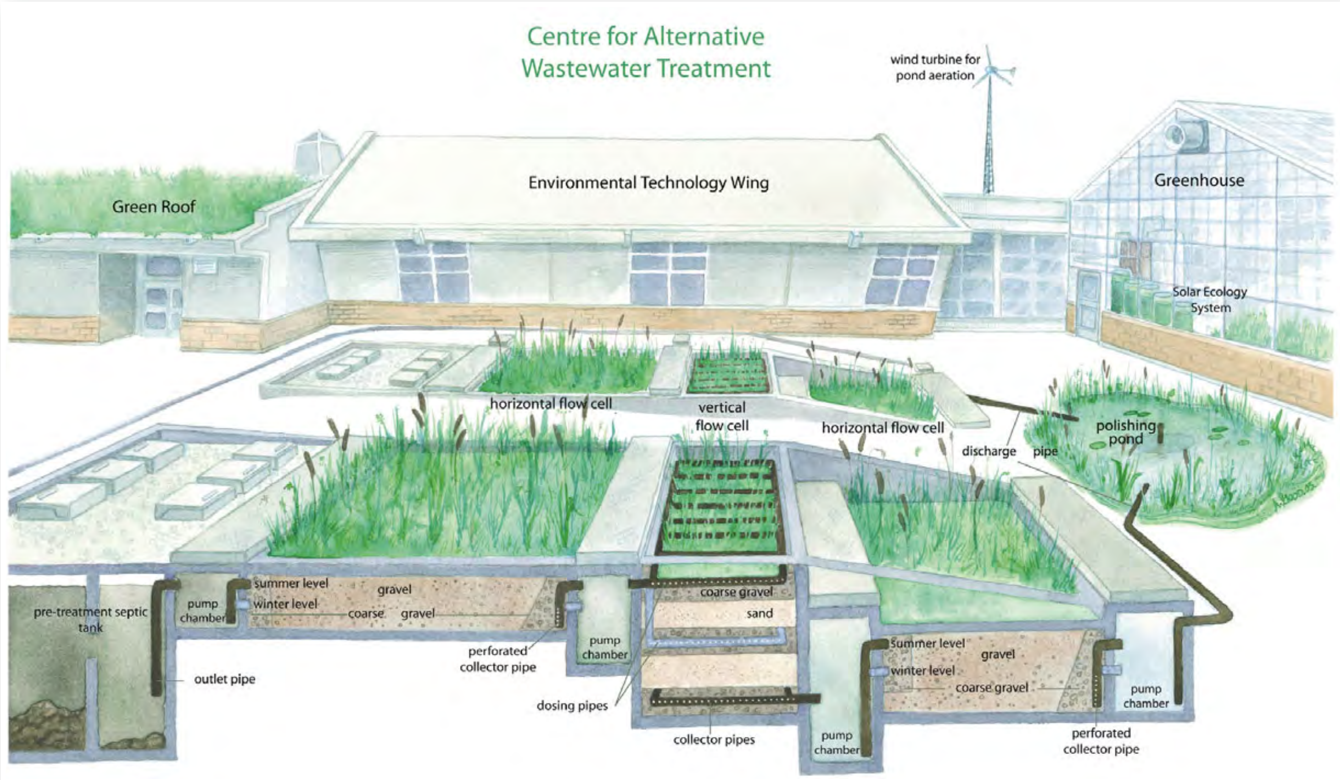
Engineering treatment wetlands for various wastewater streams

By Mark O. Liner



Bringing a demonstration facility to the doorstep of a client is always an effective way to provide proof that a treatment system works. Some vendors offer the service by trucking a test unit to the site and running the treatment system on the actual wastewater needing treatment. Treatment wetlands are in a grey area between vendor technology and a consulting engineer's "solution," so no sales representative is going to show up with a wetland on a flatbed.

However, there are facilities, such as the Centre for Alternative Wastewater Treatment (CAWT) at Fleming College in Lindsay, Ontario, that routinely test wetland systems. Another example is New Brunswick's NATECH, which is currently testing the suitability of wetland treatment technology on byproducts of the local natural gas industry. Experience from these facilities has played an important role in taking the science of wetlands and using it for the engineering of projects.

Wetland systems are larger than mechanical systems. There is a trade-off between mechanical complexity and land. Wetland systems don't need as much attention, or care, as their mechanical counterparts, are typically constructed on-site by civil contractors, and have few, if any, moving parts. Historically, the question of how to quantify performance has been left to statistics and heuristics. Recent improvements in the engineering of wetlands have helped increase predictability.

Engineers have borrowed the biology, chemistry, and hydraulics of the wastewater industry and are employing them successfully to create treatment systems that perform like sewage plants but look more like … a field of plants.

Inclusion of aeration in subsurface wetlands has greatly advanced the ability of the systems to degrade hydrocarbons and ammonia reliably. This is critical for the design of wetland systems used for spent de-icing fluids at airports, contaminated groundwater, or tailings water from gold mines. And, by using proven hydraulic and thermodynamic principles, designers are creating wetland "reactors" that are stable and more reasonably sized. These reactors increase the reliability and performance over past systems by ensuring proper reactor kinetics and complete use of the wetland, with minimal short-circuiting.

Dr. Jim Higgins of Stantec, an early leader in treatment wetlands, piloted a number of systems at the University of Guelph's Campus d'Alfred. The work was carried out to support development of kinetic variables that can be used to scale up systems from pilot to full scale.

For example, Buffalo Niagara International Airport decided to pilot-test an aerated wetland to examine the rate at which de-icing fluid in cold stormwater could be degraded. The only way to go forward with confidence in this case was to build a model, put it in a walk-in freezer, and give it a test run. The results more than proved out the concept and were ultimately used to size the system now being operated at the airport.

At Fleming College's CAWT, Dr. Brent Wootton, director and senior scientist, leads a team of researchers who study innovative forms of wastewater treatment. The centre has carried out extensive research on constructed wetlands and alternative forms of wastewater treatment technology, such as anaerobic bioreactors for metal removal, and floating wetlands for use in stormwater ponds. The CAWT has state-of-the-art facilities, including six outdoor research rest cells for wetland studies, 20 ponds, an indoor greenhouse research facility, climate-controlled environmental chamber, and a fully equipped analytical laboratory.

1. Airport de-icing glycol. Buffalo Airport uses over 200,000 gallons of glycol-based product for aircraft and pavement de-icing annually. Spent de-icing compounds are collected within the airport's stormwater collection system and require treatment prior to discharge. To evaluate the ability of an aerated gravel bed to treat the stormwater on-site, a treatability study was conducted on a pilot-scale treatment system at Campus d'Alfred.

Results from the testing demonstrated 95% treatment and were used as a basis for sizing the full-scale 10,000 pounds-BOD_5/d treatment system. Then Naturally Wallace Consulting (NWC) was selected to take the pilot results to full-scale design.

2. Gold-mine tailings. A remote gold mine in South America was in need of a low O&M system to treat ammonia from the cyanide-laden water in the tailings pond. Over 16,000 m^3/day of water required treatment prior to discharge to the adjacent

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Cells at Haliburton hatchery being planted by students.

river. A treatability test was conducted to determine the rates of ammonia removal and to support the sizing of the wetland system.

Testing was done in three phases. In the initial phase, artificial leachate was formulated and tested in a wetland reactor located at Campus d'Alfred. During the second phase of testing, actual water from the site was shipped to the laboratory for testing in the same reactor. During the final phase of testing, a reactor was constructed and tested on-site. Results from the testing demonstrated successful removal of ammonia, with no inhibition of nitrification.

3. Refinery wastes. A pilot scale subsurface vertical-flow wetland was constructed at the former BP refinery in Casper, Wyoming, to determine degradation rates for chlorinated organics. In particular, the water required treatment for benzene, toluene, ethylbenzene, and xylenes in cold weather.

The four-cell pilot system, operated in 2002, provided insight into the value of utilizing aeration within the wetland system to expedite the rate of treatment. The value of a mulch cover for bed insulation was also investigated. Treatment rates from the pilot work were used to design a full-scale system capable of treating up to 11,400 m^3/d of gasoline-contaminated groundwater. The full-scale system, which was designed by NWC, achieved compliance levels within one week of startup.

4. Aquaculture. Sedimentation and screening are primarily used for solids removal in flow-through aquaculture facilities. These physical treatment methods remove settleable solids and particulate-bound nutrients from the wastewater. But they do not treat the dissolved fractions such as total ammonia nitrogen, phosphate and biochemical oxygen demand (BOD_5), that can harm the receiving aquatic environment.

A constructed wetland was installed after a septic tank at the Haliburton Highlands Outdoors Association in Haliburton, Ontario, which operates a 300m^3/day flow-through salmonid hatchery. Intensive monitoring examined the ability of a subsurface flow constructed wetland to

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Haliburton wetland one year after planting.

CAWT College cells in winter.

treat the concentrated wastewater flow that is produced during daily vacuuming of the hatchery's raceways. The wetland was operated for a year as a saturated horizontal flow system and has just been switched to a partially unsaturated vertical flow system for comparison purposes.

The saturated horizontal flow configuration successfully treated concentrated wastewater even in extreme cold conditions. It is anticipated the unsaturated vertical flow configuration will increase treatment performance.

5. College wastewater. An integrated treatment system, which combines an engineered wetland and Phosphex^{TM} technologies (EW-Phosphex), was installed to study treatment efficacy of college wastewater. The system configuration consisted of a conventional septic system, followed by a horizontal wetland, then by a forced aeration engineered wetland cell, and ending in a Phosphex polishing unit. The Phosphex polishing unit contained steel slag intended for removal of phosphorus and pathogens.

The integrated system was monitored in the winter of 2010 to determine treatment efficiency, including removal of phosphorus, ammonia, nitrate, BOD_5, total coliform, *E. coli*, metals, metalloids and pharmaceutical compounds. Most of the contaminants monitored were effectively removed by the treatment system. Ammonia removal was as high as 79%, while phosphate, BOD_5, total coliform and *E. coli* were greater than 99%. Pharmaceutical removal ranged as high as 98%.

Treatment wetlands are now being used over a wide spectrum of applications. Their success depends greatly on the front-end pilot work and the people and companies doing it. Pushing science to the limits, the pilots allow full-scale engineering of wetland projects. And, all this work can be done at a number of Canadian facilities, without having to put a wetland on the back of a truck.

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