The Ultimate *Recycling*

AN OREGON PLANT USES A PROPRIETARY PROCESS TO EXTRACT NUTRIENTS FROM WASTEWATER AND USES THEM FOR SALMON RESTORATION AND A HIGH-QUALITY FERTILIZER

By Jim Force

Treatment ponds at the Clean Water Services Durham plant with secondary clarifiers in the background. (Photography by Tim Batchelor)

Bob Fitzgerald, left, maintenance supervisor with Clean Water Services, and Noah Harvey, operations supervisor.

NUTRIENTS REMOVED FROM MUNICIPAL WASTEWATER in Oregon are helping to restore the salmon fishery in British Columbia. It's a novel arrangement built around stringent phosphorus and ammonia removal requirements at the Durham Advanced Wastewater Treatment Facility near Portland, innovative technology from Canadian nutrient recovery company Ostara, and the need to counteract overfishing in the coastal waters along Vancouver Island.

Rob Baur, senior operations analyst at Clean Water Services (CWS), the public water resource management utility that operates the Durham facility, explains: "We remove phosphorus biologically because we have strict effluent limits, including the first total maximum daily load (TMDL) for phosphorus on any river in the country. The Ostara process removes phosphorus and ammonia from our dewatering centrate and converts it into struvite pellets, called prills by the fertilizer industry."

The British Columbia Ministry of Environment purchases some of the struvite; volunteers bag it and place it in the headwaters of salmon streams where the struvite slowly releases nutrients into the water. The nutrients are critical because overfishing has reduced the population of adult salmon, which normally would swim upstream to spawn and die.

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ROB BAUR

In the natural cycle, their decaying carcasses nourish the larvae and algae required to sustain the new salmon fry. Without the imported nutrients, the fry would struggle to grow strong enough to make it to the ocean and back again. "For 35 years, I've been removing phosphorus and ammonia from wastewater," says Baur. "It's hard to believe that now I'm putting them back into a river."

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LOOKING BACK

When the Durham facility was completed in 1976, it used high lime treatment as best available technology to achieve about two parts per million of phosphorus in the effluent, before release to the Tualatin River. In 1993, after the imposition of the phosphorus TMDL, the facility began using alum to remove the phosphorus with lime addition to adjust alkalinity. Durham later transitioned to biological phosphorus removal, dramatically reducing chemical usage and saving ratepayers money.

Today the plant, in Tigard, Ore., is designed for an average flow of 20 mgd (up to 100 mgd during wet weather) and includes a number of innovations besides the struvite process.

A new influent pump station has achieved the first LEED Silver certification for a pump station in the nation from the U.S. Green Building Council. The station has a peak capacity of 180 mgd and has a self-cleaning wet well. Each pump (ITT Water & Wastewater — Flygt) has a 1-ton flywheel to keep the pumps spinning while the check valves close to prevent water hammer.

In the updated headworks, Vulcan 3/8-inch continuously cleaning bar screens remove debris and trash, and the material is sluiced by water to a washer/compactor. A Smith & Loveless PISTA grit removal system follows. Primary tanks are covered, and primary effluent is pumped to the biological system. A surge basin helps the plant deal with wet-weather flows.

FLEXIBLE SYSTEM

In the face of widely varying seasonal flows and seasonal nutrient removal requirements, the biological system is highly flexible. The first two cells are anaerobic. Cells three and four are anoxic, using mixed liquor recycle to denitrify and recover alkalinity and oxygen. Cells five and six are aerobic. The first six cells represent 50 percent of the basin volume.

The second half of the basin is a serpentine plug-flow system that enables cost-effective nitrification during summer. During high flows, the primary effluent is sent to cell three, while cells one and two are 100 percent return activated sludge (RAS) to reduce the solids load on the clarifier. At extreme flows, contact stabilization is accomplished by sending the primary effluent to cell seven so that 50 percent of the aeration basin is RAS. The required weekly median is 0.2 mg/l for ammonia from May to November. (The phosphorus limit is 0.1 mg/l monthly median.)

After the secondary clarifiers, the treated water passes through three tertiary clarifiers where alum is added. Then a series of three chlorination units disinfect the water before it is filtered in a battery of 13 mixed-media units, followed by dechlorination before discharge. Between 1.5 and 2.0 mgd of purified effluent is recycled for irrigation use on community golf courses, parks, schools and athletic fields.

"It's unusual to disinfect before filtration, but we're set up that way to avoid additional pumping costs," says Nate Cullen, CWS engineering division manager.

Before 1994, biosolids were incinerated, but today the waste activated sludges are thickened in Sharples centrifuges (Alfa Laval) and anaerobically digested, and the digested material is dewatered in Humboldt centrifuges (Andritz). The 23 to 25 percent solids cake is a Class B product.

In winter, the material is trucked to the arid regions of eastern Oregon to support alfalfa crops. In summer, it is spread on farmland in the nearby Willamette Valley. Digester gas generates electricity plus hot water, and both are used within the plant. The plant is in design for a fats, oils and grease (FOG) receiving system and new cogeneration facility.

RECOVERING NUTRIENTS

The centrate from the dewatering step is where things get really interesting. About two years ago, the utility contracted for Ostara's proprietary fluidized bed reactor system to recover phosphorus and ammonia from the dewatered sludge centrate. When magnesium chloride (purchased by Ostara) is added to the mix, the nutrients form struvite, which precipitates out of the system in pure white prills, 1.0 to 3.5 mm in diameter.

Capturing the centrate phosphorus as struvite results in a 20 percent reduction in the phosphorus load to the plant. Operations analyst Mike Mengelkoch, responsible for operating the complex plant, explains, "Removing all that recycled phosphorus is like having an additional aeration basin removing phosphorus."

The prills are stored in a hopper, then bagged in 1-ton sacks. Ostara buys all the product, trucks it away and markets it as Crystal Green slow-release fertilizer. "It is approved by the Department of Agriculture as a commercial fertilizer, but it's an order of magnitude lower in heavy metals than mined phosphorus," says Baur. "It measures 5-28-0-10. That means 5 percent nitrogen, 28 percent phosphorus as P205 (12.6 percent as P), zero potassium, and 10 percent magnesium."

The Durham plant is the first in the nation to successfully employ the Ostara technology. The $2.5 million system produces about 300 tons of Crystal Green fertilizer a year. In addition to the amount sent north to enrich the salmon streams, the product is marketed to landscapers, turf farms and container nurseries.

"The slow release results in deep root development and green, healthy growth," says Baur. "People really like it, especially in sandy soil conditions." Operation of the Ostara system has been fairly simple since startup in May 2009, and the payback has been encouraging.

ABOVE: The Durham plant is the first in the nation to successfully employ the Ostara technology. The $2.5 million system produces about 300 tons of Crystal Green fertilizer a year. RIGHT: Operator Brett Laney loads prills for shipment using the Spiroflow conveyor with Siemens control panel and fabric silo from Contemar Silo Systems.

CONTROLLING QUALITY

"We were the first of the lot, so it was new to everybody," says Baur. "Some bugs popped up, and we had to do some thinking on our feet. We tried two different kinds of knife gates and changed some piping, but once we got to a steady state, things ran smoothly." The system was installed in an existing building.

Durham Advanced Wastewater Treatment Facility
PERMIT AND PERFORMANCE

	INFLUENT	EFFLUENT	SUMMER PERMIT	WINTER PERMIT
BOD	200 mg/l	<2.0 mg/l	5.0 mg/l	10.0 mg/l
TSS	200 mg/l	<2.0 mg/l	5.0 mg/l	10.0 mg/l
Total P	6 to 8 mg/l	<0.1 mg/l	0.1 mg/l	NA
NH3-N	25 mg/l	<0.1 mg/l	0.2 mg/l	NA

profile

Durham Advanced Wastewater Treatment Facility, Tigard, Ore.

BUILT:	**1976**
AREA SERVED:	**Communities of Beaverton, Tigard, Sherwood, Tualatin, Durham, and King City, and portions of Clackamas County**
POPULATION SERVED:	**250,000**
FLOW:	**20 mgd (average, dry weather)**
TREATMENT LEVEL:	**Tertiary with nutrient recovery**
TREATMENT PROCESS:	**Activated sludge/mixed-media filtration**
RECEIVING WATER:	**Tualatin River**
BIOSOLIDS:	**Anaerobic digestion and centrifuge dewatering; cake to land application**
ANNUAL BUDGET:	**$4.5 million (operations)**
AWARDS:	**U.S. EPA Best Operated Plant, 2005; Pacific Northwest Pollution Control Association Outstanding Reuse Facility, 2006; Lower Columbia Section Plant of the Year, 2004**
WEBSITE:	**www.cleanwaterservices.org**
GPS COORDINATES:	**Latitude: 45°24'4.85"N; Longitude: 122°45'45.29"W**

TRAINING REGIMEN

Besides conducting onsite training on new processes like the Ostara system, the Durham Advanced Wastewater Treatment Facility management team makes training available to its operating staff in several ways. Operators are encouraged to attend a three-day short course on wastewater treatment at the local Clackamas Community College. They earn CEUs for course completion, and they learn a lot through contact with operators from other plants.

"Quite a few of our own staff make presentations," says Noah Harvey, Clean Water Services operations supervisor. "We support it with a lot of staff, both presenting and attending."

Wednesdays are "overlap days" at the Durham facility. The graveyard staff is held over in the morning for that session with part of the day shift, while the training is repeated in the afternoon so that the swing shift and the rest of day shift operators can attend. One-hour classes are devoted to safety, process training, and other important topics.

The staff also attends the CWS College of Clean Water training courses, and in the past the plant has invited a retired chemistry teacher to teach chemistry to the staff using plant processes as the examples.

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Ostara controls the recipe via a Web-based system and is responsible for the quality of the end product. The Durham staff handles startup and shutdown, preventive maintenance, repair and cleaning. "We haven't had to add any operators," Cullen notes.

Durham uses Grundfos digital dosing pumps for hypochlorite and caustic and specified them for magnesium chloride in the Ostara system. "The pumps are now part of Ostara's standard design because of their smooth delivery and Profibus control link," says Baur.

A NEXTChem online analyzer measures phosphorus in the Ostara effluent, which is basically centrate. "In spite of all the solids in the sample, the NEXTChem analyzer does not use a filter," says Baur. "The turbid sample, which could not be analyzed colorimetrically, is measured with a titration using a pH electrode.

"The sample is titrated to pH 4 and lanthanum nitrate is added. The lanthanum reacts with the phosphorus to release nitric acid, and the pH drops. The sample is titrated back up to pH 4. The amount of titrant is proportional to the initial phosphorus concentration. The online data is used to monitor reactor operation."

In fact, Baur and Cullen say the only issue with the Ostara process was tying the remote operation of the system into the plant's SCADA network. It was necessary to work around stringent internal security protocols that do not allow Internet access to the plant SCADA system.

Maintenance technician Dennis Wolfe tweaks the Watson-Marlow Bredel hose pumps.

The Durham facility is highly automated, using GE-Intellution iFix software and ChemScan analyzers (ASA Analytics) to measure nitrites, nitrates, ammonia and phosphorus in the secondary effluent. Sixteen critical alarm signals, with voice-over, are annunciated over the facility's radio system.

RETURN ON INVESTMENT

The plant receives revenue from the struvite, and Baur anticipates a seven-year payback on the system. Other benefits are already apparent. The plant is using 40 percent less alum for phosphorus removal, since the Ostara system recovers about 85 percent of the phosphorus in the centrate. Biosolids contain less phosphorus and are easier and less expensive to manage.

Ostara provided 30 days of concentrated training to acquaint staff with the operation of the nutrient recovery system. "They had staff on site, conducting formal training with each of our shifts," Baur says. "They had to make 20 tons of product within the 30-day period for substantial completion of the construction contract.

"Brett Laney, one of our operators, really got involved with it, so we now have him dedicated to the process. He stays in touch with Ostara, giving them feedback and interfacing with them. Brett is also involved with piloting and implementing modifications to the nutrient removal system.

"We used to treat the same phosphorus over and over again due to the heavy recycle load. But not anymore. The system has improved our biological phosphorus removal, it's reduced our operating cost, and it's producing revenue. It's been fun." **tpo**

Rob Baur, senior operations analyst, checks the ChemScan analyzers (ASA Analytics). They measure nitrites, nitrates, ammonia and phosphorus in the secondary effluent. Sixteen critical alarm signals, with voiceover, are annunciated over the facility's radio system.

INVENTED HERE

Staff members at the Durham Advanced Wastewater Treatment Facility don't just implement innovative processes — sometimes they invent them. The UFAT (Unified Fermenter and Thickener) process, recipient of a patent from the U.S. Patent Office, is an example.

Senior operations analyst Rob Baur is the inventor. The process consists of two gravity thickeners in series that allow independent fermentation and thickening of primary sludge before it is fed to the plant's anaerobic digester. As a result, volatile fatty acid (VFA) production is increased when stripped out by elutriation. The VFAs improve the phosphorus release by bacteria in the secondary biological processes and are required to make biological phosphorus removal work at Durham.

UFAT saves the Durham plant more than $100,000 a year in chemicals, biosolids processing, transportation, and energy, according to plant estimates. License for use of the process is available for $1 from Clean Water Services, since CWS wants to promote biological phosphorus removal.

Baur says the city of Bozeman, Mont., has taken up the offer and is working on installing the UFAT process at its municipal wastewater treatment plant.

A more recent Baur patent granted to CWS is called WASSTRIP (Waste Activated Sludge Stripping To Remove Internal Phosphorus.) "It was developed and patented by CWS to convert nuisance struvite in digesters to revenue in the Ostara reactors," Baur says.

Waste activated sludge is mixed with VFA from the UFAT fermenter, causing phosphorus and magnesium to be released just as in the anaerobic zone of the biological process. When the WAS is thickened, the phosphorus and magnesium in the digester feed are reduced and moved to the centrate, which is fed to the Ostara reactor, where it makes struvite.

"Every 100 pounds of magnesium diverted from the digester to Ostara represents 1,000 pounds of struvite not forming in the digester," says Baur. "Rather, it's now available to make revenue as struvite captured in the Ostara reactors." WASSTRIP has been licensed to Ostara.

more info:

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