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Engineered Wetlands Clear the Waters

Inside this issue:

How Damper Designs Differ Pg 24

Outsourcing EH&S Pg 30

Pump Changes Waste to Revenue Pg 36

Cleaning Former MGP Sites Pg 42

WEFTEC Preview Pg 48

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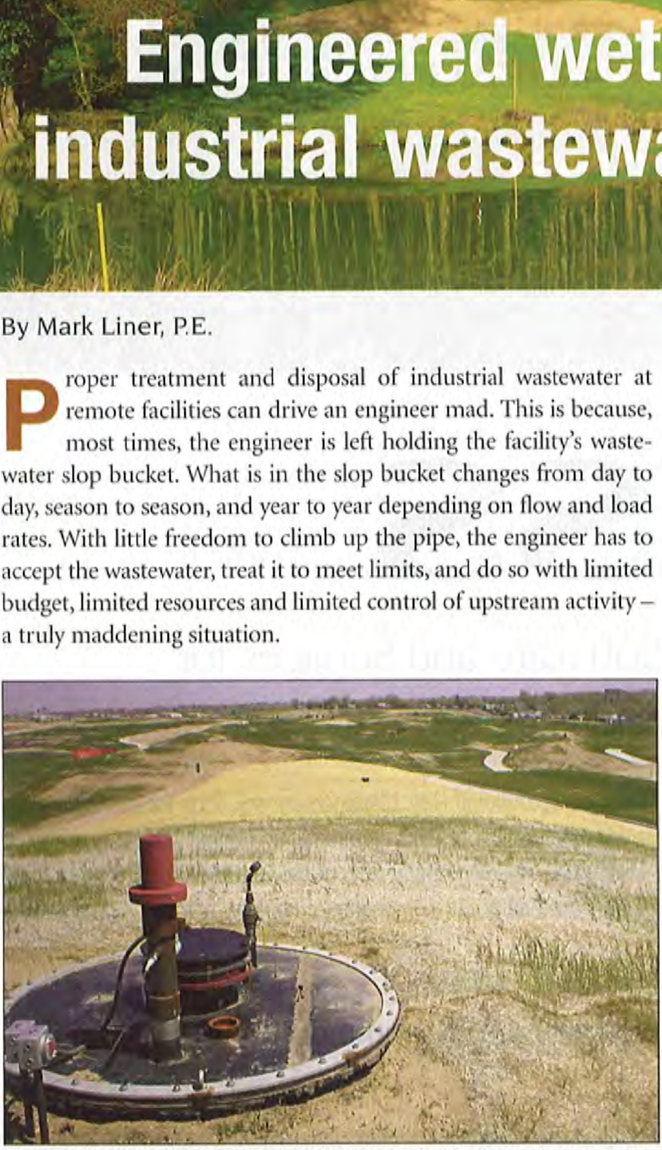
No Big Pipe? No Problem

Engineered wetlands provide industrial wastewater treatment.

By Mark Liner, P.E.

Proper treatment and disposal of industrial wastewater at remote facilities can drive an engineer mad. This is because, most times, the engineer is left holding the facility's wastewater slop bucket. What is in the slop bucket changes from day to day, season to season, and year to year depending on flow and load rates. With little freedom to climb up the pipe, the engineer has to accept the wastewater, treat it to meet limits, and do so with limited budget, limited resources and limited control of upstream activity – a truly maddening situation.



The treatment system had to handle up to 3 MGD of gasoline-contaminated groundwater, blend into the middle of a premier golf course, and operate for over a century.

For discharges to a large publicly owned sewage plant, the treatment of facility slop is clear: bumped up equalization and targeted pretreatment with discharge to the *big pipe.* But for those facilities without such a luxury, taking care of wastewater is a never-ending soap opera. The variable characterization of flows and loads coupled with the variable nature of environmental regulators often makes a simple black-box approach more like a spin-art project.

For facilities not connected to a sewage plant, there are practical, sensible wastewater treatment and disposal options. These include land disposal, reuse and hauling away discharge as the most common practices. Each option has its pros and cons, and each has its place. Each requires a treatment system that can handle the unpredictable nature of what is coming out the back end every day. In all of this, what is certain is that the system must work, it must be low-maintenance and it must be within budget.

Natural systems for industrial treatment

Oddly enough, natural systems can play a viable role in industrial treatment. The biological complexity of these systems can be exploited to cope with the complexity of industrial waste streams, be they waste solids, air or water. Moreover, typically they are mechanically simple, which translates to low operation and maintenance costs. The self-organizing nature of reed beds makes them excellent choices for sludge dewatering. Mulch biofilters are used to control odors from a complex matrix of volatile organics. It is the use of *engineered* wetlands, however, that is proving to be particu-

Engineered wetland treatment systems can blend into the surroundings that provide valuable land use facilities while treating industrial wastewater.

larly flexible for use in industrial treatment.

Currently, industrial wetland systems are used for petroleum remediation and the treatment of landfill leachate. Uses with airport deicing facilities, concentrated feed lots and mining operations are also establishing the flexibility of wetlands to meet an array of maddening scenarios.

With the chemical, physical and biological science of wetlands clearly understood, these engineered systems are now tailored to the parameter for treatment, which makes for their widespread use. A wetland cell can be rigorously engineered to be a stand-alone treatment process, or it can be coupled with other processes – like lagoons – to augment performance. Their real value is not in the science of treatment, but these industrial wetlands are designed into parks, golf courses nature centers, trail networks, natural habitats and other green spaces, where they become a central amenity and an asset to the community.

Key to making natural wetlands work in industrial applications is the use of disciplined engineering practices. Taking away the geometric uncertainty is first, closely followed by installation of impermeable liners, and specific placement of influent and effluent points. With additional water level control, the systems begin to behave more like an engineered reactor.

But this is just the start. Loading rates are controlled to exploit bacterial growth. Wetland cells are filled with gravel media, which is cleaned and sized to optimize hydraulics and treatment. A blower aerates the bed, which allows the engineer freedom to control location and size of aerobic zones. Flow within the wetland is recirculated to optimize treatment and mulch is used for insulation.

Eventually, what seems to be a passive, uncontrolled technology begins to have a process schematic similar to advanced sewage plants. Given such freedom of control, engineered wetlands can be tailored to successfully treat a number of pollutants. It is simply the correct use of engineering tools that limits the application.

Engineered wetlands achieve petroleum remediation

Treatment for benzene, toluene, ethylbenzene and xylene (BETX) occurs through volatilization and aerobic biodegradation. The microbial communities in wetlands have been proven to break down many of these and other VOCs that are associated with petroleum products. The challenge is to engineer a system that provides the right, consistent environment to allow such microbial communities to flourish. In these cases, an aerated, subsurface wetland is an effective, stable means for achieving BETX degradation.

A wetland system implemented by British Petroleum (BP) in Casper, Wyo. was the largest and most recent remediation wetland in the United States. The treatment system had to handle up to 3 MGD of gasoline-contaminated groundwater, blend into the middle of a premier golf course, and operate for over a century. The site included an office park, river front trails and a white-water kayak course.

The wetland system included a cascade aeration system for iron oxidation and air stripping, a soil-matrix biofilter for gas-phase benzene removal, surface flow wetland cells for removal of ferric hydroxide precipitates, stormwater retention wetlands, and radial subsurface flow insulated wetland cells for BTEX removal. Support of the design required conducting a pilot, which permitted the derivation of site-specific rate constants. Also, non-equilibrium gas/liquid benzene phase-change calculations were necessary in addition to the heat balance requirements.

At another site, Williams Pipeline, Watertown, S.D., an aerated, 40,000-sq. foot wetland remediation system at the terminal facility was designed for on-site remediation of a variety of waste streams, including petroleum contact water, ethanol-contaminated stormwater and tank bottoms. The processing capability of the wetland exceeded design expectations, and wastes from other facilities in the Dakotas have since been bought to the wetland for treatment.

Landfill leachate can be treated utilizing engineered wetlands.

Wetland use in landfill leachate treatment

Due to the variable nature of landfill leachate, a treatment system must be able to receive and properly treat a wide range of parameters over a wide range of concentrations. For this reason, a complete leachate system must include a number of unit processes that target removal of a certain group of parameters. Wetland treatment systems are used in concert with other processes to completely treat a full range of leachate parameters. In particular, wetlands are used for bacterial-mediated degradation of some of the more difficult-to-degrade organics. Aerobic and anaerobic zones can be engineered in the wetland to expedite the degradation of xenobiotic compounds. Subsurface wetlands with properly sized gravel media provide a stable surface for attached growth bacteria, which allows the bacteria to be resident in the wetland and acclimate to the variable load.

For the Anoka County Landfill in Minnesota, a bioremediation system was designed for 288,000 GPD of leachate-contaminated groundwater. The design included eight, 50,000-square foot, horizontal subsurface-flow wetland treatment cells. In order to provide year-round treatment, the wetlands were insulated using energy balance design methods. Mulch was employed as an insulation layer, a system that has previously proven effective in permitting cold weather operations of subsurface wetlands. Forced bed aeration was also employed within the cells to create alternating aerobic/anaerobic zones for degradation of complex organic compounds, including tetrahydrofuran.

Detailed pilot work on an engineered wetland was conducted at the Jones County Landfill, Anamosa, Iowa. The pilot program was designed for the remediation of up to 500 GPD of landfill leachate, and was operated as a research facility by the University of Iowa Department of Civil and Environmental Engineering. Results from the pilot project focused on the ability of the wetland to treat for ammonia during cold weather and dramatically illustrated the benefits of wetland aeration.

The challenge at airports, mines and feedlots

The increased scientific understanding of wetlands has improved the use of known engineering practices to address an array of industrial flows and loads. Aside from petroleum remediation and landfill leachate, engineered wetland systems are currently in design or being constructed for treatment of airport deicing liquid, goldmine tailings and concentrated feedlot waste.

> **“The biological complexity of these systems can be exploited to cope with the complexity of industrial waste streams, be they waste solids, air or water.”**

Each application has different influent loads and effluent targets, and each presents its own maddening scenario. For airport deicing, the issue is a high-strength first flush of glycol during cold weather. For a gold mine, the issue is a treatment of a cyanide-laden leachate to achieve low ammonia toxicity in the effluent. For a feedlot, it is treatment of a high ammonia load after an anaerobic lagoon. For each scenario, an industrial wetland can be engineered to respect the science behind the treatment and result in a cost-effective solution.

Conclusion

When the big pipe is either not so big or not there at all, environmental managers must have solutions that work for the long haul. The treatment must work today and far into the future. An engineered wetland system designed to handle future flows and variability in influent offers low life cycle costs that are attractive. More attractive, however, may be integrating such a wetland with a facility to provide a natural asset that is enjoyed by plants, animals and, just possibly, a formerly mad engineer. **PE**

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