Workshop Summary

Looking at how far we've come towards integrated nutrient management

National Research Center for Resource Recovery and Nutrient Management
Capstone Summit (STAR_N9R18/4935)

Context and Background

In 2013, U.S. EPA awarded The Water Research Foundation (WRF), formerly the Water Environment Research Foundation (WERF), a grant valued over $2.2 million to oversee the National Research Center for Resource Recovery and Nutrient Management. The goal of the Center was to provide innovative data, demonstrations, and tools to catalyze a paradigm shift in the water quality community – one where nutrients (nitrogen and phosphorus) are not regarded as wastes, but rather valuable resources and an integral part of a sustainable managed system that includes nutrients, energy, and water. Under the Center, seven projects were conducted. With the projects nearing completion, WRF hosted a two-day Capstone Summit in August 2018 to showcase the research findings to a group of 50 people which included utility, engineering/design, regulatory, academic, and non-profit representatives. Other partner organizations were invited to present their nutrient-related work. All participants were asked to help identify new research needs and gaps on effective nutrient management.

Sally Gutierrez (U.S. EPA) started the Summit by providing an insightful context of the national nutrient problem and an overview of EPA's future nutrients policy directions to help address point sources, non-point sources, and drinking water challenges. She emphasized the need to work together collaboratively help solve this "wicked" problem. The U.S. EPA Project Officer for the grant, Ben Packard, provided the context for EPA's national priority focus on nutrients and its systematic approach to manage nutrient pollution from various sources. This systems approach allows for better understanding the interactions and feedback loops among economic, ecological, and social systems. It helps to consider the consequences of human interventions, such as new policies, new technologies,

This event brought together a diverse group of people who have the same goal of finding solutions for the "wicked" problem of nutrients.

and new business practices. He also provided an overview of all four EPA-funded Nutrient Management Research Centers.

Additional presentations were grouped in various sections, with the first being all projects related to nutrient removal and recovery technology and approaches. This included the majority of the projects conducted under WRF's Research Center: urine separation, mainstream deammonification, manure resource recovery using ammonia stripping, and novel urban runoff treatment systems. The other major section focused on projects related to strategies and management options using modeling and decision support tools, including: an Excel-based tool to determine if resource recovery from agriculture is a viable option, an agricultural best management practices database, and a nutrient life-cycle management decision methodology. One of the other funded U.S. EPA Centers for Water Research – RAINmgt – was also featured.

Tanya Spano explains MWCOG's efforts to address nutrient reduction. MWCOG was instrumental in convening WRF's first technical workshop to develop its nutrients research

This Summit provided an opportunity to examine nutrient management activities outside the scope of WRF's Nutrient Center. Guests from the Water Environment Federation (WEF), Association of Clean Water Administrators (ACWA), National Association of Clean Water Agencies (NACWA), and the Metropolitan Washington Council of Governments (MWCOG) shared their nutrients-related efforts. WRF staff provided a brief synopsis of nutrient-related research in the Program Areas of LIFT (Leaders Innovation Forum for Technology); Linkages with Water Quality, Reuse from Agriculture, Integrated Water Management, and Nutrient Removal and Resource Recovery, the latter two are part of WRF's primary research efforts since 2005. Because the Nutrients Program Area has been a predominant focus for the Foundation, the Principal Investigators were invited to share their findings on innovative nutrient removal technologies and nutrient regulations.

All of the Summit presentations are outlined on the following pages and are available at: www.werf.org/nutrientcapstonesummit

Outcomes

Summit attendees identified the research needs and gaps that must be addressed in order to effectively manage nutrients in an environmentally sustainable manner.

Research Needs and Suggested Action Items

- Better water quality models and watershed-based solutions that consider all nutrient species, all nutrient sources, and innovative-protective approaches, such as robust, reliable, and sustainable treatment technologies.
- Data sufficiency or guidelines on the frequency and number of samples needed of nutrients within the treatment system.
- Examination of the impact that water conservation plays on nutrient removal design, operations, and overall management, especially with shifting wastewater characteristics and climate impacts.
- Although there is a scientific basis that lower nutrient effluent concentrations will need to be achieved, safety and other factors (e.g., climate change and nitrogen and phosphorus speciation) need to be considered. The science of nutrients and reasonable numbers today and in the future are not what they were in the 1990s, therefore numbers must be based on current and future needs.
- A way to more effectively engage the nonpoint perspective and the public to solve the nutrient loading issues.
- Focus on other approaches such as nutrient removal from natural systems, e.g., the SWIFT project in Hampton Roads, VA, that is meeting multiple objectives (not just nutrient removal) in a general way.
- Further exploration of sidestream treatment and nitrogen recovery, i.e., rather than just removing the nutrients.
- Examination of sea level rise and associated impacts on septic systems/decentralized systems. Long-term assistance could include tying into sewer systems for more effective nutrient management.
- Address possible outreach issues, especially with farmlands. Low-lying farmland is getting salt incursion which impairs the farmland and may release nutrients from the soil.
- An outcome-based approach that is flexible, encourages innovation, and provides incentives for exceeding requirements. For example, guidance on innovative funding opportunities and collaboration with small businesses (SBIR program, etc.) and how to deal with nutrients and other contaminants on a more regional level.

U.S. EPA recognizes nutrients as a huge challenge. Sally Gutierrez explains how the Agency is working collaboratively with states, industry stakeholders, and other federal partners to find solutions.

- Continued communication with permit writers. Flexible permits could account for variable conditions and incentives to improve performance.
- Address the barriers to water quality trading, early nutrient reduction incentives, and better BMP design.

Additional Questions

- Can treatment systems take care of TMDL requirements? From the practitioner's standpoint whose budgets are slim, there is insufficient scientific information on what is happening to nutrients in the watershed? Is the system providing other benefits aside from removing nutrients and how can that be quantified and proven? Can TMDLs track nutrients, salt, suspended solids, etc.?

Principal Investigator David Sedlak (University of California-Berkeley) presents an overview of his research to use novel unit-processes to remove nutrients from urban runoff.

- What are the unintended consequences of removing nutrients within the treatment system (e.g., additional costs in dewatering)?
- How can the water community work with the market sooner to justify that recovery of nutrients makes a good business case for the utility? What has greater value on the market side (agriculture, farmers, food industry)?
- Are there less expensive technologies available to remove phosphorus from wastewater to ensure the protection of surface water?
- Is there a method that can be used to bring nitrogen and phosphorus removal and recovery processes together in a way that balances other aspects such as wastewater treatment, biosolids land application, and other end products? What is the difference in how much we pay for different processes? How do we improve what we are currently doing to improve removing N & P? How can utilities combine tools and practices (restoring streams to meet TMDL requirements, using BMPs, etc.) to get the most out of the investment?
- What is the current use of nutrients? By recycling and reusing nutrients within the watershed, is there a point along that trajectory where we start getting ahead of ourselves on cost of treatment?

Summit Presentations

Opening Remarks

Title and Presenter	Synopsis
EPA's Future Policy Direction of Nutrients Sally Gutierrez, U.S. EPA	Almost half of rivers and streams have elevated levels of N and P associated with degraded biological conditions, with states listing almost 17,000 waterbodies for nutrient-related impairments. There are diverse sources of nutrient pollution that impact public health, the environment, and economy. EPA recognizes this huge challenge and is working collaboratively with the states, industry stakeholders, and other federal partners to find solutions.
Overview of the Centers for Water Research on National Priorities Related to a Systems View of Nutrient Management Ben Packard, U.S. EPA	EPA has made nutrients a national priority and adopted a systematic approach to manage nutrient pollution from various sources. This allows for better understanding the interactions and feedback loops among economic, ecological, and social systems. It helps to consider the consequences of human interventions, such as new policies, new technologies, and new business practices. An overview of the four EPA-funded Nutrient Management Research Centers was provided.

Part 1: Nutrient Removal and Recovery Technology and Approaches

Nutrient Recovery Through Urine Separation (STAR_N1R14) Krista Wigginton, University of Michigan	This research project integrated four major objectives to address practical and safety issues related to urine reuse: 1) understand how urine pretreatments impact pharmaceutical and biological contaminant concentrations; 2) evaluate the fate of nutrients, pharmaceuticals, and biological contaminants following urine product application; 3) compare the efficacy of using natural urine and urine-derived product as agricultural fertilizers; and 4) understand practical issues related to the implementation of urine separation and collection systems.
Development and Implementation Process Technology Toolbox for Sustainable Biological Nutrient Removal Using Mainstream Deammonification (STAR_N2R14) Kartik Chandran, Columbia University	Mainstream deammonification offers a significantly more cost-efficient alternative (with almost half the energy and most all of the external carbon) compared to conventional approaches for biological nitrogen removal. The objective of this research project was to develop a fundamental science- and technology-driven approach and a process toolbox to harness the potential offered by mainstream deammonification for sustainable nitrogen management. The project includes participating universities and utilities in the U.S. and abroad with key lessons learned from each.
Manure Resource Recovery (STAR_N3R14) Christine Radke on behalf of Georgine Yorgey, Washington State University	This research project assessed the use of pilot- and commercial-scale ammonia stripping systems within the context of a proposed sequential manure treatment system of anaerobic digestion, coarse fiber separation, fine solids separation, and ammonia stripping. It included a life cycle analysis to determine the water and energy use, and nutrient balance impacts of anaerobic digestion systems, including those that incorporate nutrient recovery, as compared to current manure handling practices in the Yakima, Washington region. The project also developed field days, a video, and durable products that help improve decision making about dairy nutrient recovery.

Title and Presenter	Synopsis
Manure Nutrient and Resource Recovery: Co-Digestion with Low-Cost Ammonia Stripping (STAR_N3R14a) David Stensel and Ryan Ziels, University of Washington	The overall objective of this research project was to increase energy production by managing co-digestion of fats, oils, and grease (FOG) with manure. It studied the relationships between FOG feeding strategies with digester stability, digester performance, long-chain fatty acid degradation, kinetics, and inhibition thresholds; as well as microbial populations and community shifts. Anaerobic co-digestion can be the key to energy positive wastewater treatment as FOG has greater than 50 times higher energy content compared to manure.
Enhanced Removal of Nutrients from Urban Runoff with Novel Unit-Process Capture, Treatment, and Recharge Systems (STAR_N4R14) David Sedlak, University of California-Berkeley	This research project investigated the ability of geomedia mixtures to sequester or transform drinking water contaminants likely to be encountered during recharge of the underlying aquifer with urban stormwater. It included an assessment of contaminant removal under field conditions. The fieldwork employed geomedia-containing test columns to demonstrate proof-of-concept studies of a novel approach to treatment with actual stormwater, while laboratory studies under controlled conditions provided mechanistic understanding of system parameters.
Part 2: Nutrient Efforts from Partnering Organizations	
Water Environment Federation Morgan Brown, WEF	The Water Environment Federation provided a brief synopsis of its nutrient-related programs – which include technical sessions, workshops, conferences, and symposiums. WEF completed its *Nutrient Roadmap* in coordination with a number of stakeholders, is nearing completion of a nationwide data-collection survey of resource recovery from wastewater (including nutrients), and is working with ACWA on a series of nutrient permitting workshops.
Association of Clean Water Administrators Patrick McGuire, ACWA	ACWA's series of workshops in partnership with WEF focus on nutrient permitting funded by a U.S. EPA Office of Wastewater Management Grant. The workshops are intended to support states and EPA to further identify challenges and barriers to nutrient permitting program implementation, highlight opportunities for program improvement and enhancement, showcase innovations, and assist with analysis of training, guidance, tools, and other support material needed to solve some of the most intractable nutrients issues.
National Association of Clean Water Agencies Cynthia Finley, NACWA	NACWA has long been advocating on nutrient issues by working with EPA and federal (e.g., the Farm Bill) and state agencies. NACWA provides its members with information about EPA's five-year study of POTWs to identify low-cost nutrient removal through optimization of secondary processes. NACWA has also responded, on behalf of its members, to EPA's request for scientific views on draft human health recreation ambient water quality criteria and/or swimming advisories.
Metropolitan Washington Council of Governments' Nutrients Efforts Tanya Spano, MWCOG	MWCOG has long led the Metropolitan Washington region's nutrient reduction efforts. This included working with WRF to convene the first *Nutrient Removal: How Low Can You Go?* technical workshop that featured more than120 nutrient removal technical experts which identified the research roadmap for WRF's Nutrient Removal and Recovery challenges. MWCOG also convened other nutrient-related knowledge exchange workshops and seminars in the Washington Metro and Chesapeake Bay Watershed. Utilities (MWCOG members) in the National Capital Region have achieved significant success in reducing nutrient loads in the Bay over the past two decades.

Part 3: Water Research Foundation Past, Ongoing, and Future Nutrient Research

Title and Presenter	Synopsis
Linkages with Water Quality Focus Area Lola Olabode, WRF	The objective of WRF's LINK (Receiving Water Linkages in Water Quality) challenge is to enable the water quality community to fully participate in the development and implementation of water quality-based discharge standards for contaminants (principally nutrients) by developing independent methods to confirm linkages between receiving water quality, wastewater discharges, and other sources. Projects including the *Nutrient Modeling Toolbox* were presented.
Reuse from Agriculture Focus Area Kristan VandenHeuvel, WRF	WRF's Agricultural Water Reuse research program has gained momentum in recent years. Treated municipal effluent is becoming more commonly used for irrigation of crops (for food and non-food, as the nutrient content of recycled water is perceived as a benefit), with the majority of this water being used for common space, parks, and public property. Agricultural reuse for food crops is also gaining momentum as a traditional water supply alternative. Ongoing and planned reuse projects were presented.
Integrated Water Management Focus Area Katy Lackey, WRF	WRF's Sustainable Integrated Water Management (SIWM) research program takes a holistic approach to wastewater, stormwater, drinking water, and reclaimed water to achieve the goals of *One Water* and Integrated Water Management. Four nutrient-related projects were presented: 1) International Stormwater BMP Database, 2) Community-Enabled Lifecycle Analysis of Stormwater Infrastructure Costs (CLASIC), 3) Stream Restoration Crediting Guidance and Case Studies, and 4) Incorporating Forestry into Stormwater Management Programs for Nutrient Reduction and Volume Control.
LIFT and EPA Nutrient Recycling Challenge Fidan Karimova, WRF	LIFT (Leaders Innovation Forum for Technology) is a WRF/WEF initiative to accelerate innovation and help move new water technologies into practice. LIFT has helped EPA as a partner with the EPA Nutrient Recycling Challenge – a competition for technologies to recycle nutrients from livestock manure.
Nutrients and Resource Recovery Focus Areas Christine Radke, WRF	WRF's Nutrients and Resource Recovery research programs have been working for over a decade to enable the water community make the paradigm shift for wastewater treatment facilities to become "Utilities of the Future" by removing nutrients (once considered a pollutant) to recovery of these valuable resources. This large and sustained effort includes more than $10 million of research funding, with over 500 volunteer subject matter experts from utilities, consultants, academics, regulatory agencies, vendors/manufacturers. Over 60 reports have been published; numerous workshops and webinars have been conducted; and various tools have been produced to assist utilities to better manage nutrients. Additional research needs were identified and prioritized through a technical workshop in early 2018.

Part 4: Strategies and Management Options – Using Models and Decision Support Tools

Title and Presenter	Synopsis
Tool for Evaluating Resource Recovery – Agriculture (STAR_N5R14) Ankit Pathak, Hazen and Sawyer	Commercially available nutrient fertilizer using the Haber-Bosch process and phosphorus mining assumes an unlimited supply of resources and energy. Wastewater treatment facilities (municipal and agricultural) can help minimize deleterious environmental discharges while recovering these valuable nutrients. WRF's *Tool for Evaluating Resource Recovery (TERRY – Phosphorus)* for municipal wastewater treatment was expanded to include agricultural facilities, and was demonstrated for input at the Summit. *TERRY-Ag* helps provide a high-level, conceptual cost and energy estimation for P recovery by estimating potential fertilizer production and revenue from the recovery processes, and provides a method to look at criteria beyond cost to help with technology selection.
Finding and Adding Agricultural BMP Performance Studies to the Agricultural BMP Database (STAR_N6R14) William Stack, Center for Watershed Protection	The key objective of this project was to enhance the data available in the Agricultural BMP Database (AgBMPDB) for the Upper Midwest and Chesapeake Bay (CB) regions. The project team accomplished this by: 1) contacting researchers (three Upper Midwest states and three states from CB Watershed) to identify studies for populating the database, 2) compiling and translating Ag-BMP research data for up to 12 studies in the upper Midwest (IL, MN, IA) and 12 studies within the CB watershed, (MD, PA, VA) into suitable format for entry into the AgBMPDB, and 3) developing a summary report to describe the research studies uploaded and their added value to the database.
Nutrient Life Cycle Management Decision Methodology (STAR_N1aR14) Walter Graf for Steven Skerlos, University of Michigan	This life cycle analysis project quantified inputs and outputs to evaluate the environmental performance of a urine diversion system where the urine is used as fertilizer (either via pasteurization or by struvite precipitation) and compared with conventional wastewater treatment of urine and conventional production of fertilizer. The project included a case study in Vermont at the Rutherford WWTP, which favorably compared the WWTP operations and production of conventional synthetic fertilizer with an alternative where 70% of urine was diverted for fertilizer produced either by struvite/ion exchange or by urine concentration.
Center for Reinventing Aging Infrastructure for Nutrient Management (RAINmgt) Qiong Zhang, University of South Florida http://usf-reclaim.org/	RAINmgt, led by Dr. Jim Mihelcic from the University of South Florida, is one of the four EPA-funded National Nutrient Management Research Centers. The key mission of this Center is to achieve sustainable and cost-effective health and environmental outcomes by re-imagining aging coastal urban infrastructure systems for nutrient recovery and management contributing to sustainable and healthy communities. The overall goal is to develop the science behind new technology and management innovations and a deep understanding of the integrated system while demonstrating and assessing these innovations to provide new knowledge for students, community members, and other stakeholders. Systems approaches focused on three thrust areas (point sources of nutrients, diffuse sources of nutrients, and life cycle thinking and systems integration) allow the Center to evaluate and optimize an integrated system of technologies and management strategies. Results and outcomes from the Center were presented at the Summit.

Part 5: Water Research Foundation Nutrients Challenge

Title and Presenter	Synopsis
Nutrient Challenge Overview and Nutrient Removal Technologies JB Neethling, HDR	The lead Principal Investigator for WRF's Nutrient Challenge provided an overview of this multi-million dollar and multi-year effort to provide science-based solutions and recommendations to support and inform utilities and regulatory agencies on nutrient management practices using sustainable nutrient removal technologies and flexible and adaptive permitting.
Innovative Nutrient Removal Technologies Phil Zahreddine, U.S. EPA	U.S. EPA's ongoing effort documents case studies of utilities that are using innovative nutrient removal technologies to enhance other U.S. EPA reports related to nutrient control and management.
Nutrient Regulations David Clark, HDR	One of the major efforts of WRF's Nutrient Challenge was to review current permitting practices and identify alternative approaches to nutrient discharge permitting. One of the Challenge's core team members provided an overview of findings and recommendations for a path forward for municipalities and regulatory agencies to use to work together on nutrient permitting.

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