Automated: The broadcast is now starting. All attendees are in listen-only mode.

Bruce Lung: Good afternoon. This is Bruce Lung with the US Department of Energy's Better Buildings, Better Plants program. I'd like to welcome everyone to this April edition of Better Buildings Webinar series. As you know, in this series, we profile the best practices of Better Buildings, Better Plants Challenge and Alliance partners, as well as organizations that are working to improve energy efficiency in US states. Today's webinar, entitled "Because Wastewater Matters," will examine decentralized wastewater treatment. As with distributed power generation, decentralized wastewater treatment refers to localized wastewater treatment users. It can include everything from treating greywater *[audio cuts out]* sludge, to cleaning of industrial wastewater containing heavy metals, greases and chemicals.

We'll hear about two partners, whose presenters will discuss their experience implementing water reviews of treatment systems at sites, as well as the benefits that these systems have yielded. However, first, we will see an overview of market-ready wastewater treatment technologies that can be implemented in buildings, institutions, and manufacturing plants, along with the energy efficiency gains that these technologies can yield. At the very end, we'll wrap up with a question-and-answer session, and then remind everyone about some upcoming Better Buildings, Better Plants events. So, first, let me introduce our first presenters. So, before we get started with the presentation, I do wanna remind the audience that we will hold questions until near the end of the hour. Please send in your questions through the chat box on the webinar screen, and then we'll get to as many of them as we can. I also wanna remind you all that this session will be archived and posted to for your reference, probably about one week after today's date.

Our first panelist is Eric Lohan, from Sustainable Water. Eric is the director of technology at Sustainable Water, and a cofounder of Grayworks. Previously, Eric worked as a general manager for Living Machines. Eric has been involved in the process design of over 100 wastewater treatment *[audio cuts out]* water reuse projects. He is the coauthor of six patents on innovative wastewater treatment technologies, and he's been involved in permitting some of the first decentralized water reuse systems in Portland, San Francisco, San Diego, Atlanta, and other areas in the US. His water reuse projects have won awards from the Water

Reuse Association, twice, the AIA Water Alliance, American Council of Engineering Companies, and the Water Environment Federation.

Eric, go ahead.

Eric Lohan: Thanks, Bruce. So, walk through kind of an overview of decentralized water reuse, and then go through a couple of kind of quick actual examples. So I like to think of water reuse with sort of three main axes; there's a variety of different water , some like rainwater; others like greywater or wastewater it's called *[audio cuts out]* variety of business applications. Typically, we think about irrigation and toilet flushing also makeup water for towers and . And then there's different scales of decentralized water reuse projects, as well. So, typically building-based systems are reusing somewhere less than 10,000 of water, per day. A multibuilding project might be reusing between 10,000 and 100,000 gallons per day. And I think a district-scale system's at a 100,000-gallon per day to one million-gallon per day range.

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So this is a map of different water sources, different treatment steps required for those sources, to reach a given water reuse application. I've sort of listed these in order of yuck factor, if you will, but also in order of how difficult certain water sources are to treat. There's kind of three stages in that treatment process. Primary treatment *[audio cuts out]* process typically includes screenings for any kind of gross solids; some kind of flow equalizations to balance flow source. Typically, there is a secondary biological treatment phase, to remove   constituents that might be in the water. And then finally, depending on the reuse application and water source, there's some kind of tertiary process: filtration to remove suspended solids; disinfection to remove potential pathogens; and RO to remove potential salts in the water. Obviously, between different reuse applications, there's different levels of treatment. For subsurface irrigation, not much chance of public contact, so a lot less tertiary treatment. For a public contact reuse with toilet flushings, vehicle washing, or surface irrigations, greater need for filtration, disinfection, and in some cases reverse osmosis.

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Somewhat similar type of approach for cooling towers and boilers

– obviously, in these types of applications, salt becomes more paramount, and so, the consideration of RO gets greater weight. This is a kind of quick map; there really aren't hard and fast rules, and project by project *[audio cuts out]* need to be evaluated, of course, for given reuse applications.

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So just, honing in on wastewater reuse, and the kind of different sort of metrics that are looked at in designing of water reuse systems. All wastewater reuse systems require some level of BOD removal to remove dissolved organics, some level of TSS removal to remove suspended solids, and typically nitrification to remove ammonia from the wastewater. Beyond that, it's highly dependent on what the source is and what the reuse is, so, public health regulations weigh in, and disinfection is required, as mentioned before, for public contact applications. In certain areas, environmental regulations also apply, for disposal to the environment, for removal of nitrogen and/or phosphorous. But even if you meet both environmental regulations and public health regulations, the water may not be fit for use in certain applications, based on cooling equipment, foilers, or soil conditions. And so, deionization or RO is required in those situations.

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Rainwater's typically the easiest source to collect onsite and to reuse, certainly from a permitting perspective, typically a four-step process. Rainwater's collected off of a roof; it goes through a vortex filter to remove solids that are in the water, such as leaves; a smoothing inlet kind of distributes this into the tank or cistern to prevent roiling. Floating intake connected to a submersible pump is used to kind of preferentially take the cleanest water out of the tank, pump it into the building for reuse. There's typically a skimmer outlet on the overflow, that allows floating pollen or other floating material to be skimmed out of the cisterns during high-level conditions. Water that's pumped back into the building may also be filtered and disinfected before reuse. Rainwater is a great source of reuse when it rains, in climates that have a regular rainfall, or in times of the year when it's regularly raining.

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Greywater reuse is a more reliable source of water throughout the year, in most projects, and greywater is defined as water collected from sinks, showers, and laundries, inside buildings; a particularly good source of water for multifamily residential projects, dorms, barracks, or mixed-use projects. Again, there's typically a multistep process: lint and hair are removed in a screening process, at the beginning; biological treatment will remove dissolved organics in the wastewater. By that point in time, filtration is required to remove any residual suspended solids; some form of disinfection through UV or chlorine is the final step in the process.

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We're sort of stepping up, now, from building-based greywater systems to building-based wastewater systems. And just to give a sort of case study example that always works, treatment systems don't need to look like boxes in your basement. This is a project for the SFT's *[audio cuts out]* headquarters in downtown San Francisco, treating 100 percent of the wastewater from about 1,000 employees, in a wetland-based treatment process. Erin will talk more about the wetland treatments – this process reuses wastewater back into the building for toilet flushing into the building, and also for irrigation around the site.

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So we'll sort of step up in scale, again, from a kind wastewater building-based project to a wastewater district-scale project. This is a project we completed for Emory University, outside of Atlanta, a couple years ago.

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This was Emory's water budget for the year, so about 60 percent of water on campus is used for potable applications, and about 40 percent of wastewater onsite is used non-potable applications. And this is pretty typical of most campuses that we see in the southern portion of the US. It's also typical that the split between heating and cooling water use and irrigation is quite pronounced, as it is here. Irrigation tends to be one of the more visible uses of water, but typically for a district-based treatment system, heating and cooling make up significantly larger amounts of flow. So in general, there's plenty of sewage; that's 60 percent of domestic use available to treat, to meet the non-potable demand.

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This is a quick schematic of our treatment systems at Emory: wastewater is harvested from a sewer lateral running through the campus, pumped through primary screens, into the moving bed bioreactors the top of the screen; it then flows through our sort of indoor hydroponic reactors in the greenhouse. These are treatment reactors with plant roots growing inside the water; the plant roots catalyze an ecology of organisms that help degrade nutrients and other constituents in the water. The project wastewater then flows through a series of outdoor hydroponic reactors, through a clarifier and filtration UV disinfection, into a clean water storage tank, where it's pumped throughout the site.

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A treatment system supplies about a mile of purple pipe, pumping reclaimed water to three campus cooling towers and the steam plant on campus. A second phase – it's under construction, right now, and that will add about an additional mile, and will pick up Emory Hospital and a couple other smaller cooling towers. And there is a third phase already in the works.

Next slide?

So, typically, municipal-scale water reuse projects can take up to a decade for planning, permitting, funding, and implementation. Our project at Emory took little over two years, from initial feasibility through construction and commissioning and startup.

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So, the engineering and planning of decentralized water reuse is often considered a lot more sexy than the operations, but no less important. I think operations are sort of critical, not just for district-scale projects like these, but for building-based systems, as well. The Emory WaterHub today has treated about 150 million gallons of water for reuse; we've offset about 92 percent of the potable water at their three chiller plants, at an overall net reduction in the energy use for infrastructure on the campus.

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Emory project, to my knowledge, is the first project of this scale that was funded by a water purchase agreement. So, Sustainable Water provides funding for feasibility, engineering, design, construction, commissioning, and operations of wastewater treatment plants. So there was no sort of upfront capital by Emory University for the installation of the system or the operations of the system, long-term. And Emory has sort of guaranteed savings based on their water usage over time: as municipal prices increase, their savings increase over that period of time, as well.

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So, I've worked on water reuse project for almost 20 years, now, and I can say that, you know, 20 years ago, people were not this interested in water reuse – we've been pretty blown away by the level of interest in this project and in others. And I think what's most sort of interesting is that water reuse is of interest not just to water organizations and green or sustainable organizations, but also to the Atlanta Chamber of Commerce, and others. So, just a quick recap of kind of the basics of decentralized water reuse, and two project examples.

Thanks.

Bruce Lung: Thank you very much, Eric – that was a great presentation. I think we've got some questions that we're gonna hold to the end, but now I'm gonna introduce our second speaker.

Our second speaker, as you can see on the screen, is Stephen Pierett of Volvo Trucks Mr. Pierett has been the environmental manager, since 1999, for the New River Valley Plant in Delmont, Virginia, the helm of Volvo Trucks, there. And he has 23 years of environmental experience with EPA and DOD contractors, consulting . Over the past 18 years, Mr. Pierett has managed projects for processed wastewater recycling and reuse, certification for both standard performance. They were one of the first plants in the US to get certified, and in 2013 achieved "Zero Landfill" status for the plant, under his leadership. Mr. Pierett has a master's of science in hazardous waste management from Wayne State University, a master's in management from the University of Redlands, and a degree in chemistry from Anderson University.

Stephen, take it away.

Stephen Pierett: Thank you.

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First of all, I'd like to give you some context on the NRV plant situation. It is located about an hour south of Roanoke, between the Blue Ridge and the Appalachian Mountains; the valley is named after the New River, the second- or third-oldest river in the world. The plant is 1.6 million square feet, and paints Volvo and Mac cabs for all North American production, but only assembles the Volvo trucks locally. For purposes of this discussion, I may refer to the plant as a big fish in a little pond, since we were the largest discharger to the regional POTW, in the past.

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As an overview, we'll examine some of the benefits of the system over the past ten years, review a couple of water savings projects, describe how the system became a *[audio cuts out]* management tool for the plant, and discuss an analysis of water savings versus energy savings.

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The water management program at NRV began as early as 2004; we use 2004 as a baseline. At that time, we had usage of some 62 million gallons per year. Since then, the average water use has been about 39 to 40 million gallons *[audio cuts out]*, and we overall have achieved about 40 to 41 percent reduction, on average.

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testing is similar to a high-intensity carwash, but from many angles, testing the cab for leaks before it drives off the lot. Reducing water usage by 22 percent, for this process, was the first major improvement at the plant, in the early 2000s. For that particular testing, it started around 1,100 gallons per truck; we dropped it to 700, or, actually, had a savings of 700 gallons per truck; and the investment was about a half-a-million dollars.

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This is an introductory slide for the second project; our basic dual-train wastewater treatment system is the "WWT" shown in the top-left corner of the page, and that is onsite, the wastewater treatment plant. And, originally, the wastewater system received the processed water from the plant, and was then treated for metals by precipitation. The effluent was discharged by permit directly to the local POTW, publicly owned treatment works. And for the remainder of the slide, the original wastewater recycling system was installed in 2006, and upgraded fully in 2015. The original installation was based on nanofiltration and low-pressure reverse osmosis, or RO. This system required replacement in 2015, and was converted to an ultrafiltration system with a high-pressure RO.

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So what are the drivers for something like that? Sitting in an environmental office, how do you pull this off? So, what are the drivers that would prompt you to spend hundreds-of-thousands of dollars on a wastewater reuse system? Sometimes, it's a regulatory issue that allows an internal environmental requirement to be fulfilled or achieved, when there is a high price tag associated with the change. Sometimes, as it's said, never waste a good crisis: launch towards installing a wastewater reuse system was prompted by a foaming issue at the POTW. Generally, the big fish in the little pond gets the first call. From a corporate perspective, the water position for manufacturing plants was to achieve reuse of all processed wastewater. In this case, there was an impending investment on the horizon. In the analysis, the question is, could we achieve the Volvo goal and fulfill the regulatory requirement, with one investment?

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Compared to other industrial sites for environmental sustainability footprint, the plant's processed water use is small, probably, by comparison to others. For the environmental risk management evaluation, the POTW was also considering additional effluent limits for the region, at the time of   foaming issue. As such, the scenario for the capital investment was a comparison of whether the plant could double the size of the wastewater treatment facility to address the additional requirements, or could we significantly reduce the discharge rate to the POTW by installing a wastewater reuse system with a lesser investment, basically going offline. The end goal was to eliminate all discharges to the POTW, if possible, although we did maintain a permit for possible discharges.

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As I mentioned, we're rather small compared to some manufacturing sites, but we run about 40,000 gallons per day. The influent is primarily from a ten-stage pretreat system, and an electrocoat system for steel cabs, and primarily, at this time, it's for the Volvo product. *[audio cuts out]* the applied technology is a conventional precipitation system for metals, as mentioned before.

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Usage points – the original system was installed with the purpose of servicing non-process use points, including a booth water recirculation system for sludge control. At the time, we did not supply reuse water to processes, to avoid being a scapegoat for future quality issues – didn't want any finger pointing going on, so, we didn't want to take the brunt of that. So, once the paint shop observed that the system was highly reliable and capable of producing high-quality, low-conductivity water – better than city water – there was a transition to direct half the reuse water to the electrocoat system. However, the water quality demands of e-coat did increase the discharge rate to the POTW, lessening the efficiency of the RO system, somewhat. The non-process systems were receiving high-quality reuse water, and at the same time less chemistry was required for maintaining those non-process operations.

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As I stated, the nanofiltration low-pressure RO system was installed in 2006, but signs of wear and tear over time prompted an upgrade to a new system with an ultrafiltration and high-pressure RO, in 2015. Storage capacity also was increased, to improve the water balance between production and nonproduction periods.

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the system upgrade, overall, the upgrade improved the capability to meet the needs of the e-coat system, by allowing treatment conductivities, as listed above. We reduced the solids loading to the ultrafiltration and high-pressure RO system, with additional pre-filter systems, and added water storage to improve the water balance. Overall, the upgraded system further reduced the discharge events to the POTW.

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These are just a few shots, in the next few slides, that kind of give you some idea of the hardware involved in the system. We use UV light for bacteria control, cartridge filtration for a pre-filter.

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On the left, we have the ultrafiltration system, and on the right the high-pressure RO system.

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As part of the process improvement, we've put in a pre-filter system, to take out as much of the solids from the e-coat discharge, before it went to the wastewater treatment plant, to help maintain the conductivity of the overall output of the system.

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Then, as part of that, as we mentioned before in terms of the water balance to address issues that we incurred during the sometimes short shutdown periods over a weekend, or lengthy ones over Christmas shutdown, we added some water storage, to allow us to hang on to the good water as long as possible, and feed it into the plant when the demand was there.

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Overall, the system, we continue to pursue a high reuse rate of 93 percent for process water. And overall, the pursuit of this goal has allowed us to use this system as a metric for the paint process performance as far as water is concerned, much like a blood test for an ailing patient.

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Beyond sustainability – over the past couple of years, we've found that the system had added value for evaluating the overall quality of processed water influent to the wastewater treatment plant onsite. Overall, the quality of the wastewater had been impacting the ultrafiltration system, which reduced recycling rates. In addition, a third-party developing plans for a paint shop expansion had noted, to myself, that the chemical treatment for booth water at our plant was one of the most expensive operations that he had reviewed, and that's pretty much across automotive and truck. Since most of the issues were recent, the financial data was retrieved from the booth water contractor, and it was found that the cost per truck had gradually doubled, or more, over the past few years.

And so, we compared that contractor's data over the past few years, to the early part of the contract '07-'08, and as we show in the next slide, that raised a major red flag for us. You can see on the left, on the bottom, the dark blue, that maybe the cost was a little maybe around $1.00 per truck. That increased up into the $2.00 and $3.00 range, for our chassis units. And then, we started out around $7.50 and $8.00, for the main paint shop for the truck cabs and the plastic parts, and that escalated up into the lower-teens. So, it was definitely a major red flag for us to look further.

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I guess I wanted to add that this discovery alone represented thousands of dollars of excess cost in excess chemistry for treatment, even at the water treatment plant. And over a short time, a new contractor was selected, and they were required to provide monthly performance metrics for the solids *[audio cuts out]* the system, to manage paint overspray removal and booth water management. Although this was a major find for the wastewater treatment plant management system, work continues to improve the reuse rate, as other challenges have been presented by the paint shop expansion with the additional chillers, air supply houses, *[audio cuts out] [brief silence] –*

Bruce Lung: I think we need to *[audio cuts out] –*

[Silence from 0:30:40 to 0:31:10]

Stephen Pierett: – treatment savings for water is approximately $69,000.00 to $70,000.00. In contrast, the energy cost for the system is an additional $18,000.00 per year. But overall, the net savings is $51,000.00 per year, as you look forward. So, as you add on a system, you add on a lot of pumps and a lot of electrical use, but there is a water savings associated with that, that offsets that.

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Then, a couple of years ago, there was an interest whether the system provided any additional benefit to the community or county, in terms of energy savings, because onsite costs you some energy to run that program. But for the offsite, for the county and the community, it was determined that there was very little financial savings, maybe upwards of $100.00, per year, but we calculated that to be about $70.00, per year.

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So this is, in essence, the same slide as we started with, but just reaffirming that these things have been a benefit to – there have been benefits to a wastewater reuse system at the plant. Overall, the benefits have been considerable for the plant, and some major benefits and value added have been over an extended period. In summary, some of these recent developments continue to compensate for the capital investments and ongoing cost of operation of the system.

We are the end of this presentation, and I just wanna thank you for your time and attention.

Next slide.

Bruce Lung: Thanks a lot, Steve – that was a nice presentation and a good example of how a manufacturer can reuse water. I like, also, the benefit to the community *[foreground noise interferes with audio]* one of the things that that the type of wastewater that would get sent to the *[foreground noise interferes with audio]* works is a little different, so now, they focus more on BOD, biological oxygen demand, and *[foreground noise interferes with audio]* .

I'll go ahead and introduce our last speaker *[foreground noise interferes with audio]* Erin English from Biohabitats. Miss English brings 15 years of engineering expertise to the work innovative water planning and wastewater treatment, stored water treatment, and water reuse projects. She her educational background in chemical engineering for advanced ecological wastewater process design and innovation. As a senior engineer for Biohabitats focused on ecological restoration planning and regenerative design, she applies ecological water design through her ongoing daily engineering practice. Her experience includes landmark high-performance building projects that prioritize water reuse, including Living Building Challenge, Net Zero Water, Sustainable Sites Initiative, and various LEED projects. Her portfolio includes wastewater treatment reuse systems for various in D.C., the Boy Scouts of America's West Virginia, and the Omega Institute Center for Sustainable Living in New York. I think Erin's gonna focus on the Sidwell Friends School project, today.

So, Erin, please go ahead.

Erin English: Great, thank you. Hello, everybody.

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So, I'm gonna focus the time I have here for the presentation, today, on a reflection on a project that we've had in operation for ten years, at the Sidwell Friends School, in Washington, D.C. And I'm mostly gonna focus on some of the softer aspects of wastewater treatment, and water reuse, and the idea of integrating these systems into the landscape. *[Audio cuts out]* complements the more technical aspects of the Volvo presentation, and that from Sustainable Water.

So go ahead to the next slide, there.

So, at the Sidwell Friends School, there are three water systems at work, within the courtyard of the middle school. This includes on the upper terrace, as a part of the landscape, a wastewater system component, a storm water bioretention rain garden, and then at the bottom of the hill a biology study pond. Even though all three of these appear to be contiguous, they are not necessarily connected to one another.

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But they appear to be relatively seamless and form part of the landscape. So, this particular project was the outcome of an integrated design project of the big team of architects and landscape architects and engineers that I've listed here. It is also a very award-winning project, one of the first LEED Platinum schools, it is an AIA on the environment top ten, and a US Department of Education Green Ribbon school, among many others. So, a pretty landmark project.

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The project itself was to basically expand and renovate an existing middle school at the Sidwell Friends School, near Washington, D.C. Several hundred middle schoolers attend school inside this building; the wastewater design flow was approximately 3,000 gallons per day, so this was a relatively small project, in comparison to some of the others we've seen, today. One of the main goals was to provide treatment and reuse for toilet flushing, to reduce the building's potable water demand, but also – and arguably as importantly – to showcase, from an educational and immersion perspective, what is possible with ecological design and ecological engineering, particularly for children and for their interpretation.

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So I'll walk you a little bit through what's happening, here. We have a multistage treatment system that begins with a primary treatment tank, which is a glorified septic tank, which is basically out in the front of the building, underground. All of the wastewater from the building is routed to that tank; it has an overflow to the sanitary sewer, so that if the system has to be taken offline, or for maintenance, or whatever, then the water can passively flow to the sewer. So we basically have decentralized the wastewater treatment, but we've maintained our connectivity to the grid, if you will.

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After the primary treatment tank, we come into a series of constructed wetlands, which are on those three uppermost terraces. And those are subsurface flow wetlands; all of the wastewater remains under the gravel, and is spending about two to three days in those wetland cells, being slowly degraded and treated by the plants, and the roots, and the beneficial bacteria living in there. You can walk right across the surface of those gravel wetlands with no problem, so there's no sewage wastewater, here.

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After that, we recycle back through a trickling filter, which is sitting *[audio cuts out]* on that uppermost terrace, there – it's a little tower. That's basically like a showerhead over a bunch of media inside of the filter, that helps provide nitrogen treatment. As you will see at the end, we have a lot of nitrogen in this system.

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We do polishing, with an open bed recirculating fan filter, which is located under the walkway. This provides a high level of clarity, and reduces any odor and turbidity in the water.

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And then finally, in the basement and out of sight, here, is a filtration and disinfection system, using high levels of filtration and UV disinfection. We go down to about one micron for filtration, here, and then the water is reused for the toilets. Any water that's unused is just discharged clean back to the sanitary sewer.

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So that's just a very quick overview, right there, of what I just walked you through. But the idea is that it's a multistage system, using all very low-tech, low-energy, low-sludge processes, that allow the heart of the system – which are the wetlands and the trickling filter – to be exposed within the landscape as a teaching tool.

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So just some shots – there's a really interesting that happens, here, with the seasonality and the feeling of being surrounded by water. This is a springtime shot.

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So, students who are walking on these pathways and who are accessing the site – this is one of the main entrances to the building – are seeing the system over time in different seasons. And it's maintained like a piece of landscaping, like a garden, and so, we don't try to use just tropical plants; this doesn't require a greenhouse. These systems are very much open and connected to nature, and you get the sense of the seasonality of it by experiencing it throughout the schoolyear.

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The biology study pond is not connected to the wastewater treatment system, but it is part of the storm water system, and also part of a recirculating pond and stream feature. So we did incorporate some biological treatment into this system, and it recirculates water as you walk by, students are able to come down and sample and touch the water. And then water, when it rains a lot, it can basically overflow into the adjacent rain garden.

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These are some images of the wastewater system components themselves, which, again, are not connected to the biology study pond or the rain garden, but are immediately adjacent to it, so it's seamless in its form and this idea of being surrounded by water. So, over time, we have worked with the school to help them experiment with different plant species, flowering species, treatment types of plants. The plant species we focus on are those which are known to provide high levels of robustness in wastewater treatment – cattails and bulrush – but we've also been working with them on ornamentals and some other *[audio cuts out]* species.

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I wanted to say a little bit about the education and the interpretation aspects of the project. Obviously, for a school like this to invest in this kind of landscape, you know, they had multiple reasons for doing it. Treating wastewater is certainly one of them, but providing opportunities to get closer to nature and to wildness, for the students, in an urban setting; to give them a place to actually come and study and learn hands-on. They have a robust science program here for the middle schoolers, and so, teachers are bringing students out, they're doing sampling, they're engaging with the infrastructure systems, and that is very much part of the active learning. So, this wastewater and storm water and water infrastructure – the pond itself, also – basically replaced what might've otherwise been a more conventional landscape. And so, you're trading in the idea of the working ecological landscape as a teaching tool, as it's really a beautiful space. And so, having that, I think, was a big part of the motivator for folks.

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They also have an active building dashboard system that shows energy use of the building. The building has all sorts of innovative energy systems, which I'm not touching on here, per se, today. And then water use, and you can track how much potable water is being saved, and how much water is being reused, and how much wastewater is being generated. There's a display in the school, for this; it's touchscreen that the students can use, and there's also access online.

I had a quote I just wanted to read, also, about this interpretation and education part, from one of the teachers, there, who's called Margaret Pennock; she's a middle school science teacher. And what she told us was that: "The wetlands highlight two central goals of the Green Building: to create habitat on our urban campus, and to reduce the nutrient pollution our school contributes to the Chesapeake Bay watershed. We ask the students why they think our school made the effort to build the wetlands system, when our wastewater would otherwise go to the Blue Plains Sewage Treatment Plant, once of the best in the country. Once they understand the nitrogen and phosphorous cycles – these cycles are on display every time they step outside, and they understand in a very concrete way how their actions affect the environment."

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The other thing that has happened at Sidwell, over time, are extensive tours and opportunities to influence policymakers and regulators, and so there's been a number of groups, obviously, that come through. You can see some of the people on the upper terraces, there – you can actually kind of walk into the system and experience it. And so, this has also been a good general thing for all of the people who are in the wastewater decentralized realm, in terms of being able to show off these kinds of systems.

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We've also included some interpretative signage in creative ways: we wrapped the trickling filter with a flowchart, essentially, that shows visitors and students what's happening in the system, and that's located right at the top of the site.

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And then finally, just in closing, I did wanna say a few words about the operations and maintenance of the system. We've had the opportunity to work closely with Sidwell Friends School and their facility staff, and with the local operator. Inside the trickling filter, there – actually, on the top of it – is one of our staff who has had the opportunity to take care of this system, alongside the client, for the last ten years. That's Olin Christy, one of our engineering techs. And, basically, we've provided assistance to the school, in a periodic checkup a few times a year, to just do preventative maintenance and ensure that operations are proceeding smoothly. But they do have their own operators, and we help them. Since this is a relatively unique system, we help them with all of the things to make sure that it's moving smoothly.

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A few very quick lessons learned: From a water quality perspective, there's certainly – on both of these slides, particularly the lower chart, there – there's an immense amount of nitrogen that is generated from schools like this. And so, we had designed the system to be able to treat that nitrogen, and bring it back through the toilets, and remove the rest of the nitrogen on its way through. And so we've definitely seen much higher levels than you would normally expect in residential wastewater. And so, all of this learning has been applied to future systems. We've built many, many systems since this one, but this is just an example of the kind of benefit even us as engineers get with these kind of long-term relationships with the clients and the operators, is to be able to learn from the work, and see what needs to be adjusted, and how things perform over time.

So, that's pretty much the bulk of the information that I wanted to present, and so, thank you very much.

Bruce Lung: Okay, if we can get to the next slide, I just wanted to add some additional resources, right here. And while you guys are looking at those, I'm gonna start teeing up some questions for our panelists.

The first question, for Eric, dealing with the WaterHub, the question is: What is the minimum amount of water use needed to offset the financial hurdles of self-funding? I realize that the rate will have a huge impact. Go ahead?

Eric Lohan: So, we've typically found that somewhere around 50,000 gallons per day, at about $10.00 per 1,000 gallons combined rate for water and sewer. So that's about *[foreground noise interferes with audio]* average. *[Foreground noise interferes with audio]* found somewhere around 50,000 gallons per day of wastewater produced and need for reclaimed water is typically the threshold . But I'll say that we're actually now looking at a few decentralized greywater systems for urban reuse projects and other kind of smaller scale projects, as well.

Bruce Lung: Excellent. Another follow up question for you, Eric: How many billions of square footage did the Emory WaterHub serve, and how much did this district-scale project cost?

Eric Lohan: So, it serves somewhere around 3 to 3.5 million square feet; I don't know how many buildings that is, but dozens of buildings. Total project cost all-in, for engineering, construction, commissioning, was somewhere around $10 million. We've got projects, now, generally ranging somewhere between $3 million and $30 million, in terms of kind of total project cost.

Bruce Lung: Great, excellent. Got a question for Stephen, right here – somebody asked: Who makes the cartridge filter system? And if you can't answer that, can you answer why is it a separate system than the eco filter?

Stephen Pierett: You know, is located in southwest Virginia, and they actually installed the system for us, and they actually put together the nanofiltration system. Some of the materials they use for the UF unit are what we call a PAN UF membrane, and some of the systems also have a ceramic or a PVDF membrane, when necessary. We pull that separately to another filter, because the material, the resins, and such, that go into the electrocoat are somewhat harder to process. So we try to pre-filter that out for the larger particles anyway, and pull that aside, filter it in, then put it back into the wastewater treatment system as part of that batch. But really it's just to protect and ensure protection for the nanofilters – or the UF filter in this case, ultrafiltration – and extend the life of the system by pre-filtering that.

Bruce Lung: Thank you. Got a question, here, for Erin: The questioner said that their understanding is that the District of Columbia would not allow the treated water to be used as potable water. But that students that actually tested the water treated onsite, and also tested the D.C. tap water, have found that the onsite water was cleaner. Is this true?

Erin English: So that's a question I haven't heard, but two parts to that. So, the system is treating all of the wastewater generated by the building, and it's treating it to non-potable standards: to a standard that is suitable for toilet flushing reuse, and it would also be suitable for landscape irrigation. We did not try to, nor did we desire to, meet a potable water standard to, like, drink that recycled wastewater – at this scale, that's not really something that's very appropriative to do. I would be surprised if they found that the onsite water was cleaner than D.C. water, because I do know that the onsite water still has some remnants of nitrogen in it, and it has some remnants salt. So I don't think it's true that the onsite water was cleaner than D.C. potable water, though if you held them up next to one another, they would look very similar to the eye.

Bruce Lung: Another quick question for Eric: What were the keys to assure feasibility to completion time for the Emory project? from Emory project's? *[Foreground noise interferes with audio]*

Eric Lohan: Yeah, so, excellent question. I think early engagement with regulators – Georgia EPD and Municipal Water Authority – were sort of key to that. Bringing them in early in the process, and making them participants in it, and gaining their valuable feedback, I think, . I think knowledge, coming in ahead of time with solid knowledge of the water reuse requirements for the heating and cooling systems was essential. And then, from a practical implementation perspective, working in a design process also significantly set up that timeline.

Bruce Lung: Excellent, thanks. Another question, here, for Stephen – the questioner asked: Your filtration steps has a reject stream, in terms of concentrate, and is wondering if that concentrate does go to the publicly owned treatment works sewer, you're loading to the POTW smaller volume but more concentrated?

Stephen Pierett: Well, everything that we remove meets the permit limits, so that's always verified before we discharge to the POTW. We do concentrate that for some materials in the waste stream, but I guess at the end of the day, the simple answer is we discharge within the permit limit.

Bruce Lung: Great, thanks. Another quick question for Erin – it says: The source of your water *[audio cuts out]* sinks and showers, why are the nitrogen levels so much higher than you expected? *[Crosstalk]*

Erin English: Yeah, this is an interesting question. So, the wastewater we're treating from Sidwell is all of the wastewater generated by the school. So that's toilets, sinks, showers, janitor sinks, et cetera – it's the full wastewater itself, not just greywater. And as part of that, what we have found – and I know Sustainable Water is working on this, too – is that, as buildings become more and more water-efficient, as we get better at water efficiency, essentially, what that means is that the concentration of pollutants go up. So, in a day-use setting like the Sidwell Friends School, it's mostly urine, and with very water-efficient fixtures, and so you get higher concentration. We anticipated that, but also, there have been spikes that were probably beyond typical anticipation, like, numbers that are in the 200-and-over milligrams-per-liter of nitrogen – that's very high. And so, this is a challenge for all people considering doing onsite wastewater reuse systems, in the context of high-performance buildings that incorporate waterless urinals or low-flush fixtures, is that you just have to adapt your systems to address that higher loading rate, basically. And it's doable, it's just, you have to make sure that it's planned for.

Bruce Lung: Thanks very much. Another question for Eric, also related to the Emory University project: During the commissioning, what was the like? If something didn't work as planned, was there a backstop or contingency ?

Eric Lohan: Yeah, excellent question. So, I should've made the point that our non-potable source is always one source heating and cooling complications. So, they always have a potable source, and so, if for any reason we're not able to meet demand at a cooling tower, the potable water valve kicks on and makes up that water. So it's a system that sort of open: if there's a problem with the wastewater treatment process, then we turn off our sewer mining pumps, and all the sewage that was flowing by us continues on down to the treatment plant. That said, it is a complex system; it does have miles'-worth of pipe, and there is a very real commissioning process. We brought the systems on in phases, starting with the biological treatment plant, commissioned it over a period of a couple of months. When it was producing water to desired levels, then we turned on the first cooling tower, and then gradually, gradually brought the whole system online.

Bruce Lung: Okay, excellent, thanks. One more question, here, for Stephen, and this may be something that, Eric or Erin, if you feel inclined to answer, you may do so. The question is: Is LED technology used in the UV disinfection systems? I couldn't remember if you all had that in your presentation, but I've heard that UV disinfection systems may at some point be able to use LED technology. So, Stephen, answer it, go ahead *[crosstalk]*.

Stephen Pierett: Yeah, we're not using it, at this time – it's a fairly recent development at the 254 wavelength – but I have read where it's being developed, and I guess on the cusp of being commercially available – sounds like it would be rather expensive

Bruce Lung: Eric or Erin, any thoughts on that?

Eric Lohan: *[Foreground noise interferes with audio]* there definitely are commercial-ready systems, now. I can't speak to the *[audio cuts out]*, but there are very significant .

Bruce Lung: All right, well, I think that's gonna bring us right up to the fourth earmark, so, I'd like to close and thank our analysts very much for taking the time to be with us, today. Feel free to contact *[audio cuts out]* additional questions. On the last slide you should be seeing their contact information, and questions. You will receive an e-mail notice when the archive of this session is available online. Also, I will make a shameless plug for our Better Building Summit coming up May 15th through 17th – if you haven't registered, yet, please go ahead see the link, right there. And this concludes today's webinar, and the season's webinar series. I'd like to invite you to join us in the fall, for webinars. Thank you very much.

[End of Audio]