Waterloo Biofilter system reuses treated sewage – allows facility expansion

Article as printed in ***Onsite Water Treatment*** magazine, October 2007

by David C. Richardson

Over the years there had been problems getting enough water into an Ontario, Canada, truck stop. During the summer months, the two 80-foot-deep wells had to be pumped vigorously to keep the restaurant and facilities supplied with fresh water. However, during dry spells the water table sometimes dropped lower forcing the wells to pump harder. "We were getting more sulfur in the water, and even then, we couldn't supply enough water for the truck stop," says David Harsch, P.E. "And the water had that sulfur rotten egg smell. That was not good for the restaurant; they couldn't make good coffee with that water. So when they started talking about expanding and renovating that truck stop, I knew we had a problem."

A Brewing Challenge

Harsch is a design engineer with K. Smart Associates Ltd. and has been working on various civil engineering projects over the past 15 years. During that time he became familiar with the London, ON, truck stop site and was aware of some of its concerns. The company planned to improve the London, ON, truck stop by adding several shower-stall washrooms, upgrading the laundry facility from a single washer and dryer to a full laundry, and doubling the capacity of the restaurant from 100 to 200 seats.

The goal of the planned renovations was to make the facility more appealing to long-distance truckers, who would put a strain on a potable water supply that was already testing its limits.

Location, Location, Location

According to Justin Harper, a project manager with HIRA Construction, the contractor on the project, the site was in the middle of a land squeeze. Hemmed in by eight lanes of Highway 401 to the north, and otherwise surrounded by farmers' fields, the truck stop's plans for additional truck parking placed real estate at a premium.

An existing sewage treatment plant on the property, which managed waste from the original restaurant and truck stop, comprised a lagoon, a pump station, and a tile bed. Harper says the operation was basic: The effluent would be pulled from the bottom of the lagoon and pumped through the tile bed. Once a year the sludge would be collected and distributed to nearby farms.

It was an economical arrangement, but according to Harper it was an arrangement that would have to be scrapped for one simple reason: "The lagoon was located in an area behind the truck stop, and that was an area they wanted to use for parking."

Relocating the lagoon on the reconfigured site would not have been practical either, says Harper. "The prerequisite for doing this type of treatment cell is that you have a lot of land and that you have a separate area house it. If it's a farm on the back 40, and you want to put a pond there, then great—but if you want to build a parking lot and have overnight truckers sleeping there, it's just not going to work. It's not suitable for anything that's near public use."

Further, the projected increase in water usage, after the renovation, would mean two to three times more wastewater than the current establishment generated. A system would be needed that could process much more wastewater, while taking up much less real estate. The lagoon was out; a new solution had to be found.

Harsch put it simply: "How do we get rid of three times more wastewater? And because we knew the wells could never produce enough water to satisfy the demand, how do we get more water?"

In thinking over the problem, Harsch says he reviewed data on household water usage. From this he estimated that simply due to the nature of the business, 60% of the water used at a typical truck stop would be used for flushing toilets.

"That's when the notion came across that, wow, if we've got all this wastewater, why don't we treat it and reuse it for flushing toilets?"

The old truck stop was demolished "right down to the light standards." A completely new truck stop went up, with a brand new wastewater system.

Harper says putting together all the pieces took several months. The lagoon was drained and brought to grade with 240,000 cubic feet of fill, he says, "so now its truck parking." His crews fixed up the existing tile bed for overflow, and "we brought the sanitary pipes out from the new building to supply the system. The Waterloo Biofilter system was all pretty much turnkey."

Not to say there were no hurdles. Harper says shutting down the old lagoon was a bit of a problem. "We had to bring in a specialized contractor for that," he says. "We thought there would be significantly less material to dredge, and the sludge was soggier than expected. They had to bring in a pump to empty it," which he says cost about $100,000. "It highlights the difficulty in transitioning between two systems."

It Starts With the Plumbing

"The treatment process starts with the plumbing," says Harsch. At the new truck stop the kitchen wastewater is collected separately and runs through a grease trap. Wastewater from hand washing, sinks, and urinals is gathered together in a separate sewer. After the kitchen grease is removed, the wastewater from the two streams is combined and conveyed through a conventional sanitary sewer system to the first stage of the treatment plant.

"People in the business call them trash tanks," Harsch says, "or pretreatment tanks; they really are four septic tanks in a row." The first in the series of four 50,000-liter, underground concrete septic tanks acts as a settling basin "for removing solids, straining out hair, or whatever else gets into the wastewater."

Harsch says the majority of settlement takes place in the first tank in the series, which settles out about 60% of the solids. "The rest of the tanks are there to control any grease that bypasses the grease trap and anything else that settles out more slowly."

The effluent flows from tank to tank, passing through the series of Zabel effluent filters between stages, before finally ending up in the fourth tank, which serves as the dosing tank. From the dosing tank the filtered wastewater is pumped to the two Waterloo Biofilter units for aerobic treatment.

Modified Trailer

The Waterloo Biofilter System was developed and designed for use in difficult sites such as "fill areas or areas with a lot of bedrock or a high water table places where you can't use conventional septic systems," says Brady Straw, an engineer with Waterloo Biofilter Systems.

Waterloo's treatment systems are offered in several configurations, for either at-grade or underground installation. The treatment units selected for the truck stop consisted of two modified 40-foot shipping containers, which Waterloo has branded as the SC 40 Configuration. They are bulk filled with Biofilter medium and prepackaged with fans and rheostats, inline filters, interior plumbing, and control room heaters.

Setting up the system was simple, says Justin Harper, who managed the installation process. "We brought the sanitary pipes out from the new building to supply the system. The Waterloo Biofilter system was all pretty much turnkey."

David Harsch says the units' economy and style might also be considered. "It was the most economical of their designs. For some sites like campgrounds they wouldn't want to use this design because it might spoil the setting. It didn't bother my client; in this setting there are transport truck trailers sitting all over the place, 24 hours a day, so they blend right in."

Foam Homes

The Biofilter medium consists of specially manufactured foam cubes measuring about 2 to 3 inches per side. Within the shipping containers, the effluent is sprayed uniformly over these foam cubes and is allowed to trickle down through the medium. Treatment takes place in the tiny pores of the foam where the bacteria live and grow.

"It's a proprietary synthetic similar to a mattress foam, but it's very open so air will flow through it," says Straw. "There's space for oxygen within the tiny pores inside." In addition to being very durable, he says, the foam has a unique quality. "If you put your hand on one side of the cube and blow through it, you can actually feel the air going through."

The key to the Waterloo system is this highly efficient, absorbent-foam medium, which allows microbial growth on the interior surfaces of the foam where they are protected and can grow out into large open-pore spaces.

Photo: Waterloo Biofilter Systems Inc.

Discoloration of effluent is part of the removal and degradation of solids and organic matter.

Unlike traditional trickle filter systems that rely on solid particles—such as sand—as a filter medium, Waterloo Biofilter's foam cubes provide separate flow paths for air and wastewater, promoting effective treatment at high loading rates.

Straw says, "It's a living system. It's the bacteria that do the treatment. We just provide them with a home."

Waterloo Treatment Zones

Waterloo describes the treatment environment in the foam column within the trailer as divided into two zones; on top is zone 1, which treats biological oxygen demand (BOD) and total suspended solids (TSS), and below it is zone 2 where fecal treatment and nitrification occur.

Visible biomat discoloration occurs in the upper 40 centimeters of zone 1. This upper section of the filter is where Waterloo says most of the solids and organic matter are degraded and removed. The lower section of the filter column attenuates fecal bacteria and ammonium (removing disease-causing bacteria and helping to oxidize nitrogen species).

When the effluent filters to the bottom of the tank, treatment is complete. Harsch says, "What comes out of the bottom of the Waterloo Biofilter is very clean water." According to Harsch the effluent could be discharged into the environment at that stage without ill effect. However, the Biofilter units designed for the truck stop project were delivered with watertight, sealed beds to allow collection of the treated water for reuse.

A Second Pass

After the biofitration stage, 50% of the treated water is gravity fed back into the second in the series of septic tanks to facilitate further nitrogen reduction. The rest of the effluent is directed for additional treatment.

Harsch says at this stage the effluent is odorless and clear. This essentially clean water is directed into a sand filter to remove any residual turbidity, "but prior to that we send it through an ozone contact tower. The ozone is primarily there for color control." Harsch says the water picks up a slight yellow-brown tint from the Biofilter medium. "The ozone removes the color."

Harsch says, however, mastering the ozone treatment provided a challenge. "If you overdo the ozone, you kill off too much bacteria before it gets to the sand filter." He says since a sand filter works in concert with a layer of bacteria on the surface called a *Schmutzdecke*, the goal is to not disinfect too much. "If you don't get any living bacteria there, then the performance of the sand filter decreases.

We're trying to keep the ozone down as low as we can, and that's been a trial and error process. If that top layer is not developing, then you know you've got too much disinfection going on ahead of time, so you turn down the strength of the ozone."

After passing through the sand filter, the water is dosed with low strength chlorine and pumped to a storage tank. The final step of chlorination, Harsch says, was applied mainly for cosmetic purposes. "We drip in a little bit of chlorine to stop any bacteria that may have managed to get through the sand filter." He says the chlorine is there to prevent an overgrowth of bacteria while the water is being held in the storage tank.

"You can end up with chunks of bacteria that can be flushed into a toilet. When you flush a toilet, the water should be clear. When you're done you shouldn't have a hunk of bacteria floating there." He says there is no need for customers to know that they are flushing with recycled water, but "you do want to assure the guests that it's a very clean operation."

Photo: Waterloo Biofilter Systems Inc.

The water reuse by the truck stop was the first time this technology was utilized commercially in Ontario.

Meeting With Approval

Ontario Ministry of Environment (MOE) approval is required for any wastewater system within the province, treating over 10,000 liters per day. The truck stop's system was designed to treat 60,000 liters per day. Though the MOE had observed short-term experiments with residential water-reuse systems, the truck stop project represented the first time water reuse had been done in a commercial setting, on such a large scale. According to Waterloo's Straw, the MOE decided to require weekly sampling "because the reuse part of the system was something that had never really been tried before."

David Harsch says, however, that the MOE and other regulatory agencies voiced no other major concerns during the approval process. "Locally the building inspector's only concern was that we make sure the recycled water was in a totally separate piping system, isolated from everything," Harsch says. The inspector also required that all the pipes carrying recycled water be marked, every 2 feet, with a 1-foot-long piece of tape with the word 'non-potable.' That, Harsch says, would ensure that "nobody would tap into a pipe erroneously, thinking it's drinking water."

Surplus Water

"We now have surplus water in the range of 30% over our requirements. The kitchen is taking in fresh water for cooking and washing dishes every day, so whatever they take in we have to discharge," says Harsch. He adds, "That amounts to about 7,000 or 8,000 liters per day, which he says is discharged through the old tile bed. Again, he says the MOE had no concerns about this discharge because "the quality of the water we were putting into the ground was much cleaner than you would have got out of a normal septic tank.

"We keep filling our storage tank until it overflows; whatever overflows gets pumped out to the old tile bed so we're always working with a full tank," says Harsch.

Quality Sewage

Though Harsch says BOD readings can vary widely for raw sewage at commercial truck stops, ranging from 200 milligrams per liter, to 800 milligrams per liter. Chris Payette, the certified operator for the truck stop treatment plant, says regular maintenance helps even out the variation. "Pumping out the grease trap on a regular schedule keeps the sewage quality fairly consistent," says Payette. He says he pumps out the grease trap every two months and pumps out the first septic tank every four months.

Under the MOE certificate of approval the wastewater facility operator must perform weekly sampling of both raw sewage and treated effluent. Harsch says that sampling results demonstrate that the system deals equally well with a wide range of sewage strength. "You don't see uniform sewage quality going in, but coming out it's virtually identical every time."

Over the three years the system has been in operation Payette says the test samples have consistently met or outperformed MOE regulatory standards. "The result is almost the same any time of year," says Payette. "The monthly averages for TSS [total suspended solids] and BOD [biological oxygen demand] are around 1 or 2 milligrams per liter and for *E. coli* and coliform it's generally less than 1 milligram per liter."

Harsch concurs, "We're actually far below the design. It's designed for a BOD of 10 milligrams per liter and I usually see BODs of less than 5 milligrams per liter down to as low as 2 milligrams per liter or in other words—undetectable."

Operations and Maintenance

Payette says routine maintenance help, "I never really run into any problems if I do it on a weekly basis." He says in addition to sampling duties he is responsible for maintenance and upkeep of the Biofilter system.

During a normal site visit, Payette takes readings from the Neptune flow meters, checks the grease traps for clogs, and inspects the treatment system panels for any alarms. In addition to collecting the samples from the tanks for testing, he inspects the condition of the sand filter, making a note of turbidity, and if necessary, he refills the secondary chlorine supply tank.

Photo: Waterloo Biofilter Systems Inc.

These septic tanks make testing a simple task.

To get all this accomplished, Payette says he seldom has to spend more than two hours onsite on a weekly basis. In fact, he considers the system low maintenance. According to Payette, it is the lab costs associated with sampling and analysis that accounts for about 70% of the total operations and maintenance cost.

Payette says routine tasks such as changing the filters are easy because "all of the handles are right at grade." He says there is even a connection for a hose on the supply line that runs to the toilets. "I use that to take my samples," he says, adding that with a clean hose attached "I can use that same source to clean my filters."

He believes the system "was designed very well from a maintenance and operations perspective; everything you need to get to is right at grade; if you have to pull out a pump, you don't have to deal with confined-space issues. It makes my life a lot easier when systems are designed like that."

Kitchen and Bath

Payette says human factors play a role in the successful management of the Waterloo Biofilter system, and he works closely with the truck stop kitchen staff to educate them on the practices that will keep the system healthy. "Every week I talk with the staff to make sure they know what's going on with the system. They're very good with cleaning products; they've been trained from the start to avoid putting harsh cleaners down the drain. They let me know if they've switched to a different cleaning product, and they're very good about not pouring kitchen waste down the drain."

Payette says the staff is also very responsive to any concerns he may raise about the performance of the system. "If I see a spike in a flow, I'll ask them to check if a toilet has been running continuously. They usually get it figured out pretty quickly."

Open for Business

It takes several weeks for a new biofiltration system to completely "come to life." Harsch says he waited until about four weeks after the restaurant was open before sending the recycled water up to the toilets. In the meantime, a new well had been dug to supply water to the facility. Supply lines from this well, fitted with backflow preventers, would also be used temporarily to supply water for toilet flushing. If necessary, Harsch says, the well can still be used as a backup in the case of an emergency. "We used it during initial startup and thought maybe we'd use it if we had a problem with the plant—we haven't had a problem in three years."

A Good Blend of Goals

The new well was dug with another goal in mind—to provide better-tasting water than the two original deep wells. "When we built the new well we wanted to be careful not to go too deep. We wanted enough water to feed the kitchen, and no more—it's worked fine," says Harsch. In past summers, he says, when the water tables dropped, the pumps were forced to work harder, bringing up water an unpleasant smell. He says the new system, with reduced demand on the well, "seems to have cured that problem."

Of the restrooms, Harsch says, "There's no hint that we're using recycled water in their toilets; the water is perfectly clear."

Harper says it was the kind of project he likes to be involved with because it achieved a good blend of goals. "I had never seen a Waterloo system before that brings back graywater to flush toilets in a truck stop," he says. "It's a well-integrated solution that looks like it has always been there."

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