undergoing optimization since 2011. Further improvements in phosphorus effluent quality are expected once a new Ostara phosphorus recovery facility is constructed by late 2015.

Treatment Process

The Stickney WRP was designed as a single-stage nitrification activated sludge plant that treats domestic and industrial sewage from mostly combined sewer systems. In 2014 it had an average flow of 728 million gal per day (mgd) and maximum daily flow of 1,406 mgd. In order to achieve nitrification and EBPR in the same activated sludge process, the current aeration tank operations were modified using existing infrastructure, and a unique anoxic-anaerobic-aerobic (AAnO) process was developed. This process involved converting the long-open return-activated sludge (RAS), mixing and influent channels in the secondary system to an anoxic zone by minimizing the air input into these channels. By doing this, the nitrate in the RAS, an artifact of nitrification and inhibitor to EBPR in the anaerobic zone, can be removed by denitrifying microorganisms in the activated sludge. This denitrification may result in a 15%

or more reduction in total nitrogen in the Stickney WRP effluent. At the beginning of the aeration tank itself, the air input in a small segment was minimized to create an anaerobic zone to promote the enrichment of phosphate-accumulating organisms (PAOs), which thrive in an anaerobic and aerobic alternating environment. In the subsequent aerobic zone, luxury phosphorus uptake by the PAOs, additional biodegradable organic removal by aerobic and facultative heterotrophs, and ammonia removal by nitrifiers are achieved.

Features of this site-specific EBPR process include:

- Use of open channels in addition to the aeration tankage;
- Use of the air distribution system rather than the mechanical mixers normally used to establish anoxic and anaerobic zones;
- Lack of the internal recycles often found in biological nutrient removal systems; and
- Lack of a physical separation between the anaerobic and aerobic zones in the battery tanks due to the plug flow conditions that exist.

However, these also are limitations in the ability to maintain the stability of the EBPR process. Further limitations include:

- Inconsistent readily biodegradable organics needed for both denitrification and biological phosphorus removal;
- High nitrate in the RAS, resulting in more incoming readily biodegradable organics being used for denitrification rather than biological phosphorus removal;
- A high-effluent dissolved oxygen (DO) NPDES permit limit, resulting in high DO concentrations to be returned to the anoxic zone via RAS;
- Use of the airlifts to return the RAS, limiting control over the RAS rate and making it difficult to achieve anoxic conditions in the select channels; and
- High phosphorus in the recycle streams at the plant, which sometimes can overload the treatment capacity of the process.

Overcoming Limitations

To combat some of these limitations, MWRD has developed strategies, including:

- Utilizing fewer primary tanks to increase the biodegradable organic load to the secondary batteries;
- Increasing the solids retention time in the primary tanks to encourage in-tank fermentation and increase the biodegradable organics sent to the EBPR process;
- Converting some of the new sludge gravity concentration tanks to primary sludge fermentors, which will increase the biodegradable organics sent to the EBPR process;
- Increasing the sludge blanket within the secondary clarifiers to return thicker RAS to the process, thus minimizing the nitrate loading;
- Installing baffles between the anaerobic and aerobic zones to increase solids deposition and allow for mixed liquor inline fermentation to occur for additional biodegradable organics; and
- Installing Waste Activated Sludge Stripping to Remove Internal Phosphorous (WASSTRIP) and Ostara Pearl reactors to recover the captured phosphorous from the EBPR process, thereby reducing the amount of phosphorous returned via the recycle streams.

The WASSTRIP and Pearl processes also will help the MWRD achieve its goal of resource recovery. The WASSTRIP process is the engineered phosphorous release from the waste-activated sludge (WAS) enriched in phosphorous from the enhanced biological removal process. Old sludge gravity concentration tanks at the Stickney WRP are being repurposed for this process. In select tanks, WAS



will be thickened, and primary sludge will be fermented to produce biodegradable organics. The thickened WAS and fermentate will be combined in the remaining tanks to encourage phosphorous release in the WASSTRIP process. Additionally, the anaerobic digester draw at the plant is centrifuged, and the centrate, which is rich in phosphorous, normally is recycled to the headworks. Here, both the WASSTRIP effluent and centrate will be treated by Pearl reactors for phosphorous recovery. Modeling results suggest that the plant effluent phosphorous concentration could be decreased by up to 0.6 mg/L once these processes are employed. At this time, one Pearl reactor will be operational in early 2016, and the WASSTRIP process will be operational in 2017. These combined processes could recover

approximately 1.8 million lb per year of phosphorous. With the improvements made at the Stickney WRP, an annual average total phosphorous effluent concentration of less than 0.9 mg/L in 2014 was achieved, which is much lower than 1.3 mg/L in 2010 prior to any phosphorous removal efforts. Once further optimization is made through the addition of fermentors, baffles in the EBPR process and Ostara processes, MWRD expects that the effluent total phosphorous concentrations will be lower and become more consistent throughout the year and under different plant conditions. **WASSTRIP**

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