HRSD Nutrient Removal Program: Advancement Through Management of Sidestream Loads

Introduction: As a large Chesapeake Bay discharger with 13 treatment plants serving 17 counties and cities in Coastal Virginia, an area with a population greater than1.6 million, nutrient (nitrogen and phosphorus) removal issues affect every aspect of HRSD's activities. More than one-third of our $900 million capital improvement program over the past 10 years has been invested in nutrient removal upgrades at five treatment plants, with three more to be completed by 2023. HRSD values both achieving high levels of nutrient removal and promoting fiscal responsibility, which necessitates minimizing resource use—particularly in terms of energy, chemicals, concrete tank volume/footprint/land area and labor. Our goal has been the creation of a sustainable nutrient removal program that provides value to our ratepayers and also contributes to the development of innovative and efficient wastewater treatment throughout the world. This nomination focuses on three ground-breaking initiatives implemented to reduce the cost of nutrient removal compliance.

HRSD's York River Treatment Plant DEMON® Sidestream Deammonification Process

A public-private partnership made possible the first operating implementation of the innovative DEMON® sidestream deammonification process in North America. In fact, this was the first operating full-scale installation of any form of anammox sidestream treatment in North America. HRSD and World Water Works, Inc. joined forces to successfully install a centrifuge centrate treatment process previously used only in Europe.

Deammonification, partial nitritation by ammonia oxidizing bacteria (AOB) combined with anaerobic ammonium oxidation (anammox), provides up to 70-90% total nitrogen removal with a 65% reduction in aeration energy, a 100% reduction in supplemental carbon, and an approximate 50% reduction in alkalinity requirements as compared to traditional nitrification-denitrification. The DEMON® process is one of several available forms of single-step (in the same tank) partial nitritation-anammox designed for centrate treatment from anaerobically digested biosolids and operated as a sequencing batch reactor (SBR). While this process had been applied at approximately 30 plants in Europe, it had not been implemented elsewhere in a full scale application, primarily because of the requirements for seeding this process using biomass imported from

operating facilities in Europe. The stability of the DEMON® process has improved in recent years with the addition of a hydrocyclone for selective anammox bacteria retention in the process, and this improvement resulted in considerably more interest in other parts of the world.

HRSD's York River Treatment Plant currently includes a fully aerobic nitrifying activated sludge system with post denitrification filters. Only minor piping needed to be done to install DEMON®, making the project more affordable and sustainable. The system was seeded in October 2012 with 5,000 gallons of concentrated anammox biomass shipped from Europe by mixing the imported anammox biomass with plant effluent. After some minor modifications to the equalization tank were made in November/December 2012, the process achieved operating objectives for ammonia loading and total nitrogen removal in early January 2013.

Project Results: The operational savings associated with the DEMON® process is approximately $200,000 per year. This savings is attributed to reductions in the usage of methanol, sodium hydroxide (caustic) and electrical power for blower operation. Total nitrogen and ammonia removal efficiencies of more than 80% and 90%, respectively, have been achieved. Sidestream nitrogen removal using partial nitritation and anammox has been demonstrated to be an effective tool for improving nitrogen removal performance and reliability while achieving a savings in aeration energy, chemicals (alkalinity and supplemental carbon), and sludge production. This sustainable nutrient removal technology should be considered at any plant with nitrogen or ammonia permit limits and anaerobic digestion. Furthermore, this technology paves the way for continued research and development in the area of mainstream or main plant deammonification and mainstream nitrite shunt. With the added potential of wastewater carbon redirection to energy generation processes, mainstream deammonification could revolutionize wastewater treatment as we know it, allowing cost effective nitrogen removal, while maximizing resource recovery and minimizing resource utilization (chemicals, energy, concrete tank size and land). It has also now been documented that one-step sidestream deammonification technologies like the DEMON® process are beneficial from the perspective of generation of gaseous nitrous oxide (N_2O) as compared to the two-step partial nitritation-anammox processes.

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HRSD's James River Treatment Plant Startup of A Full-Scale ANITA™ Mox Sidestream Treatment Process and Development of A Novel Control Process

The first installation in North America of the Veolia/Kruger ANITA™ Mox process, a single-stage deam-monification moving bed biofilm reactor (MBBR) for treating high nitrogen waste streams, occurred at HRSD's James River Treatment Plant. This process followed the York River DEMON® installation as the second full-scale anammox process in North America, and the third installation of this technology worldwide. In this process, partial nitritation and anaerobic ammonia oxidation (anammox) occur simultaneously within a biofilm attached to plastic carriers. A key component of the process is controlling dissolved oxygen to a low level to limit the growth of nitrite oxidizing bacteria that compete with anammox bacteria for substrate and to limit oxygen penetration into the biofilm, which allows anammox growth in this location. An existing tank at the 20 MGD plant was modified to install the ANITA™ Mox process. Four months after seeding with 10% pre-colonized media imported from Europe, the reactor was achieving greater than 85% NH4 removal at the design loading rate of 2.37 g/m2/day, signaling the end of startup. The ANITA™ Mox system is consistently achieving 80%-90% NH4 removal at the design loading rate. pH based aeration control has proven to be an effective and stable method and is preferred over DO based aeration control.

Project Results: Centrate from dewatered anaerobically digested solids can comprise 15-25% of the total incoming nitrogen load for a wastewater treatment plant, though it represents only 1% of total incoming flow. By treating the centrate sidestream separately, the plant can reduce the nitrogen load on the mainstream process, thereby providing more cost-effective and more efficient overall plant nitrogen removal. The ANITA™ Mox process has proved an economical option for sidestream treatment because of decreased aeration energy requirements, no required external carbon or alkalinity, and decreased sludge production over traditional nitrification/denitrification. TN and NH4 removal has been as expected.

HRSD's Nansemond Treatment Plant Struvite Recovery Facility

HRSD's Nansemond Treatment Plant was the first wastewater treatment facility in the Chesapeake Bay watershed to recover nutrients from wastewater and transform them into a premium, environmentally-safe

fertilizer product, and the second facility in North America. As is common with biological phosphorus removal facilities, phosphorus and other nutrients from the solids handling processes are recycled within the plant and increase the effective nutrient load on the main treatment process. Additionally, phosphorus, ammonia, and magnesium become highly concentrated in the solids-handling process and cause the formation of struvite (magnesium ammonium phosphate). This struvite formation coats pipes, valves, and other equipment, which reduces flow capacities and increases maintenance requirements. HRSD implemented Ostara's Pearl® Process, a highly-efficient and cost-effective technology that 1) recovers nutrients, such as phosphorus and ammonia, from liquid waste; 2) maximizes treatment process capacity and reduces operational costs; and, 3) provides the wastewater utility with a method to offset the capital expenditure of installing the facility through the creation of Crystal Green®, which is marketed and sold by Ostara.

Project Results: Implementing the Pearl® Process has delivered key benefits to HRSD and the wider environment by: Decreasing the centrate nutrient load returned for treatment (reducing the biological phosphorus removal requirement by approximately 25 % and avoiding alkalinity addition for nitrification); Minimizing the use of metal salts for chemical phosphorus removal (lessening the costs of chemical purchase and solids disposal); Reducing the phosphorus content of biosolids (providing a new avenue to remove phosphorus from the system); and, Producing more than 500 tons/year of Crystal Green - enabling mineral phosphate reserves to be conserved and eliminating approximately 4,000 tons/year of greenhouse gas emissions.

Conclusion: HRSD was able to meet its annual mass discharge limits for nitrogen and phosphorus in three different river basins in the first year of compliance (2011) and each year thereafter due to the plant upgrades. Although HRSD was meeting permit, operational cost increases associated with nutrient removal were not sustainable, leading to a focus on implementing improvements to reduce operational costs. These projects are a sample of initiatives that demonstrate commitment to the development of sustainable nutrient removal practices that lower operational costs. This provides economic benefits to our ratepayers along with the environmental and social benefits realized from healthy waterways that enhance the quality of life in Coastal Virginia.