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Technologies and Innovative Solutions for Harvesting and Nonpotable Use of Rain and Stormwater in Urban Settings
April 24-25, 2013
Cincinnati, Ohio

Meeting Summary Report

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ABSTRACT

The workshop on *Technologies and Innovative Solutions for Harvesting and Nonpotable Use of Rain and Stormwater in Urban Settings* was held on April 24–25, 2013, in Cincinnati, Ohio. The purpose of this workshop was to identify: (1) innovative strategies currently being employed for the use of urban rain and stormwater; (2) water quality characteristics and standards that are protective of public health; (3) barriers and challenges to use of rain and stormwater; (4) technology gaps, needs and opportunities for innovative solutions, including those requiring further research and development; and (5) potential opportunities for collaboration among workshop participants and regional companies interested in local and national rain and stormwater use markets. Approximately 100 individuals attended. This document contains summaries of presentations, questions and answers, and discussion sessions held at the workshop. A list of common terms and definitions related to water reuse, as well as a list of workshop participants and their affiliations are included as appendices to this document.

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ABBREVIATIONS AND ACRONYMS

ARCSA	American Rainwater Catchment Systems Association
AWS	auxiliary water system
CSO	combined sewer overflow
EPA	Environmental Protection Agency
GCWW	Greater Cincinnati Water Works
HVAC	heating, ventilation and air conditioning
IgCC	International Green Construction Code
L2L	Laundry-to-Landscape (Greywater Program)
LEED™	Leadership in Energy and Environmental Design
MSDGC	Metropolitan Sewer District of Greater Cincinnati
NERL	National Exposure Research Laboratory
ORD	Office of Research and Development
PCR	polymerase chain reaction
QMRA	quantitative microbial risk assessment
qPCR	quantitative polymerase chain reaction
RPZ	reduced pressure zone
SD1	Northern Kentucky Sanitation District No. 1
SFPUC	San Francisco Public Utilities Commission
ZLB	zero liquid blowdown

INTRODUCTION AND OVERVIEW

The workshop on Technologies and Innovative Solutions for Harvesting and Nonpotable Use of Rain and Stormwater in Urban Settings was held on April 24–25, 2013, in Cincinnati, Ohio. The purpose of this workshop was to identify: (1) innovative strategies currently being employed for the use of urban rain and stormwater; (2) water quality characteristics and standards that are protective of public health; (3) barriers and challenges to use of rain and stormwater; (4) technology gaps, needs and opportunities for innovative solutions, including those requiring further research and development; and (5) potential opportunities for collaboration among workshop participants and regional companies interested in local and national rain and stormwater use markets. Approximately 100 individuals attended. This document contains summaries of presentations, questions and answers, and discussion sessions held at the workshop.

APRIL 24, 2013

Opening Remarks
Brewster Rhoads, Executive Director, Green Umbrella and Board Member, Confluence; and Jim Henning, President, Duke Energy Ohio and Kentucky

Mr. Brewster Rhoads welcomed the participants to the workshop and thanked the planners and sponsors. Rainwater is an incredible asset in the Ohio River Valley, and this workshop provides the opportunity to share best practices that allow the use of this resource to decrease costs and meet needs. Researchers in the Cincinnati area perform cutting-edge work that makes a difference in the world. The region also is celebrating a century of federal government-sponsored water research.

Mr. Rhoads introduced Mr. Jim Henning, who welcomed the participants to Cincinnati and the Duke Energy Building. Duke Energy is the largest electric utility in the United States, serving 7 million electricity customers in six states. The company focuses on safety and sustainability, and its generation portfolio is diverse, consisting of several different kinds of electricity generation (e.g., nuclear, gas, coal). The company operates 48 different generating units that use water as part of the energy-generation process for its customers. In honor of Earth Day, Duke Energy recently released its 2012 sustainability report, which outlines the company's five core sustainability principles, namely, to: (1) provide affordable, reliable and increasingly clean energy; (2) reduce its environmental footprint; (3) attract, develop and retain a diverse, high-quality workforce; (4) help build strong and resilient communities; and (5) deliver industry-leading shareholder value, governance and transparency. Finally, Mr. Henning thanked the planners of the workshop.

EPA Remarks and Overview of Regional Water Technology Cluster Efforts
Sally Gutierrez, Director, Environmental Technology Innovation Cluster Development and Support Program, Office of Research and Development (ORD), U.S. Environmental Protection Agency (EPA)

Mr. Rhoads introduced Ms. Sally Gutierrez, who explained that building a sustainable community is the ultimate goal. Everyone has a stake in safe and clean water, which requires energy. The indoor environment is important to human health and well-being, and recreational opportunities are important to the community as well. Partnerships need to be created to move forward and ensure that all communities have a clean, safe water supply.

She thanked Dr. Dennis Lye, Ms. Abby Waits, Ms. Evelyn Hartzell, Ms. Teresa Harten and other EPA staff for their efforts in moving the workshop forward. This workshop addresses an important topic because harvesting and use of rainwater improves water management, particularly in urban areas. Zero discharge for buildings is an attainable goal. There are examples of buildings around the world that can be viewed as markets that can adopt these technologies, which also can be used in residential houses. It is necessary to examine alternate water sources for irrigation and integrate these into urban system practices, ensuring that they are safe and do not introduce risk. She thanked the participants for their leadership and efforts in this area.

Welcome to Cincinnati
Laure Quinlivan, Council Member, City of Cincinnati and Chair, Mayor's Green Steering Committee

Mr. Rhoads introduced Ms. Laure Quinlivan, who welcomed the participants to the city and explained that Cincinnati is working toward being the greenest city that it can be. The Greater Cincinnati Water Works (GCWW) is a leader among utilities, using cutting-edge technology to ensure safe and clean drinking water. Under a consent decree to remove overflows, the Metropolitan Sewer District of Greater Cincinnati (MSDGC) is working diligently to obtain EPA approval to address the consent decree in the most environmentally conscious manner possible. Cincinnati's green efforts include tax breaks for Leadership in Energy and Environmental Design (LEED™) certification and instituting the largest block of renewable energy credits. The Cincinnati Zoo & Botanical Garden is the greenest zoo in the country, and Cincinnati has the highest rate of U.S. urban recycling. Recently, the city passed legislation to allow the reuse of rainwater for toilet flushing. These and many other efforts are earning Cincinnati, known as the "Queen City," the new name of the "Green Queen."

SESSION 1: OVERVIEW OF RAIN AND STORMWATER USE

Session Introduction and Overview—Definitions and Terms
Session Moderators: Maryanne McGowan, Manager, Strategy and Implementation, Duke Energy; and Kevin Oshima, Chief, Microbial Exposure Research Branch, Microbial and Chemical Exposure Assessment Research Division, National Exposure Research Laboratory (NERL), ORD, EPA

Dr. Lye introduced the moderators for the first session, Ms. Maryanne McGowan and Dr. Kevin Oshima, who explained that the agenda was developed with considerable thought. After providing an overview of the workshop agenda, Dr. Oshima explained that the list of definitions that the participants had received with their meeting materials had been provided to ensure that everyone was approaching the issue of water usage in the same manner.

Water Reuse: The 21st Century Opportunity
Doug Pushard, Founder, HarvestH_2O

Mr. Doug Pushard stated that the goal of zero runoff for business and residential areas is achievable. He performed a comprehensive market study, and his resulting vision is net metering for water, in which water is captured and sold to municipalities and other entities. Water is a critical issue, and water rights continue to make headlines across the United States. Current law suits between states and between states and tribes will take decades to be resolved.

The U.S. rainwater market was expected to exceed $1 billion in 2013 or 2014 prior to the recent recession but now is expected to reach this amount in 2018 or 2019. Rainwater should be a substantial market, but $1 billion is not relatively significant. Labor is a small part of the market, but the residential sector provides an opportunity for growth despite existing barriers. Rainwater technology installation is similar between residential and commercial entities, but revenues are significantly different. To be viable despite the small rainwater reuse market, above-ground technology products must have uses in multiple markets. A significant portion of systems do not use filtration, and only one-third of installed filters are made in the United States, which is of concern.

In terms of market distribution, Texas is the leader, with nearly 20 percent of all installed rainwater systems existing within the state. Both drought and excess water drive interest in rainwater technologies. As a result of recent droughts, use of potable rainwater is allowed in Atlanta, Georgia, which is one of the few U.S. cities that allow such use. Hawaii does not have significant water issues, but it is completely dependent on rainwater for all of its needs, including drinking water. There are supply- and demand-side drivers for rainwater industry growth, but there are several growth inhibitors as well, such as the economy, lack of government support and industry standards, and the fact that rainwater is not included in discussions. Importantly, rainwater regulations often are more stringent than well water regulations despite the fact that rainwater is cleaner than surface and groundwater.

There are many different conflicting guides being developed across the United States by various levels of government. Templates or a master guide from a large entity that can affect multiple jurisdictions are needed. Regulations and incentives work to increase water conservation, and the federal government can lead by example and implement zero-runoff strategies at federal buildings. Other potential solutions include: funding and developing a relevant database similar to the U.S. Department of Energy's Database of State Incentives for Renewables and Efficiency, creating sample rainwater usage guides that can be used by local and state governments, rationalizing water quality standards, and funding grants to research and develop U.S. products and technologies. Rainwater needs to be part of the solution rather than a problem. Although the rainwater market is growing, it is extremely fragmented, and regulations and incentives vary greatly from state to state and within states. There are many actions that can be taken, but the discussions must be initiated immediately.

San Francisco's Nonpotable Water Programs
Paula Kehoe, Director, Water Resources, San Francisco Public Utilities Commission (SFPUC)

Ms. Paula Kehoe explained that SFPUC works on three enterprises within the city and county of San Francisco, California: water, wastewater and energy. The majority of the Hetch Hetchy Water System was built in the early 20th century, with some built in the late 19th century. In response to the aging and vulnerable water infrastructure in the area, a $4.6 billion Water System Improvement Program, which includes water supply diversification, was implemented. The effort, which is 70 percent complete, has included the repair, replacement and seismic upgrade of the system's deteriorating pipelines, tunnels, reservoirs, pump stations, storage tanks and dams. SFPUC also is embarking on major sewer system improvements, including green infrastructure, during the next 20 years via its Sewer System Improvement Program. These capital improvements will improve regulatory permit compliance, system reliability and functionality, and sustainable operations of the sewer system and wastewater treatment plants.

The SFPUC approach to water reuse is occurring on multiple scales (e.g., building and district scales), and area implementation of water reuse is driven by requirements and incentives. The city's recycled water ordinance affects large new developments and irrigated landscapes and requires recycled water systems for toilet flushing, irrigation and cooling. San Francisco's stormwater design guidelines establish performance measures, provide guidance on compliance and development of a stormwater control plan, and encourage the use of green infrastructure to meet the established performance measures. Within these guidelines, opportunities to collect and use alternate water sources are being examined.

At the building scale, residential programs include those focused on rainwater harvesting (via cisterns and rain barrels) and greywater. San Francisco residents can purchase SFPUC-subsidized cisterns and rain barrels to harvest rainwater for use. Public outreach on the topic is accomplished through a website and technical workshops; a manual is in development. The Laundry-to-Landscape (L2L) Greywater Program allows San Francisco residents who meet certain criteria to receive subsidies toward L2L kits and free training and technical support. SFPUC is using the program to collect data and assess the market and feasibility of such systems in San Francisco. Following 1 year of use, one-third of the sites decreased their water use, and the other two-thirds of the studied sites increased their water use; analysis is ongoing.

Beyond the residential scale, the Watershed Stewardship Grant Program funds sidewalk landscaping, rainwater harvesting and green infrastructure projects at the community level and also provides opportunities for education and outreach to further engage the community. For example, 20 area public schools have used grants to install rainwater harvesting systems. To set an example for onsite water reuse, the new SFPUC headquarters building harvests rainwater and collects, treats and reuses its black and greywater, reducing water use in the building by 60 percent. Several other buildings in the San Francisco area also have proposed onsite nonpotable water projects.

Integrating onsite nonpotable water systems can be challenging. There are several regulatory challenges, such as permitting issues and water quality standards. For example, current California codes only address two types of alternate water sources: municipally supplied recycled water and onsite greywater for residential subsurface irrigation applications. A 2013 update to the California Plumbing Code will expand onsite greywater reuse standards and include onsite rainwater standards. Although the California Plumbing Code provides construction requirements, the question still remains regarding which entity will provide ongoing operation and maintenance of alternate water source systems to ensure the protection of public health and the public water system. This question led the city to develop a new ordinance that mandates that SFPUC is responsible for program administration, the San Francisco Department of Public Health is responsible for public health, and the San Francisco Department of Building Inspection is responsible for construction. Within each of the three basic project phases—design, construction and operation—the program includes steps to help projects move through the regulatory process. SFPUC also provides technical assistance and financial incentives. A water use calculator was developed that helps to calculate the grey and blackwater potential and water demands of a project. Costs for onsite treatment systems can vary but generally make up approximately 3 to 5 percent of the building cost; the most significant costs are the dual plumbing and collection systems for greywater applications. To encourage the use of such systems, SFPUC has developed a grant program for large alternate water source projects that meet certain criteria.

After months of discussion, a nonpotable water identification system using colored pipes and labeling/signage was implemented. Makeup and backup systems are required with the same backflow protection requirements as potable water. Recycled water quality criteria are consistent with state codes. The San Francisco Department of Public Health will permit onsite systems and require monitoring and reporting at a frequency determined by the type of water. Foundation drainage requires monitoring and reporting because of leaking sewers and the presence of volatile organic compounds.

District-scale projects are defined as those that share water between two or more buildings. SFPUC is identifying the regulatory hurdles associated with these systems and evaluating public and private ownership models. District-scale projects from all over the world were examined, resulting in the identification of 30 case studies. Regardless of size, district-scale water reuse is being undertaken across the United States and in countries around the globe. Potable offset goals and drivers vary; some drivers include need, government mandates, marketability and motivated developers. SFPUC also examined the role of public utilities in the projects, determining that public utilities owned the majority of the systems in place. This information can be used in conjunction with San Francisco's current development "boom" of more than 80 planned or in-progress large projects, many of which are located within the recycled water zone. These projects could take advantage of the updated California Plumbing Code, which allows sharing of greywater if there is an agreement between adjacent property owners; water rights are not an issue as there are no downstream water users. There is a need, however, to work with the appropriate state agency regarding irrigation.

Ms. Kehoe outlined the next steps, which are to amend the nonpotable ordinance to address district-scale water-sharing opportunities, including the necessary legal agreements, and establish a grant program to encourage district-scale applications. Future planning will consider which scale works best for water reuse. There has been discussion about forming a coalition of counties to consider appropriate policies and implementation for use of alternate water resources.

Reuse, Energy Needs and Incentives
Maryanne McGowan, Manager, Strategy and Implementation, Duke Energy

Ms. McGowan stated that Duke Energy has been serving its customers for more than 150 years and has been named one of North America's leading companies for 4 consecutive years in a measurement of financial, environmental and social performance. The company also retains its position on the Dow Jones Sustainability Index for North America. Duke Energy's aspirations are to decarbonize its power generation and help to make the communities it serves the most energy efficient in the world. To achieve these goals, the company has built more efficient generation units, retired its older coal-fired units and replaced less-efficient analog technology with advanced digital technology. Duke Energy has made energy efficiency the "fifth fuel."

Population growth, increasingly stringent environmental requirements and increasing customer concern about water quality are expected to raise electricity demand and consumption in wastewater treatment plants during the next decade. Therefore, the ability to provide services in an energy-efficient manner is increasingly desirable. Sustainability initiatives are becoming commonplace among business trends, and federal and state energy reduction goals are in place. Green roofs, permeable pavements and rainwater use provide opportunities for water and energy savings. There are, however, many challenges in the water sector, including aging infrastructure, reduced budgets, and legislative and regulatory issues.

Energy management is important because it is the largest subset of a facility's environmental footprint. Energy efficiency provides financial returns that can be used to implement additional green features and strategies. Additionally, energy represents the largest controllable cost of providing water and wastewater services to the public. To increase energy conservation and efficiency, companies should have a highly visible strategy for going green, including educating employees to reduce energy at work and home by engaging in energy-saving behaviors. A sustainable energy management plan, including water reuse, provides a strategy for continuous improvement in energy performance over time and demonstrates environmental stewardship and financial responsibility. In the traditional energy utility model, utilities earn a return on capital invested in power plants; in the new utility model, utilities earn a return on capital invested in energy efficiency. The new model is more cost-effective for customers and better for the environment. In line with the new mode, Duke Energy has implemented a number of energy-efficiency programs, including energy assessments, nonresidential incentives and a demand response program.

Regional Water Reuse Utilities Perspective: Rainwater Harvesting in Northern Kentucky
Samantha Brown, Environmental Engineer, Water Resources Department, Northern Kentucky Sanitation District No. 1 (SD1)

Ms. Samantha Brown explained that SD1 serves three counties in Northern Kentucky, protecting public health and the environment through wastewater and stormwater management for 30 cities and a portion of three unincorporated counties. SD1 is a special government entity established by the state in the 1940s to treat wastewater; it is not associated with any city or county government in a regulatory manner. SD1 took over the sanitation infrastructure in the 1990s and the stormwater infrastructure in the 2000s. SD1's watershed-based consent decree—signed by EPA, SD1 and the Kentucky Division of Water in 2007—requires the development and implementation of watershed plans to eliminate sanitary sewer overflows and reduce combined sewer overflows (CSOs). The plans, which are the first watershed-based plans in the United States, will be updated every 5 years. Water quality will be addressed in terms of stormwater runoff and dry weather sources. The first plan was submitted to EPA in June 2009; a revised draft based on EPA feedback was submitted in March 2011. SD1 still is awaiting approval of these plans. Currently, the deadline to meet the requirements of the consent decree is December 2025. SD1 also manages National Pollutant Discharge Elimination System regulations on behalf of 30 cities and three counties.

Much of managing stormwater runoff in Northern Kentucky focuses on postconstruction stormwater management. Rainwater harvesting is a potential solution with many benefits (e.g., reduced flooding, erosion and CSO volume), but it also has many challenges, such as decreased revenues and uncertain regulatory authority. SD1's Green Infrastructure Partnership Program is a financial incentive program for nonresidential property owners located in the combined sewer area to implement postconstruction stormwater controls with the goal of reducing combined sewer overflow volume. Projects are evaluated for participation in the program based on cost-effectiveness of the control and business-case evaluations. The Disconnection–Redirection–Infiltration Program is a voluntary residential program that provides public education and outreach about downspout disconnection, rain barrels and gardens, and infiltration drains. One example of rainwater harvesting in Northern Kentucky is the Prisoner's Lake Project. In an effort to reduce CSOs, SD1 partnered with the City of Covington to capture and store stormwater runoff in Prisoner's Lake that then is utilized to irrigate a nearby golf course owned and operated by the City of Covington. Advantages of this project include reduced CSOs, rate-payer benefits and decrease irrigation costs for the city. Two schools in the Kenton County School District collect and store roof runoff to use for toilet flushing and football field irrigation. Although SD1 did not participate directly in the school projects, it maintains a technical partnership with the school district to promote postconstruction storm water management.

Regional Water Reuse Utilities Perspective: Rainwater Harvesting in Cincinnati: A Sewer District's Perspective
Andrew Reynolds, Environmental Planner, MSDGC

Mr. Andrew Reynolds explained that the MSDGC is a publicly owned and operated wastewater utility that serves a population of 855,000 in 49 different jurisdictions in southwestern Ohio. The largest environmental challenge to the more-than-100-year-old system is CSOs. The 212 CSO locations handle 11.5 billion gallons of sewage annually; the area receives annual rainfall amounts similar to Seattle. The MSDGC is under a consent decree to decrease CSOs and is focusing on hybrid grey/green solutions. Information is available at http://www.projectgroundwork.com. The sewer district is investigating rainwater harvesting to reduce CSOs to comply with the federal consent decree. Rainwater harvesting reduces peak stormwater flows within the CSO system and lessens the strain on MSDGC's collection system, both of which reduce the likelihood of CSOs. There also is the potential to enter into public-private partnerships and raise community awareness about stormwater and rainwater harvesting. If a harvesting system (e.g., cistern) is in place, it can remove the need to draw in additional city water for nonpotable uses during wet weather, and it can detain a portion of the rainwater that would have otherwise contributed to peak flows. There are, however, concerns about and challenges to harvesting rainwater, such as revenue stability and the need to ensure accurate billing for provided sewer treatment services.

MSDGC is implementing a three-prong approach to sustainable infrastructure solutions: (1) direct-impact projects, (2) enabled-impact projects, and (3) an "inform and influence" effort. More than 30 public and private enabled-impact projects have been implemented throughout the Lower Mill Creek watershed, capturing more than 40 million gallons of stormwater annually. This is an example of how sustainability projects can result in public and private benefits. Complementing rainwater harvesting is a program that offers low-interest loans for green roof construction; rain barrels are available for purchase from MSDGC as well. The district currently is developing planning tools (e.g., sustainability LENS) to facilitate private investments and a simple model to calculate cistern size based on roof size and water demand. The model can help to minimize the per gallon cost invested by building owners. MSDGC also was part of a task force that led to the adoption of new rainwater harvesting legislation in Cincinnati. To encourage broader use of rainwater harvesting systems, the MSDGC is considering establishing a flat billing structure for single-family homes. Mr. Reynolds summarized that MSDGC, in collaboration with other stakeholders, will continue to educate residents and business owners about the joint benefits that can be realized through rainwater harvesting and provide assistance to those interested in taking advantage of rainwater harvesting opportunities.

Q&A and Discussion

Dr. Oshima opened the floor to those who had questions for the session speakers.

Is pushback about the combined billing of sewer and water an issue in Cincinnati? Mr. Reynolds responded that in examining billing in relation to rainwater harvesting, the sewer bill increases more than the water bill. MSDGC, GCWW and the City of Cincinnati's Stormwater Management Utility will be forming a new joint utility, so billing approaches may be discussed further as the joint utility implementation process advances. A participant added that rates are affected by decreased consumption, and this must be considered; rates have increased by 77 percent in his area.

One benefit of managing stormwater is decreased stress on the sewer system. Is the cistern the end product? Mr. Reynolds responded that effectively the cistern is the end product and can change nonpotable usage.

Who is the contact within the Kenton County School District about going green? Ms. Brown replied that the schools generally contact SD1. The Kenton County School District performed a great deal of internal work and brought in its own partners. The school district has two to three staff members dedicated to sustainability. Ms. McGowan added that schools in the area are very green and develop their plans in partnership with organizations that can help them achieve their sustainability goals.

What is the potential reduction in cost related to CSOs? Mr. Reynolds replied that this is what the model under development is attempting to show. Once the cost benefits for MSDGC can be determined, incentives can be targeted to maximize benefits.

What were the criteria used to create San Francisco's recycled water zone? Ms. Kehoe explained that the area was chosen because it was a "blank slate" prime for redevelopment after military and industrial occupants left the area.

Are independent sewage disposal plants being examined in terms of treatment and use of rainwater on site? Dr. Oshima responded that EPA is interested in additional research and technology development in the area of smaller, less centralized systems.

Dr. Oshima stated that the workshop organizers had developed several questions relevant to the session for the participants to consider. The questions and participants' answers are summarized below.

What are the most likely onsite uses for rain and stormwater in the region?

- Common uses include irrigation, toilet flushing and large wash systems for trains, buses and other large vehicles.

- Standards for groundwater replenishment established by York, Ontario, Canada, can be used as a model.

What are the drivers/incentives for nonpotable usage in the region?

- There are not enough incentives for rain barrels and larger systems; these incentives are needed as the benefits outweigh the loss of revenue. All other major sectors (e.g., energy, gas) have massive federal government support.
- Regions are very important in discussions about water reuse, and different regions have different needs. Regional guidelines should be in place to address these differences as it will be difficult for EPA to establish a single guideline that applies to all regions.
- Education (public, institution) is an incentive.
- Financial incentives are the number one driver.

What are the barriers/obstacles for nonpotable usage in the region?

- There is a paradox in that sustainability, resource recovery and water conservation are affecting current business models. Water conservation affects revenues; therefore, business models may need to change. Will municipalities change their business models to maintain economic viability while conserving water?
- Increasing rates is unpopular ("political suicide") but a fundamental issue that needs to be considered.
- An important barrier is the current regulatory framework.

What can be done to improve the acceptance/implementation of onsite usage?

- It is important to communicate any rate increases and what they will be used for. A "balancing act" is necessary. San Francisco, which has experienced a $67 million loss in revenue based on water conservation alone, is examining different rate structures to address current and future rates.
- A common question will be in regard to return on investment. Water rates do not pay for all necessary water infrastructure.
- Examining the big picture and how to achieve the ultimate goals is necessary.
- Combining drinking water, wastewater and stormwater operations/entities would be helpful because all three share infrastructure and common problems and collectively could accept the cost of water recycling. How siting and use could be completed on a watershed scale could be examined and, if feasible, funded as an initiative.
- Informing regulators that public health will be protected helps to improve acceptance.

What additional information/research is necessary?

- The definition of "sustainable" must be established. Once this is accomplished, the true cost of water must be identified and considered. Revenue loss is perceived because the true cost of water has not been analyzed. Research and cost analysis of the true cost of water will help cities understand how to build sustainability.

- Measuring and capturing natural services (i.e., how nature captures and recycles water) is important, as is research regarding how to satisfy necessary societal functions with minimal energy costs.

- Researchers must study the best way to use nonpotable water; there will not be one single best answer.

- The biggest concern appears to be loss of revenue. Can information be provided that changes the manner in which individuals consider wastewater? Wastewater treatment plant energy can be harnessed to increase revenue. Wastewater flow has a different value compared to drinking water. Population increases will ensure a steady flow of wastewater (i.e., nutrients); therefore, research on the separation of nutrients at the wastewater source rather than at the wastewater treatment plant will be beneficial. Stanford University is performing similar research under its Renew It Program.

- Research regarding how to use rainwater for potable uses also is needed.

SESSION 2: CURRENT BEST PRACTICES AND CASE STUDIES

Session Introduction and Overview

Session Moderators: Tre Sheldon, Vice President, The Sustainability Partnership of Cincinnati and Co-Chair, Cincinnati Green Umbrella Watershed Action Team, Green Streets, LLC; and Dennis Lye, Senior Research Microbiologist, NERL, ORD, EPA

Dr. Lye encouraged the participants to provide comments and ideas about the definitions that they had received in their meeting materials. Mr. Tre Sheldon explained that the session would feature examples, best practices and case studies of rain and stormwater harvesting and reuse systems for nonpotable purposes. In addition to providing descriptions of innovative strategies, technologies, applications, products and services, the presentations also would highlight educational and research components, cost/benefit impacts of application, key challenges for implementation, and the scientific studies and technology needs necessary to expand opportunities for future rainwater harvesting projects.

Case Studies: Rain and Stormwater Management at the Cincinnati Zoo and Botanical Garden

Mike Warren, Product Manager–SkyHarvester®, Watertronics, Inc.

Mr. Mike Warren explained that the Cincinnati Zoo and Botanical Garden approached his company about using stormwater for various uses including irrigation, toilet flushing and as makeup water for animal habitats and moats. The resulting installed SkyHarvester® system treats stormwater to the desired quality and delivers this water at a rate of 60 gallons per minute. Rainwater is collected, channeled into a belowground storage system and pumped to an ultrafiltration system before being stored in a filtered water tank; a booster pump allows water to be repressurized and delivered to the zoo. Approximately 60 percent of the water is sourced from the parking lot, with the remainder channeled from catch basins, roof drains, pervious walking paths and exhibit space.

The best method to filter water is at the source. The system prefilters sand and debris prior to ultra-filtration. A mechanical component of the system is the pump, which is activated based on the water level in the storage tank. The system works via a variety of computerized controls (e.g., color touch screen, pressure regulation) and uses ultrafiltration, a type of membrane filtration that forces liquid under pressure against a semipermeable membrane material with microscopic pores. This method ultimately removes microscopic suspended solids and various pathogens from the water source. It is important to note that some recovered water may be tinted despite being of acceptable quality; palatability is a water quality driver. Ultrafiltration was chosen as the filtering method for the zoo because of uncertainty about what level of water quality was required for animals; the membrane pore size chosen in the zoo system removes more than 80 percent of total suspended solids.

Other applications of SkyHarvester® include toilet flushing and vehicle washing. The Otsego Local School District in Ohio has installed the system with two belowground tanks to harvest water from the school roof for toilet flushing. City water is used as a backup system. Oakville Transit in Ontario, Canada, has installed SkyHarvester® to supply water to its vehicle wash system.

Cincinnati State Technical and Community College Green Infrastructure Stormwater Management System
Ralph Wells, Professor, Civil Engineering Technology Department, Cincinnati State Technical and Community College (Cincinnati State)

Dr. Ralph Wells stated that the Green Infrastructure Stormwater Management System was installed between 2009 and 2011 on Cincinnati State's 40-acre main campus under the leadership of the school president. The two-phase project, the largest completed within the program, was funded by MSDGC to lower rainwater runoff into the sewer system in an effort to meet the requirements of a federal consent decree. Because the campus sits on top of a hill, its neighbors' properties at the bottom of the hill were flooded from campus rainwater runoff following wet weather events. Working with MSDGC on this issue allowed the school to help resolve the problems with its neighbors.

The project includes a data logging control system that will be available to the public online once it is completed; EPA and MSDGC currently have database access. The results of the work are being used in a laboratory setting for educational purposes, providing teaching opportunities for students earning degrees in either sustainable horticulture or environmental engineering (stormwater) technology. The college also is interested in allowing other educational institutions (e.g., University of Cincinnati) to use this for academic work (e.g., graduate research).

The project was completed in two phases, with more than 75 species of native or native-adapted plants planted as a part of the effort. The $1.3 million cost of the first phase was shared by MSDGC and the college, whereas MSDGC fully funded the $1.6 million second phase. A large surface parking lot was rebuilt with permeable pavement during the first phase. Water flows to a series of rain gardens and eventually to a bioretention basin. During the second phase, permeable pavers, rain gardens, two underground cisterns and one roof rainwater collection cistern were installed. The collected water is used for irrigation. As the college is a designated emergency food and energy source for the community, the goal was to serve as an emergency water source as well, but there were issues regarding the potable use of the recycled water.

The stormwater controls will be monitored by EPA and MSDGC to gauge their effectiveness, and the rainwater diverted from the sewer system will be measured and monitored. It is estimated that this project will result in 8 to 10 million gallons of stormwater diverted from the grid annually. To increase the educational component of the project, tours are provided and more than 50 instructional plaques have been installed and mounted around campus for individuals wanting to learn about the project. Additionally, a weather station funded by the EPA has been installed on campus, and the data acquisition system for this weather station will be integrated into the Green Infrastructure Stormwater Management System. Data from the weather station also will be available to the public on the Web.

Sustainable Water Management Solutions
Ed Beaulieu, Chief Sustainability Officer, Aquascape, Inc.

Mr. Ed Beaulieu explained that Aquascape's building outside of Chicago features a native Chicago prairie on the roof, an ecosystem pond and other green components. He noted that the recent tendency of weather and climate to go from one extreme to another (e.g., floods followed by droughts and vice versa) is challenging. A typical one-quarter acre suburban property will generate 3,800 gallons of runoff during a 1-inch rain event; 90 percent of suburban runoff becomes urban runoff. By implementing rainwater harvesting, native plants and permeable paver walkways, this runoff can be reduced to 450 gallons.

Mr. Beaulieu described one of his company's rainwater harvesting solutions (RainXchange™), which includes permeable pavement and underground tanks made of recycled material that are modular in nature to provide flexible configurations during installation. The system utilizes biological filtration to ensure water quality. Individuals who install these systems become more connected to their water source and the watershed in which they live; ultimately, it allows them to understand the bigger picture of the water cycle. Mr. Beaulieu highlighted residential projects in Illinois and Massachusetts via several photographs of the installation processes and completed systems. Decorative water features, such as recirculating fountains, add an aesthetic value to the landscape and serve as a filtration system that cleanses and aerates the water. The filtration and biodiversity are similar to those of a rain garden. Commercial installations include an equipment washing station in Illinois and Phipps Conservatory in Pittsburgh, Pennsylvania.

Other projects included constructed wetlands, which use wetland filter technology developed in the late 1970s and early 1980s in rural Alabama and Mississippi. The technology exceeds all EPA regulations for discharge of water into stream systems, creating a highly oxygenated zone that maintains consistent dissolved oxygen levels. The resulting wetlands provide habitat for a variety of wildlife. The technology, though simple, provides water clarity with no foul odors. Finally, Aquascape launched the Green Community Makeover Movement during which more than 30 projects were installed in homes in one neighborhood to allow the capture 18,250 gallons of water during a 1-inch rain event. Mr. Beaulieu commented that managing the runoff at individual homes will allow the management of the overall problem. Currently, the solution is to manage the receiving water bodies, but if water is managed prior to being received by these bodies, other problems (e.g., algal blooms) will be alleviated.

Blue Roof Technologies—An Old Design With a New Twist
Paul Mitchell, Administrator, Strategic Initiatives and Alliances, Tremco Roofing and Building Maintenance Division

Mr. Paul Mitchell explained that built-up roofing, designed for level roofs that retain water, contain two separate applications of bitumen and surfacing. Coal tar pitch, a commonly used long-lasting bitumen, has been declared a carcinogen. A new roofing definition has emerged, that of "blue roof," which slows or stores stormwater runoff via various nonvegetated flow controls. The water can be temporarily stored or harvested, provide direct groundwater recharge or be discharged directly into sewer systems at a reduced flow rate or after peak storm flow. The goal is to mimic preconstruction runoff rates at the site to reduce or prevent localized flooding and CSOs. Recreational blue roofs integrate rooftop waterplay areas that also can be used to irrigate a green roof. Blue roofs are less costly than green roofs and can provide sustainability benefits through rooftop cooling.

Although the International Building Code, which is in place to protect building residents, did not cover use of roofs for harvested rainwater or storage, it has been updated to consider roof water drainage and storage via positive slope ("slope-to-drain"). Roof drainage also invokes three sections of the International Plumbing Code. It is important to note that building technology has changed in the past 20 to 30 years, and new building methods may not support a blue roof because water storage may add weight that the building structure cannot sustain. Also, roofing issues (e.g., building collapses, electrocution) have been top sources of litigation, insurance losses and building maintenance cost, and manufacturers' warranties are voided by lack of adequate drainage resulting in ponding water. Standing water on roofs is generally avoided in the construction phase and can have unintended consequences, such as increased cases of mosquito-transmitted West Nile virus, Legionnaires' disease and mold. Because water is considered the "universal solvent," it can cause decay of some building materials.

An alternating blue and green roof system in the Bronx (a borough of New York City) is being initiated that will manage more than 240,000 gallons of stormwater annually and decrease CSOs to the East River. Another project in the nearby borough of Queens will compare side-by-side blue and green roofs on the rooftop of a public school. Special requirements for the New York City projects include a secondary waterproofing membrane, unrestricted overflows, water storage of not longer than 24 hours and water depths not to exceed 4 inches. The blue roof design must consider the area's 100-year rain event, but the recent Hurricane Sandy exceeded this rate by nearly one-half of an inch. Forensic structural engineers are needed to examine the design and construction of blue and green roofs to ensure that they are safe; equipment servicing could be a safety issue as well. Finally, some data indicate that green roofs may detain water more effectively than blue roofs.

Q&A and Discussion

Dr. Lye opened the discussion to allow participants to ask questions about the first four presentations of Session 2.

What is the expected life of the RainXchange™ modular components? How can maintenance be performed on them? Is there a problem with freezing in colder climates? Mr. Beaulieu replied that according to the manufacturer the life expectancy is 50 years; they have been installed for 20 years in Australia with no problems. There are inspection ports that allow inspection from the bottom, with cleaning recommended during dry periods. Freezing has not been a problem because airspace in properly maintained permeable pavers provides thermal insulation. When the system was installed underneath roads in New Brunswick, Canada, even the road surface did not freeze during the winter.

What is the cost differential between steel and fiberglass in the RainXchange™ system? Mr. Beaulieu responded that there were many factors that were used to determine this. There is increased flexibility based on the conditions and needs.

Are filtration units required in the RainXchange™ system? Is the water safe for human contact? Mr. Beaulieu explained that biological filtration has been used successfully, with bacteria and enzymes also added to outcompete pathogens. Copper/silver ionization is used for drinking water systems in developing countries.

Was the issue of deicing salts addressed in the system installed in the Cincinnati Zoo? Mr. Warren said that this was out of the scope of his involvement, but it was possible that the zoo addressed the issue.

How do the various systems deal with extreme changes in pH? Mr. Beaulieu replied that the RainXchange™ system is inert to pH because of the nature of rainwater; the extremes are just below neutral (approximately 6.0) to approximately 10.0. Lime rock can be added to acidic water. Mr. Warren agreed that his system is similar because it collects rainwater.

What is the energy cost per gallon to treat water for ultrafiltration? Mr. Warren responded that it is similar to screening filtration. The cost of running the system essentially is the cost of running the pump at a pressure of 60 pounds per square inch. Mr. Beaulieu added that in terms of a carbon footprint, drinking water systems and stormwater management are responsible for 10 percent of the electricity consumed in the United States. Onsite rainwater management consumes 1 percent or less compared to traditional methods, so it is very cost effective.

What is the residence time of a constructed wetland? Mr. Beaulieu explained that the residence time is short because it is a closed system.

Tremco Headquarters Renovation Water Reuse Case Study
Mary Ann Uhlmann, Environmental Horticulturist, Tremco Roofing and Building Maintenance Division

Ms. Mary Ann Uhlmann explained that the recent renovation of her company's headquarters building included the installation of a vegetated roof and rainwater harvesting system. This allows the company to actively demonstrate its "Building Solutions Group" products. The vegetated roof, consisting of 46 species of native plants, uses an engineered growing medium that absorbs most of the rainwater during rain events, which decreases the amount of runoff to the sewer system. The roof's insulating qualities also help to moderate building temperature. Every part of the roof was optimized for the urban garden, with any stormwater runoff collected in a ground-level storage tank designed to provide 100 percent of the annual irrigation demand for the facility.

Because plant palettes vary in their water needs, a list of desired plant palettes was identified, and the water capture system was designed to meet the irrigation needs of the palettes following calculation of transpiration ratios and other relevant factors. The system is designed to capture water from the asphalt pavement while addressing petroleum, salt and particulate contamination. A storage vault was installed near the parking lot, and captured water moves through particulate and oil-absorbing filters to six storage cisterns before being pumped to the roof. There is a potable water backup, and multiple zone run times avoids pump cycling. The system, which is integrated into the automated building management system, is constantly monitored and generates weekly reports. Irrigation water and growing media are tested annually to monitor for contaminants and provide information for prescriptive and corrective maintenance protocols. The daily effort to manage water from a limited resource has made a change in company employee attitudes about water; no other effort could have affected such a change in habits.

Reuse of Alternative Water Sources for Cooling Tower Systems—Two Case Studies Using Nontraditional Water Sources
Matt Haikalis, Technical Resource Engineer, Veolia Water Solutions and Technologies

Mr. Matt Haikalis stated that there are many operational priorities and challenges for cooling tower systems, including water quantity and quality, discharge options, performance, reliability, and energy supply and efficiency. Water resource recovery priorities include conservation of fresh water, elimination of fresh water contamination, and increased utilization of grey and wastewater. Cost-feasible technology is needed to expand the use of recovered and alternate water sources. The energy-water nexus also must be considered so that water recovery is not negated by unreasonable energy use. For example, nearly one-half of U.S. water is used to produce energy, and then energy is consumed to manage water.

Cooling towers consume hundreds of billions of gallons of water on a daily basis, 20 to 40 percent of which typically is wasted. Evaporation of tower water causes silica present in the water to form silicates, which are outstanding corrosion inhibitors and do not form scale or deposits. An air separation unit with a single cooling tower system located in the southeastern United States was a challenging site because of water demands, a limited water supply and a zero-discharge requirement. The treatment option needed to be "plug-and-play" with minimal capital investment. The chosen zero liquid blowdown (ZLB) technology allowed water savings of approximately 3,000 gallons per day. A pharmaceutical plant in the northeastern United States implemented the ZLB system with annual projected water savings of 3.6 million gallons. This success allows the pharmaceutical company to implement this strategy at several sites across the country to help meet company fresh water reduction goals. A West Coast university chose an alternative program for its chiller plant that allows a switch from city water to municipal wastewater and a significant improvement in waterside conditions, including corrosion control and reduced concrete degradation. Return on the university's investment can be achieved in 5 to 10 months. A Midwest mission critical data center, which requires 100 percent uptime, installed the ZLB system in its chiller plants and met or exceeded all of the program goals while achieving 4.5 million gallons of water reduction annually. The company plans to mandate ZLB technology at all of its data centers.

Mr. Haikalis concluded that there are significant opportunities for cooling tower water use or reuse from a variety of alternative sources using available commercial technologies that are easy to operate, energy responsible and cost-feasible while maximizing water conservation. These technologies also minimize asset and safety risks and positively affect water and carbon footprints.

Water Reuse Strategies for Building Heating, Ventilation and Air Conditioning (HVAC) and Plumbing Systems
Michael Berning, Senior Principal and Director, Sustainable Design, Heapy Engineering

Mr. Michael Berning noted that there are multiple alternate water sources and reuse strategies. Equipment costs significantly increase for potable use compared to nonpotable use. Policy and code changes will be required to readily integrate water reuse strategies into standard building design. These changes must consider water rights, fair billing practices based on water and sewer use, and metering. As minimum plumbing requirements become standardized, it will be easier for jurisdictions to review and accept water reuse systems as safe.

Miami University routed the majority of roof drainage from two dormitory buildings to cisterns that have a domestic water backup system in place. Additional study led the university to modify the project so that, following approval from the state of Ohio, air handling unit and fan coil condensates are directed to the cisterns as well. These projects were prompted by a desire for sustainable, green infrastructure and concerns regarding dry ponds creating a nuisance hazard to students. The projects allowed condensate water to be used for irrigation and pond renewal, providing an appealing, year-round recreation space for students and reduced summer pond maintenance. A proposed design for a greywater reuse system that included holding tanks, filtration, a chlorination system, dye dispersal and pumps was developed for a Hill Air Force Base project in Utah. This proposed, but not installed, system highlighted the complexity of and available technology for this type of project. The Milton-Union School District of Ohio installed a rainwater catchment system that collects rainwater from a partial roof area and interior courtyard drains. The system supplies water for toilet flushing and some irrigation and includes a cistern and treatment and repressure systems. The total potable water savings is nearly 85 percent.

Additionally, cooling coil condensation can be collected and sent to the cooling tower for makeup water purposes; however, low production in arid areas combined with low water rates make paybacks unreasonable in dry climates. Technological advances, such as filtration and storage technologies and prepackaged systems, have helped water reuse systems to be used readily. It is important, however, to understand the source water and intended use to select the proper equipment. The systems designer must be aware of the critical elements of a successful system design (e.g., available technologies, codes, projected needs and use, type and amount of alternative water source, financial benefits) to take advantage of water that would be wasted otherwise. There must be sufficient knowledge of system application among project partners.

Q&A and Discussion

Dr. Lye opened the floor to questions for Ms. Uhlmann, Mr. Haikalis and Mr. Berning.

Did Tremco perform any plant material testing in addition to soil and water testing? Ms. Uhlmann explained that the company performs plant material testing for a client but has not done so at its headquarters, although it would like to in the future. Plant harvesting would be discontinued immediately following a poor water test.

Adding salt to cooling tower condensate increases salt pollution, which is not removed at wastewater treatment plants because the technology is not available. How can this be addressed? Mr. Haikalis said that the high-efficiency waste stream releases only 2 percent of what would be released with traditional systems. There are potential opportunities to use evaporation to collect solid salt, which could be used for roads; this is a good example resource recovery and use. Salt permitting is becoming increasingly stringent across the United States, however, so this must be taken into account.

Was the approval obtained from the state of Ohio for the Miami University project a one-time variance or was it precedence setting? Mr. Berning explained that it was a one-time variance, but as it is increasingly integrated into the system, the process will become easier.

Did the Milton-Union School District project include sinks? Mr. Berning responded that sinks were not part of the system; rainwater is used for toilet flushing only.

Dr. Lye explained that the workshop organizers had developed several questions relevant to the session for the participants to consider. The questions and participants' answers are summarized below.

What themes have emerged concerning the case studies (usage, opportunities, challenges, incentives, gaps, etc.)?

- Aspects of efficiency have emerged as a theme.
- Another theme is water quality, safety and risks associated with alternate water sources.
- There are no linear, simplistic solutions, and the solutions may introduce additional challenges.
- There are not a great deal of obvious financial incentives; water scarcity seems to be a driver.

What specific characteristics have been identified that could lead to broader implementation of onsite usage?

- Identifying the true cost of water could lead to broader implementation.
- There is no current movement to educate the general public that water is a finite resource. Water awareness must be a part of everyday life; once it is rationed, it becomes a precious resource.
- There is a disconnect between the water sector and sewage treatment sector. Use of greywater to treat vegetation would provide connection with the wastewater sector.
- In the Third World, water is a premium resource, so it is valued differently than it is in the United States. Educating the general public (schools, libraries, municipalities) on the value/importance of water is important.
- Water scarcity will encourage those in drier areas to consider alternate water sources because interbasin transfers will increase water cost and energy expenditure tremendously.
- It is difficult to project areas of water scarcity because water is shipped around the world as a result of manufacturing, food production and so forth.
- Should the role of behavior change be a part of the discussion? It is important to develop methods to educate the public on what water is, where it comes from and how it can be conserved as well as the value of water reuse. Exposure and awareness are critical.

What are the roles of regional and national agencies?

- Regional differences have a major impact on the various roles in implementation.
- Once fundamental elements are agreed on, a national scale may be possible.
- Agencies must themselves be adopters and promoters of alternate water sources and provide education.
- Once national standards are written, it is important to remember that they must be adapted and adopted locally.

What are the barriers/obstacles for usage in the region?

- Most socioeconomic groups cannot afford alternate water source technology. Unless regulations are put in place to require water reuse, implementation will be purely altruistic by those who can afford it.
- Although the cost of implementation decreases on a neighborhood scale, the bureaucracy increases. The associated bureaucracy must be addressed to reduce the cost of implementation at the neighborhood scale.

Dr. Lye recessed the meeting at 5:31 p.m.

APRIL 25, 2013

SESSION 2: CURRENT BEST PRACTICES AND CASE STUDIES (CONTINUED)

Potential of Rainwater Harvesting Systems in North Carolina
Kathy DeBusk, Doctoral Student, Department of Biological and Agricultural Engineering, North Carolina State University

Ms. Kathy DeBusk explained that the main objective of rainwater harvesting for water conservation is to have rainwater available to use in lieu of potable water, whereas the main objective of rainwater harvesting for stormwater management is to have enough tank space available to capture stormwater from the next rain event; these can be conflicting goals. A drought in North Carolina in 2008 encouraged the examination of alternate water sources. The first phase of Ms. DeBusk's research involved installation and monitoring of rainwater harvesting systems at four different sites in North Carolina. Monitoring indicated that the four systems were not being used optimally, even following a major drought that increased awareness of the importance of water. Phase 2 of the research identified designated rainwater uses, incorporated automation and backup water supplies, and increased education and outreach. Results of this phase indicated that although there was increased usage of harvested rainwater, there was no usage during the nongrowing season, which provided no stormwater benefit or mitigation. It is necessary to identify secondary benefits to facilitate implementation and use of rainwater harvesting systems.

Millions of dollars are spent on stormwater management in North Carolina; is it possible to achieve water conservation *and* stormwater management? To answer this question, Ms. DeBusk's research investigated passive- and active-release mechanisms for rainwater harvesting. The passive-release mechanism provides a detention facility for stormwater runoff with a controlled discharge. The results of the research indicate that the passive-release mechanism has significant potential for meeting stormwater management regulations. It is simple to retrofit existing systems with the inexpensive, maintenance-free mechanism, which coincides well with existing North Carolina stormwater regulations. The disadvantages of the mechanism are that it is only semipermanent, prone to freezing and results in "wasted" water. The active-release mechanism uses National Weather Service forecasts to prepare the system for rain by releasing water. The researchers concluded that the active-release mechanism preserves water conservation benefits while adding stormwater management benefits, providing excellent potential for meeting stormwater management regulations. The mechanism, however, is expensive and resource intensive.

Because there is a need to mitigate stormwater in winter but no use for the rainwater, the researchers investigated irrigation-based systems. Three zones were established with varying amounts of water used for irrigation. Preliminary results indicate that there is a large reduction in stormwater runoff volume in all three zones with no difference in runoff production, turf quality or soil nitrate. More than 140,000 gallons of water were conserved. "Over-irrigation" has substantial potential to meet water conservation and stormwater management goals using infrastructure already in place and a *de facto* treatment method. A disadvantage is the required amount of contributing drainage area and storage; also, the necessary controls can be expensive and complicated.

Each of the three investigated approaches to rainwater harvesting provides water conservation and stormwater management benefits with the potential for substantial CSO improvement. They provide mutually beneficial solutions for property owners and the environment despite being contrary to public intuition. Cost, size and return on investment will determine which approach is appropriate, but it will require a balancing act that may need to be honed. Automation is essential to ensure use, but users/owners must regularly verify that the system is operating as intended.

Urban Watershed Runoff Management: Watershed-Based Use of Urban Runoff in Santa Monica, California

Neal Shapiro, Watershed Section Supervisor and Watershed (Urban Runoff) Management Coordinator, Office of Sustainability and the Environment, City of Santa Monica, California

Mr. Neal Shapiro said that there is a wide range of U.S. rainwater catchment programs in varying stages of development. EPA wet weather discharge reference materials promote rainwater harvesting, green infrastructure and low-impact development. New EPA draft stormwater standards are expected to be published in 2013. Mr. Shapiro has created a matrix detailing U.S. rainwater harvesting projects for indoor and outdoor use.

In California, it took 3 years to pass a state rainwater harvesting law following two vetoes and conflicts with plumbing and labor unions. Additional barriers included water rights, rainwater use indoors and across property lines, and concerns about public health, prompting review by the local public health agency. The governor signed the assembly bill in September 2012, but the final bill was essentially "gutted." The open-ended and broad bill avoids water rights issues for rooftop harvesting and leaves in place water rights from existing natural channels. The bill defers input about water standards to local jurisdictions rather than the state public health agency. There is no mention of indoor/outdoor uses or harvesting surfaces. It authorizes the California Building Standards Commission to implement rainwater harvesting guidelines in the uniform plumbing code for indoor/outdoor uses and allows rainwater use and application across property lines.

The only system in the world that manages dry weather runoff is located in Santa Monica, California. A southern California policy was developed because it was less difficult than enacting a state law. The policy includes four tiers to allow rainwater harvesting. The main challenges were definitions/grammar and debates about catchment surfaces, pollutants of concern, backflow prevention devices, treatment and disinfection, indoor versus outdoor applications, and passive versus active systems. Current standards also had to be considered. Santa Monica's sustainable water master plan calls for a 30 percent reduction in the imported water gap and self-reliance by 2020. The city investigated the role of rainwater in closing the gap, and although there are proven technologies and basic legal authority, local familiarity and experience with rainwater harvesting are lacking.

Q&A and Discussion

Dr. Lye opened the floor to discussion about the last Session 2 presentations.

Was a life cycle analysis performed on all three types of release mechanisms? Ms. DeBusk explained that she had performed a life cycle analysis only on a theoretical application of rainwater harvesting; the analysis did not incorporate any of the release mechanisms described in her presentation.

SESSION 3: TECHNOLOGY GAPS AND NEEDS

Session Introduction and Overview

Session Moderators: Pam Simmons, Chairman, Sustainable Sites Committee, Cincinnati Chapter of the U.S. Green Building Council and Owner, Turpin Farms; and Nick Ashbolt, Senior Scientist, NERL, ORD, EPA

Ms. Pam Simmons welcomed the participants to Session 3 and introduced the presenters, who provided information about EPA's research perspective and the perspectives of industry, other organizations, and national and regional concerns.

National Perspective on the U.S. Rainwater Industry

David Crawford, President, Rainwater Management Solutions and President, American Rainwater Catchment Systems Association (ARCSA)

Mr. David Crawford explained that ARCSA is attempting to educate people about rainwater harvesting. He described several examples of successful rainwater harvesting projects: a LEED™-gold certified rain garden system at an elementary school with a predicted annual water savings of 1.3 million gallons; a Home Depot with a rainwater holding tank that decreased its water use by 8,000 gallons per day; a fire station in Charlottesville, Virginia, that installed a potable rainwater harvesting system for use in emergencies; a corporate example (TD Ameritrade) that installed a rainwater harvesting system because of the return on investment; and Federal Way (Washington) Public Schools, which included providing education about rainwater harvesting to ensure visibility. Oscar Smith Middle School in Chesapeake, Virginia, used a two-tiered approach. It installed two tanks that are used for indoor (toilet flushing) use and two that are used for irrigation. Other sites that have installed rainwater harvesting systems include James Madison University, Mammoth Cave National Park, Charlottesville (Virginia) Area Transit, Burton Elementary and Middle School in Michigan, and a regional jail in western Virginia.

It is important to educate engineers about rainwater harvesting systems and their design, especially because some are resistant. Payback analysis must take all factors into account; for example, one system will reduce chemical use by 75 percent during normal laundry use because salts will not need to be added. This type of savings must be included in any payback analysis. To overcome obstacles, communication is important, as is a consistent, scalable design based on potential supply and demand. To make effective ecological decisions, the potential consequences of actions must be understood.

Characterization and Quantification of Microbial Risks Associated With Reuse of Rainwater and Stormwater

Nick Ashbolt, Senior Scientist, NERL, ORD, EPA

Dr. Nick Ashbolt explained that water monitoring has several inherent problems: test results are not received before water is used, there are too many parameters for frequent testing, the only microbial indicator included (*Escherichia coli*) is a poor indicator for viral and protozoan pathogen removal and for the presences of environmental pathogens, and there is no suitable test for many hazards. As a result, a risk management approach is used. Quantitative microbial risk assessment (QMRA) essentially identifies potential microbial risks, assesses the risks and reassesses the system. During the first step of QMRA, reference pathogens are selected and hazardous events identified. In terms of rainwater harvesting, the key is to identify the pathogen concentrations in rain and stormwater and treat the water accordingly. Pathogens are not used to examine efficacy because there typically are not enough to prove that a 99.9 percent reduction has been achieved; therefore, surrogates are used. Epidemiological evidence of pathogens also is examined. Generally, there is no increased pathogen risk from rainwater, even when used for drinking water. Because the outcome of most exposures to pathogens that result in illness is gastrointestinal symptoms, incidences of diarrheal occurrences are measured rather than the causative agent (i.e., pathogen).

It is estimated that waterborne diseases cost $970 million annually; EPA's drinking and recreational water quality criteria are based on fecal bacteria. Fecal pathogen exposures are event driven. The rationale for using fecal indicators for quantitative polymerase chain reaction (qPCR) rather than pathogen detection in stormwater is that qPCR targets pathogen density. Although *Bacteroides* is an effective indicator because it always is present in human sewage, it is not an effective avian source indicator. *Catellicoccus* is a potential avian indicator. Surrogates, such as baker's yeast and bacteriophages, may be used to measure pathogen removal. EPA evaluated three stormwater recycling systems to identify surrogates for stormwater treatment; barrier efficacies were examined for removal efficiencies. Dose-response data to determine rainwater reference pathogens indicate that *Campylobacter* is more important than *Salmonella*, toxigenic *E. coli* is very infectious but rare, and *Cryptosporidium* probably outnumbers *Giardia*. Bird flu is a virus of interest. Of the environmental pathogens, dose-response data only are available for *Legionella pneumophila*. Enteric pathogen risks depend on identification and control of acute hazardous events using surrogate target levels. It is critical to be vigilant about hazardous events because these are most likely to cause illness. Environmental pathogen risk largely is a function of chronic conditions.

Dr. Ashbolt identified the following research gaps: (1) qPCR and precision estimation of infectious pathogens, (2) correlation of qPCR targets and surrogates to specific pathogens by environmental type, and (3) identification of primary risks of concern and their control parameters for effective rain and stormwater management.

Development of Tools by EPA to Determine the Effectiveness of Green Infrastructure-Based Approaches to Mitigate Stormwater
Jay Garland, Director, Microbial and Chemical Exposure Assessment Research Division, NERL, ORD, EPA

Dr. Jay Garland stated that there had been a revolution during the past 20 years in regard to the development of tools using DNA; tools are available to identify and track microorganisms in the environment. PCR amplification that allows quantitation can be performed in real time. Although new tools expand sampling possibilities, data still are "noisy." Researchers attempted to correlate fecal indicators and pathogens in rainwater tanks in Australia and found that there was poor correlation. Traditional indicators do not predict risk well; therefore, new indicators and a new approach are needed. A general plan was developed to examine how to improve the treatment efficacy for reused water. First, wastewaters were characterized and controlled decay and treatment studies were used to examine a variety of representative pathogens, indicators and surrogates. The DNA sequences found in 12 greywater samples were investigated, and 97 percent were classified as Proteobacteria, Bacteroidetes or Firmicutes. Next, the most effective indicators and surrogates are chosen for additional field and pilot testing using candidate real- or near-real-time sensors. Real-time detection is not used in the environment yet, but the medical field is able to use real-time sensing for body tissues. Chemical signatures also can be used to examine recycled water, and EPA has developed a CANARY software system to detect events that affect water quality.

Regional Water Reuse Activities, Gaps and Research
Jatin Mistry, Life Scientist, Drinking Water Section, Region 6, EPA

Mr. Jatin Mistry explained that EPA Region 6 includes five states and 66 tribal nations with drought conditions that range from severe to exceptional. The drought situation in Oklahoma is particularly bad. In Texas, 23 water systems have less than 180 days of source water available before they run out; this affects small water systems that serve less than 10,000 persons. Texas also has 1,023 water systems on mandatory, voluntary or no outside watering schedules. Wastewater treatment plants are keeping Texas rivers moving, with direct toilet-to-tap mechanisms in place. Often, rainfall comes from tropical storms or unusual rainstorm events that cause flash floods and millions to billions of dollars of damage. There are several pathogens (e.g., *E. coli*, Norwalk-like viruses) that cause public health concerns following storm events. Water from these events is diverted to reservoirs, bayous, rivers or retention/detention ponds.

There is great potential for beneficial use of stormwater. In the past, retention ponds and rain barrels were used to collect water, but these have several disadvantages. New approaches to alternate water resources in Region 6 include green construction using low-impact development principles, grassed swales, constructed wetlands, infiltration basins and porous pavement. The Tarrent Regional Water District, Dallas Omni Hotel, Perot Museum of Nature and Science and G.W. Bush Presidential Center in Texas; the city of Edmond, Oklahoma; and Lincoln Parish, Louisiana, all have implemented alternate water projects that reduce stormwater runoff. The first WaterSense-labeled home in the United States, located in Texas, was renovated to include a rainwater harvesting system and stormwater runoff control. This home proves that alternate water systems can be retrofitted and do not require new construction. The home is open to the public for training demonstrations.

To understand the microbial community present in harvested rainwater following common in-home treatment processes, EPA and academic researchers sampled six residential rainwater systems in central Texas and performed physical, chemical and biological analysis. Results indicated that filtration reduced turbidity. Ultraviolet treatment caused a shift in the amount of certain microbial phyla present in tap water compared to cistern water.

Q&A and Discussion

Ms. Simmons opened the floor to questions for the Session 3 speakers.

Where are the microbial samples acquired? Dr. Ashbolt explained that samples were taken upstream and downstream of the filtration system to assess the log reduction in microbes following filtration. Many samples are taken following dosing to obtain data regarding how well the filtration system works.

What are the control gaps? Dr. Ashbolt replied that knowledge on the range and concentration of the pathogens of concern are needed. There also is not a great deal of data regarding the performance of pathogen removal because there are not enough initial pathogens available to be able to accurately measure a log decrease. More information on surrogate systems is needed.

How does system maintenance affect acute events? Dr. Ashbolt responded that maintenance is critical to prevent malfunctions. Installation of automatic systems can help to ensure that maintenance is performed following alerts of malfunctions.

There have been Australian studies, but no U.S. studies, on whether it is better to disinfect the whole tank or only water as it leaves the tank. What is the most cost-effective approach? Dr. Garland responded that it is more effective to treat the water as it leaves the source; disinfecting the tank as a whole may not address the problem, as there also are issues of decaying microorganisms.

Panel Discussion: Stakeholder Perspectives on Technology Gaps and Needs
Moderator: Michael Miller, Professor Emeritus, Department of Biological Sciences, University of Cincinnati
Panel Members: Jens Gartner, Representative, Water Renewal Systems-USA; Jatin Mistry; and Dennis Lye

Dr. Michael Miller moderated the session, asking the panel members their opinions regarding the following question: *What gaps exist in terms of water reuse?* Their responses are summarized below.

- Homeowner education on how to operate rainwater harvesting systems is needed because homeowners are not using the systems properly or to full potential.

- Which entities will act as regulatory authorities need to be determined. For a coherent approach, EPA will need to be involved because the many potential uses for recycled water will each require regulations and guidelines. If EPA releases national guidelines, state and local authorities can institute regulations.

- Rainwater harvesting plays an important role in Germany, with city water as a backup. The rainwater is used in a closed child-proof system that limits the risk of exposure. It is important to use collected rainwater before it stagnates. There is no testing for *E. coli* in Europe. Germany offers subsidies for companies that engage in stormwater management.

- More statistics are needed regarding rare events and emerging pathogens. Droughts increase opportunistic pathogens. A great deal can be learned from the public water system that can be applied to cistern management approaches.

- Commercial and residential systems must be examined differently, especially as residential systems will not be maintained as well as commercial systems. Maintenance is important, particularly in residential areas.

- Accurate metering is an issue that needs to be addressed.

- Alternate water resources need to be placed in the context of acceptable risk. How will rainwater harvesting at a watershed-scale affect stream flow? How will commercial rainwater harvesting change the hydrology of a watershed? There will be watershed- and ecosystem-wide impacts from rainwater usage, and episodic events will become more common. A logical next step is to include rainwater harvesting in watershed plans.

- Different geographical regions will not trust data generated in Cincinnati because each watershed is unique. They will want to generate their own data to confirm the conditions in local watersheds. National guidelines still will need to be tested at the local level.

- The levels of any chlorine introduced to the system must be tightly controlled so that they do not cause soil destruction.

- Water scarcity is driving the use of alternate water sources. Once the true cost of water is known and charged, options will increase. Bureaucratic “red tape” also must be addressed.

- Green water will be a very important resource in the future with a projected 60 percent decrease in water levels globally.

Q&A and Discussion

Dr. Miller invited the participants to ask questions of the panel members; the questions and responses are summarized below.

Given the amount of non-self-sustaining activities (e.g., hydraulic fracturing) that are occurring, what are the concerns about pollution of wells and groundwater?

- Citizens are concerned about this issue as well. Recent sequestration restrictions have eliminated home and site visits to test private wells. State environmental agencies provide limited testing; there is some concern that these tests do not address other sources of pollutants.

- EPA currently is performing work to evaluate whether rainwater can be used for drinking water to alleviate some of these problems.

Although only four water companies control 50 percent of the world's water supply, the U.S. market still is diverse. Will the global drinking water market allow rainwater harvesting to be incentivized in water-scarce locales?

- Water suppliers are not receptive to incentivizing rainwater harvesting; incentives will be driven by stormwater management.

- Because individuals in the sector are retiring without replacements, outsourcing is occurring with increasing frequency.

Testing is a contentious issue because it is expensive; testing requirements must be based on Agency research rather than "hunches." It is important to establish a baseline testing protocol. What factors should be included in tests?

- Most communities have testing schedules in place regarding what is tested for and when. Education is needed on what is being tested for and how to properly disinfect water without side effects.

- In Germany, commercial and residential testing are very different. Rainwater may be used only for toilet flushing and laundry because these are low-risk activities.

- The point is well-taken, and the issue is related to the use and scale of rainwater harvesting. NERL's Microbiological and Chemical Exposure Assessment Research Division would like to relieve some of the requirements that have been put in place in the past.

How will the federal government oversee the monitoring of harvested rainwater? For example, many people do not monitor their well water and suffer no adverse affects.

- Well water often is contaminated at the same levels as rainwater, but testing is not required. EPA will need to determine that there is no additional risk to using harvested rainwater; currently, the default is that there is risk.

REGIONAL SUCCESS STORY—CITY OF CINCINNATI RAINWATER HARVESTING ORDINANCE

Introduction and Remarks
Mark Mallory, Mayor of Cincinnati; and Larry Falkin, Director of the Office of Environmental Quality, City of Cincinnati

Mayor Mark Mallory welcomed the participants to Cincinnati and explained that Duke Energy is a strategic partner to the city that helps to make Cincinnati green and sustainable. Ms. Gutierrez also is a good friend to the city, and the Confluence water technology innovation cluster allows job growth and introduction of new green technologies in the area. Cincinnati is working to be the greenest U.S. city, and there are many leaders and regional businesses who embrace the concept of sustainability and help to ensure the city's success in this area. Cincinnati is one of only three U.S. communities to adopt rainwater harvesting ordinances. Mayor Mallory thanked the participants for their commitment to rainwater harvesting.

Mr. Larry Falkin explained that the City of Cincinnati's Office of Environmental Quality channeled the efforts of community collaborators throughout the business, private and nonprofit sectors, focusing on projects that allowed rainwater harvesting in Cincinnati. The passing of the ordinance was a collaborative process that included four city departments and civic organizations that identified national best practices to guide the effort. Paramount in the discussions were the integrity and safety of the drinking water supply.

Background and Overview
Panel Members: Bob Knight, Task Force Facilitator, Green Partnership for Greater Cincinnati and Project Manager, emersion DESIGN LLC; Steve Hafele, Assistant Supervisor of Inspections and Chief Plumbing Inspector, City of Cincinnati; Jeff Zistler, Engineering Technical Supervisor, MSDGC; and Jeff Swertfeger, Assistant Superintendent, Water Quality Management Division, GCWW

Mr. Bob Knight stressed the importance of water safety, noting that public trust of water is critical. When changes are made, they must not add risk. Stewardship, leadership and collaboration were necessary to change Cincinnati's codes to allow rainwater harvesting. To be successful, collaborators focused on a pilot project, defined the agencies that would have jurisdiction, assessed and addressed concerns, researched best practices and applicable standards, applied a national standard code, and crafted language for the various agency and community needs. Cincinnati's water conservation goals were the driving force behind the effort. The first step was the passing of a resolution in April 2011 followed by a city motion to investigate codes. A task force began meeting in 2011 with four objectives to: (1) permit the Dater Montessori school for rainwater harvesting, (2) develop standards for others to follow in Cincinnati, (3) amend the city plumbing code, and (4) coordinate the findings for others in the MSDGC/GCWW service area. The first three objectives were accomplished, and meetings regarding the fourth objective will begin the following week.

Significant concerns of the task force included water quality jurisdiction, development of a backflow prevention standard and use of an existing model code. Conflicting jurisdictions were resolved when Ohio EPA confirmed that GCWW has jurisdiction for nonpotable water use, water quality standards and protecting the public water supply. The backflow issue was resolved when it was determined that existing standards are acceptable without significant modification; enforcement, however, is needed. The International Green Construction Code (IgCC) was approved in March 2012 for Cincinnati to use as a model code. The task force also examined water quality requirements, inspection issues, a certified maintenance protocol and metering. The resulting ordinance was passed in April 2013 and allows use of rain barrels, references the IgCC and defines the agencies that have jurisdiction. The task force must now focus on community outreach, permitting and metering (sewer) fees, and a certified maintenance protocol.

Mr. Steve Hafele explained that plumbing codes were written to help protect public health, and the biggest safety device, the air gap, was developed more than 100 years ago. Rainwater is a resource that must be used and kept out of CSOs. The previous ordinance written for rain barrels only interrupted the flow of stormwater; overflow must be sent to an approved location. That ordinance did not allow use of rain barrel water for toilet flushing because it violated Ohio plumbing codes. Rainwater harvesting systems are an alternative engineered design but required additional bureaucratic processes to ensure their safety. Several departments must approve the design to ensure that it meets all standards. Cross connections require adequate air gap to ensure safety and provide backflow prevention; air gaps are preferred to reduced pressure zone (RPZ) backflow preventers. All pipes conveying nonpotable water must be identified as such via color marking and labeling. Potable water must be protected from nonpotable water so that a safe building environment is provided to occupants; this is where alternate engineering designs are employed.

Mr. Jeff Zistler explained that the role of MSDGC is in regard to billing, and it is examining fair methods regarding the true cost of using a rainwater harvesting system so that everyone pays equitably. Metering will be required for commercial single-tank systems used for irrigation and nonpotable uses, with residential users allowed flat billing. Metering is not required for harvesting tanks used exclusively for irrigation. Commercial systems using multiple tanks are eligible for flat billing after being evaluated on a case-by-case basis; billing will be adjusted annually.

Mr. Jeff Swertfeger highlighted GCWW's role in the process. Water quality standards have been established. No codes currently define what must be included in the operation and maintenance manual; the owner will develop the manual for review and certification by Cincinnati's Department of City Planning and Buildings. Inspections are required to ensure that rainwater harvesting systems have not been compromised. A defined inspection process, fee and schedule must be created.

Q&A and Discussion

The participants were invited to ask questions of the panel members; the questions and responses are summarized below.

How do the panel members envision the increase in units in Cincinnati in the short and long terms?

- There is expected to be a great deal of interest on the design side; those in the design community who can educate clients will facilitate implementation. There is a strong interest in green building in the area.

Does the code specify the size of the tank relative to use?

- Unless an excavation or fill permit is needed, the Department of City Planning and Buildings is not involved in tank size. The major concern is where the water goes once it leaves the tank, as there is the potential to disregard neighbors.
- The number of occupants also has a bearing on tank size.

Is there automatic use of city water if the tank is empty?

- Yes, there is makeup water and an air gap.
- Annual inspections and backflow preventions also are in place.

Capturing rainwater decreases CSOs, which account for MSDGC's largest expenditure. Is there a tradeoff occurring that decreases MSDGC's expenditures?

- MSDGC is not interested in hidden rate increases, but to subsidize installation of rainwater harvesting systems, those who do not install a system end up being penalized. There has been discussion about the appropriate level, but MSDGC does not have the authorization to refuse payment because the regulations state that MSDGC must charge. A fair approach to recouping costs is needed.

What is the fee structure for inspection and permitting?

- A plumbing permit is based on the number of inside fixtures, with a charge of $60 for the first fixture and $17 dollars for each additional feature. Fees for outside work are based on the estimated cost of that work; work up to $10,000 will be charged a $210 permit fee. The re-annual inspection fee on a rainwater harvesting system is based on the current re-inspection fee of $105 that already is in place.

Will the ordinance take into account that superseding regulations may exist? Will the ordinance allow for existing rainwater harvesting regulations?

- This possibility of superseding regulations was discussed, and other agencies (e.g., the health department) could become involved following system installation if conditions exist to trigger their involvement.

- The structure of the ordinance provides instruction on how rainwater harvesting can be done. It is written in a way so that it can be modified in the future or be timeless. It provides enough description to implement rainwater harvesting in a fair manner so that the relevant agency's interests are represented.

- These issues illustrate the complexity of rainwater harvesting; it was necessary to work with Ohio EPA, which regulates public water systems.

Why is an RPZ not considered adequate?

- This relates to the interconnectedness of the potable and nonpotable systems. The preliminary decision was made to err on the side of safety until a final decision is made following additional discussion.

Who will be responsible for sampling and testing? Is there a protocol for where samples are obtained and is disinfection required?

- The system owner is responsible for sampling and testing, and will need to send the results to the appropriate city agency. The required sampling interval will be determined following further study. A list of laboratories will be provided; simple testing also may be offered.

- Sampling should occur at the point of use, and a disinfection requirement is included in the code.

- The design includes a spigot at the point of sampling to ensure that the water in the pipes rather than the vessel is tested to avoid cross contamination.

Will different applications require different nephelometric turbidity unit criteria?

- The developed water quality criteria are for all indoor applications. If water is collected and used outside, then these criteria do not apply. Once the water is brought inside, they apply.

- The ordinance also specifies "subsurface" irrigation.

Will new and ongoing training be required for code inspectors?

- Presently there is no training; good plumbing practices apply. An operation and maintenance manual would be used to ensure adequate testing and treatment. It is the owner's responsibility to maintain the system in good working order.

Would under-sink reverse osmosis units work to purify water intended for indoor use?

- Early discussions focused on how descriptive the language of the code should be. The solution matches the code language; specific technologies are not mentioned because technology is a "moving target." All measures are based on the results produced by the technology, which allows the community to implement newer technologies as long as they meet the measurement requirements. The code then becomes a "living document."

Mr. Knight closed the session by reiterating that the ordinance effort was a major collaboration, and he appreciated the hard work and diligence of the individuals in the MSDGC, GCWW, Cincinnati Department of City Planning and Buildings, and Cincinnati Health Department that were a part of the effort. He also thanked the task force, EPA, Green Umbrella, Greater Cincinnati Foundation and the Green Partnership for Greater Cincinnati. This was a community-driven initiative, and he is very proud to live in Cincinnati.

SESSION 4: BRIDGING THE TECHNOLOGY GAPS

Summaries of Sessions 1, 2 and 3
Kevin Oshima, Tre Sheldon and Nick Ashbolt

After the session moderators provided a brief summary of their sessions, participants were encouraged to add their thoughts, which are summarized as follows:

- The discussion included rainwater harvesting as a component of CSOs. Secondarily, green roofs increase the albedo (fraction of solar shortwave radiation energy reflected from Earth into space). Tree loss in some areas increases stream flow as a result of the decreased evapotranspiration and increased temperature. Tree planting should be included in these efforts. Man-made efforts need to be coupled with the natural actions of the environment to synergize the environmental and financial benefits.

- Providing numeric and monetary value to the natural system matches EPA's research interests and abilities. An ORD researcher is examining the inherent energy in the natural system as a measure of the value of the system.

- A formal proceedings summary is being produced, and EPA also would like to communicate the results of the workshop informally to the general public.

Panel Discussion: Rain and Stormwater Technology Needs and Solutions—Themes Emerging from the Workshop
Moderator: Jay Garland
Panel Members: Kathy DeBusk, David Crawford, Paula Kehoe and Samantha Brown

The panel members identified the following needs and solutions for rain and stormwater reuse:

- Rainwater, stormwater, greywater and blackwater must be viewed, valued and used as resources.
- The desired goals and objectives must be understood prior to installation to achieve the most beneficial use of a system.
- Economics drive installation; this must be taken into account.
- There are many counterintuitive regulations in place that require education to navigate. Although there are many political barriers, a happy medium must be achieved to serve U.S. citizens.
- Education about rainwater quality is important.
- Rainwater harvesting technology is available, but if it is not operated correctly, it may not provide the intended benefits. Correct operation and maintenance increases if the owner/operator has a vested interest.
- Appropriate water quality standards are needed; EPA should develop water quality guidelines to assist local implementation. Local entities often do not have the resources to research/develop appropriate water quality standards.

The participants were invited to join the discussion and made the following observations:

- Engineers should be educated to ensure that the appropriate technology is used.
- It is the regulator's role to ensure that technology meets safety standards; it is the role of the owner/operator to maintain the system.
- Potential hazards must be identified so that they can be managed.
- Social and economic gaps must be addressed before technology gaps.
- The shipping/delivery cost of the tanks could be lowered by increasing the amount of storage zones across the country.
- There is technology available to link monitoring devices to the network so that owners/operators are notified if there is a problem. Research may be required to identify all available technologies, which may not currently be used to their full advantage.

Summary Discussion: Bridging the Technology Gaps, Outcomes and Next Steps
Dennis Lye, Andrew Reynolds and Jatin Mistry

Dr. Lye stated that the previous session was helpful in identifying needs and gaps. He asked the participants to consider the following questions: What actions can be taken collaboratively to bring alternate water resources and their associated technologies into the mainstream? Are the participants willing to collaborate? Are any participants able and willing to help fund the effort? How mainstream should these technologies be?

He noted that some entities, such as schools, may not have the ultimate responsibility for maintaining any rainwater harvesting systems installed at their locations. So that the responsible agencies are comfortable installing systems at these locations, rainwater harvesting systems could be developed in such a way that monitoring and maintenance can be completed more easily by these agencies. He is skeptical about the City of Cincinnati giving responsibility to individual owner/operators without oversight. It is necessary to identify incentives, policies, collaborations and methods to incentivize the process and facilitate the use of alternative water sources. A participant noted that volunteers would monitor the system installed at the Dater Montessori school. Long-term trend data generated by the system could be used for monitoring, but they may not satisfy regulatory requirements. The regulating agency's protocol can be used to guide system monitoring and testing.

Ground-breaking stormwater regulations are being developed and implemented in North Carolina. If there is a model to address issues, such as revenue and liability, basic guidelines could be developed. Existing information must be leveraged to facilitate the development of guidelines, codes and so forth. EPA could create a clearinghouse for information and harness the knowledge of the participants and others. Rain and stormwater are part of the solution and part of the water supply; it is critical to change the perception that these are "waste" waters so that they are accepted more broadly as part of the solution. A potential location for such a clearinghouse could be the database of best management practices for green infrastructure that ORD is developing.

Dr. Lye thanked the participants and adjourned the meeting at 4:07 pm.

APPENDIX A: DEFINITIONS

Alternate water sources: Any source designated as nontraditional in a regional water supply plan (e.g., saltwater, brackish water, rainwater, greywater, condensate, foundation drainage, stormwater and recycled wastewater).

Auxiliary water system (AWS): A water system on or available to the premises other than a public water system. An AWS uses water from a source other than the public water system (such as wells, cisterns or open reservoirs that are equipped with pumps or other prime movers including gravity) and is often necessary in the absence or failure of existing emergency water systems. City, state or federal regulations apply to AWSs when used in proximity to public drinking water systems because they may not meet current national drinking water standards.

Building-scale (or individual) projects: A water system which is confined to one building.

Condensate: A liquid separated from a gaseous state due to changes in temperature or pressure, or both, and that remains liquid at standard conditions.

De facto reuse: A situation where the reuse of treated wastewater is, in fact, practiced but is not officially recognized (e.g., a drinking water supply intake located downstream from a wastewater treatment plate discharge point).

Direct potable reuse: The introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a drinking water treatment plant, either co-located or remotely located from the advanced wastewater treatment system.

District-scale projects: A water system that is shared between two or more buildings.

Foundation drainage water: The water recovered from tile or pipe systems for collecting seepage within or around a foundation to maintain integrity of the building or facility. Foundation drainage does not include nonpotable groundwater extracted from a well (a deep hole or shaft sunk into the earth to obtain water) which is subject to groundwater regulations.

Greywater: Untreated wastewater that has not come into contact with sewage (blackwater). Greywater includes used water from bathtubs, showers and lavatories, as well as water from clothes washing machines.

Indirect potable reuse: Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes drinking water treatment.

Municipal separate storm sewer system: A conveyance or system of conveyances, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains.

Nonpotable water: Water that does not meet the bacteriological and chemical quality requirements of the EPA's National Primary Drinking Water Regulations and/or the regulations of the public health authority having jurisdiction for potable water; water deemed not safe for drinking, personal or culinary utilization.

Nonpotable reuse: All water reuse applications that do not involve potable usage.

Onsite water treatment and use system: Equipment and technologies utilized on a property for the purpose of collecting, diverting, sorting or treatment of alternate water sources for beneficial use on the same property.

Outfall: A point source as defined by 40 C.F.R 122.2 at the point where a municipal separate storm sewer discharges to water of the United States. An outfall does not include open conveyances connecting two municipal separate storm sewers or pipes, tunnels or other conveyances that connect segments of the same stream, or other waters of the United States and are used to convey waters of the United States.

Point source: Any discernible, confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, or vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Potable water: Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming to the bacteriological and chemical quality requirements of the EPA's National Primary Drinking Water Regulations and/or the regulations of the public health authority having jurisdiction.

Potable reuse: Planned augmentation of a drinking water supply with reclaimed water.

Rain: A liquid form of natural precipitation, which is some cases is modified as it falls through the air.

Rainwater: Rain that has impacted upon a surface and whose composition has been modified by surface flow, diversion and storage processes onsite.

Reclaimed water: Municipal wastewater that has been treated to meet specific water quality criteria with the intent of being used for a range of purposes. The term *reclycled water* is becoming generally accepted as synonymous with *reclaimed water*.

Recycled water: See **reclaimed water**.

Stormwater: Precipitation from rain and snowmelt events that flows off site over land (both pervious and impervious). Stormwater runoff pollution is often called "non-point source" pollution.

Sustainability: Environmental stewardship that leads to environmental improvement over time and contributed positively, even if indirectly, to the social and economic condition.

Traditional water resources: Groundwater (underground water held in soil and impervious rock) and surface waters (lakes, rivers, reservoirs).

Urban runoff: Stormwater from city streets and adjacent parcels (includes water from both traditional and alternate resources) that carries pollutants of various kinds into the sewer systems and receiving waters.

Urbanized area: A densely settled territory that has a minimum population of 50,000 people.

Wastewater: Used water discharged from homes, businesses, industry and agricultural facilities.

Water use: The use of alternate water resources (with the exception of treated municipal wastewater and treated greywater) for beneficial applications in lieu of potable water from public distribution systems.

Water reuse: The use of treatment municipal wastewater (reclaimed or recycled water) and treated grewater. (Note: The term “reuse” is not appropriate for situations where an alternate water source such as saltwater, brackish water, rainwater, stormwater, condensate or foundation drainage is used directly after collection.)

Watershed: The area of land where all of the water that is under it or drains off of it goes into the same place.

APPENDIX B: WORKSHOP PARTICIPANTS

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