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U.S. EPA National Center for Environmental Research (NCER)

National Nutrient Management Kickoff Workshop

WERF National Center for Resource Recovery and Nutrient Management

Narragansett Bay, RI
January 21 & 22, 2015

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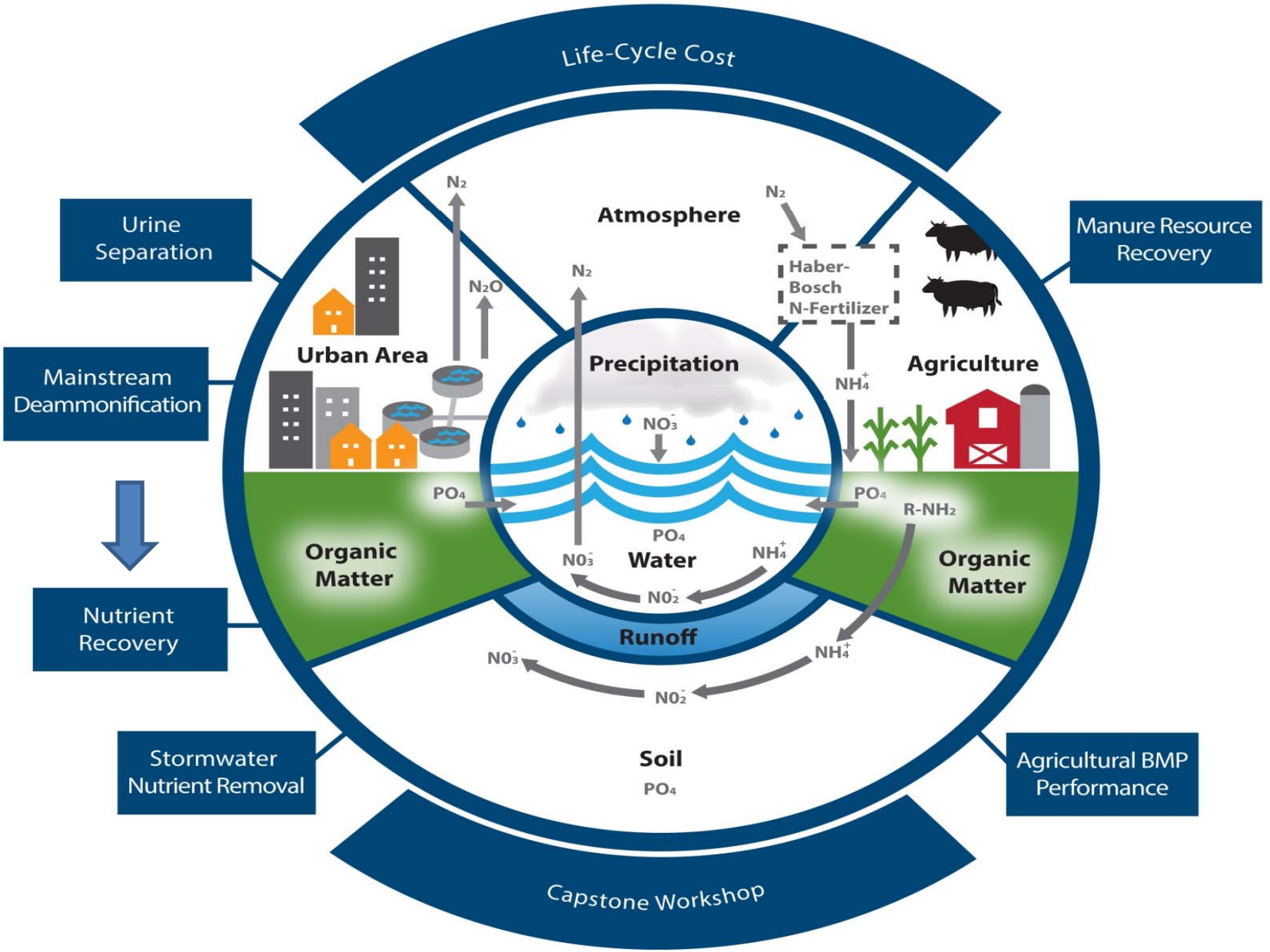
WERF's National Research Center for Resource Recovery & Nutrient Management

Mission

- Find solutions for nutrients, energy, and water resource recovery and reuse
- Provide data, demonstrations, and tools to shift the water quality community

Expands and integrates WERF's current research

WERF's National Research Center for Resource Recovery and Nutrient Management



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Science Advisory Committee (SAC)

- **Rich Anderson**
  U.S. Conference of Mayors, DC
- **Dr. Donald Gray (Gabb), PE, BCEE**
  East Bay Municipal Utility Dist., CA
- **Ted McKim, PE, BCEE**
  Reedy Creek Energy Services, FL
- **Dr. Lisa Micheli**
  Pepperwood Preserve, CA
- **Prof. Cliff Randall, Dist. M.ASCE**
  Virginia Tech, VA
- **Dr. Danny Reible, PE, BCEE**
  Univ. of Texas at Austin, TX
- **David Rouse, AICP**
  American Planning Association, DC
- **Dr. Steven R. Shafer**
  U.S. Dept. of Agriculture, MD
- **Phil Zahreddine, MSEnvEng**
  U.S. EPA – OWM, DC

Research Partners

- 7 universities
- 3 municipal utilities
- 2 national research centers
- 6 community entities

- Outreach and communication: WERF, Johnson Foundation, and US Water Alliance

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Nutrient Recovery through Urine Separation

University of Michigan, *Hampton Roads Sanitation District (HRSD), Rich Earth Institute (REI), University of Buffalo, Ostara, Brown and Caldwell*

STAR_N1R14

Project Organization

Urine collection, storage, agriculture

Rich Earth Institute (Vermont)
Konrad Scheltema
Abe Noe-Hayes
Kim Nace (co-PI)

Biological analyses

University of Michigan
Heather Goetsch
Rebecca Lahr
Krista Wigginton (PI)
Nancy Love (co-PI)

Pharmaceutical analyses

University of Buffalo (New York)
Rachel Mullen
Diana Aga (co-PI)

Struvite production

Hampton Roads Sanitation District (HRSD, Virginia)
Charles Bott (co-PI)
Brown and Caldwell
Jose Jimenez (co-PI)

Objectives

Addresses **practical and safety issues** related to urine reuse:

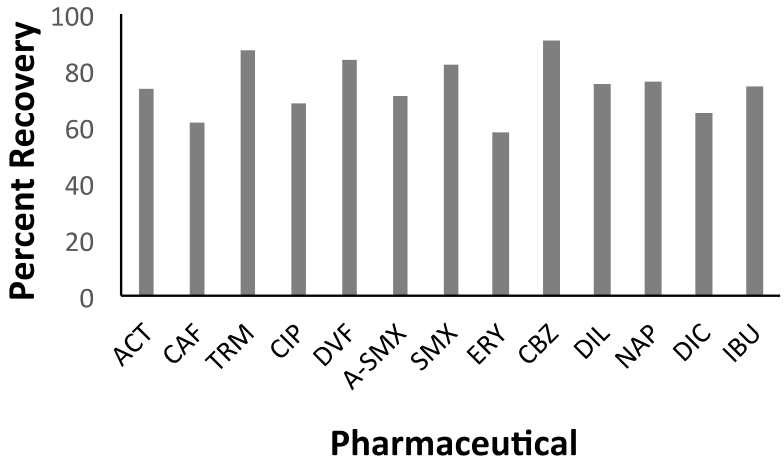
(i) provide design and permitting **guidelines** to address practical issues related to the implementation of **urine separation and collection systems;**

(ii) understand how urine **pretreatments impact** pharmaceutical and biological contaminant concentrations;

(iii) compare the **efficacy** of using natural urine and urine derived product as **agricultural fertilizers**;

and

(i) **evaluate** the **fate** of nutrients, pharmaceuticals and biological contaminants **following** urine product **application**.



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Urine based fertilizer products include stored urine and precipitated struvite crystals

Collection

Sanitation

20 °C for 1 month OR
80 °C for 2-3 min

Aged urine characteristics:

- pH of 9+
- $[NH_3]$ = 0.7-12.5 g/L

Liquid urine-based fertilizer

Struvite precipitation

$Mg^{2+} + NH_4^+ + H_nPO_4^{3-n} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O \downarrow + nH^+$

Dry urine-based fertilizer

Fertilize crops

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Major accomplishments in 2014

- ✓ Developed and optimized methods to characterize urine and quantify pollutants in urine, urine-derived fertilizers, plant tissues, lysimeter water

- ✓ Conducted urine collection events at two public festivals and analyzed urine with newly developed methods

- ✓ Completed successful first growing season of carrots and lettuce at field site at REI

- ✓ Analyzed lysimeter water for pollutants

- ✓ Participated in kick-off meeting at HRSD (March) and first growing season review meeting at REI (October)

Development and Implementation of a Process Technology Toolbox for Sustainable Biological Nitrogen Removal Using Mainstream Deammonification

STAR_N2R14

Kartik Chandran, PhD, Columbia University, NY
Sudhir Murthy, PhD, PE, DC Water, DC
Charles Bott, PhD, PE, Hampton Roads Sanitation District, VA

The People

Charles Bott
Ryder Bunce
Kartik Chandran
Norman Dockett
Haydee De Clippeleir
Dana Fredericks
M. Gomez Brandon
Mofei Han
Martin Hell
Becky Holgate
Jose Jimenez
Hansa Keswani
Qi Zhang
Heather Stewart
Heather Battiste-Alleyne
Yixuan Fang
Tanush Wadhawan
David Kinnear
Yi Wei Ma

Matthew Michaelis
Mark Miller
Sudhir Murthy
Geert Nyhuis
Chunyang Su
Ahmed Omari
Maureen O'Shaughnessy
Hong Keun Park
Sabine Podmirseg
Pusker Regmi
Chakavak Kamran
Rumana Riffat
Andrew Shaw
Beverley Stinson
Imre Takacs
Claire Welling
Bernhard Wett

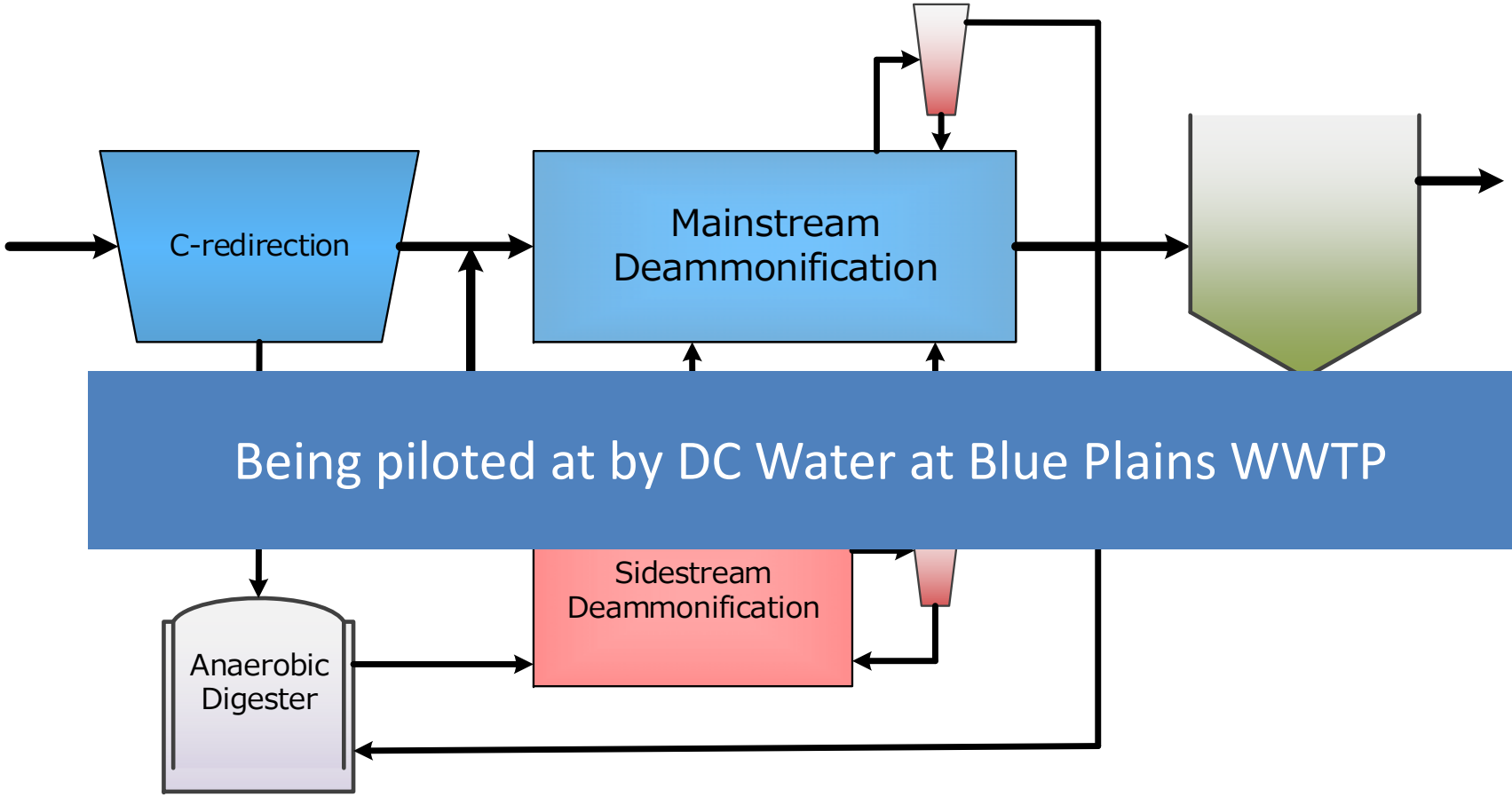
WERF Perspective / Overview

- Deammonification – important for Nutrient Removal in a Resource and Energy Constrained context
  - significantly more energy & cost-efficient than conventional biological nitrogen removal (BNR).
- Expands WERF's portfolio of EPA & Subscriber funded research
  - Aging Water Infrastructure *(INFR6R11, Full-Plant Deammonification for Energy Positive Nitrogen Removal)*
  - National Nutrient Research Center *(STAR_N2R14 , Development and Implementation of a Process Technology Toolbox for Sustainable Biological Nitrogen Removal using Mainstream Deammonification)*
  - LIFT focus area

Key Research Objectives

- Develop:
  - a fundamental science and technology driven approach
  - process toolbox
- Harness the potential offered by mainstream deammonification for sustainable nitrogen management.

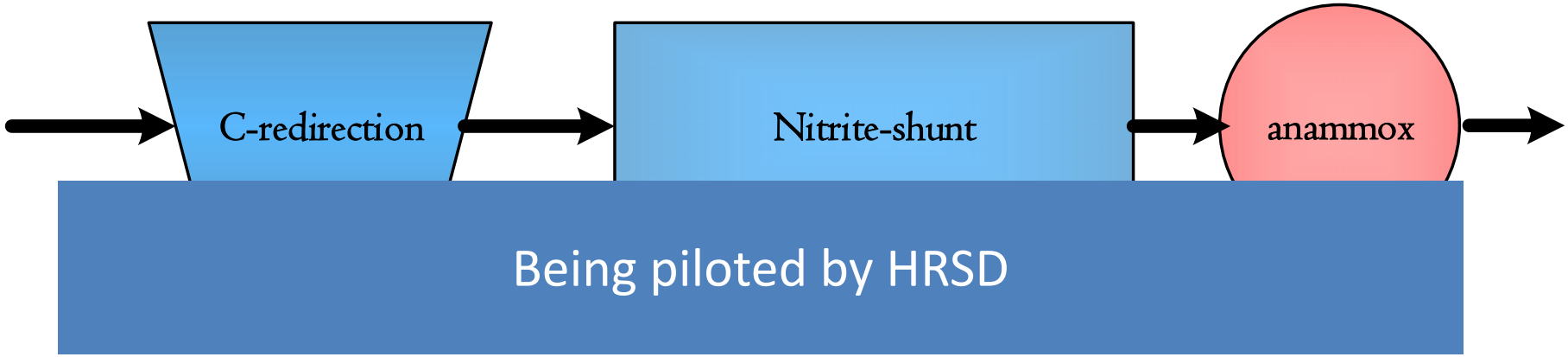
Plants with Anaerobic Digestion



Key Features:

- Direct AMX and AOB in the cyclone overflow (or screens) to the mainstream
- Cyclone/screen for AMX retention in mainstream

Plants without anaerobic digestion



Key Features:

- Bioaugmentation of AMX and AOB to the mainstream is not possible
- Anammox process (attached growth) as final polishing step
- Goal to obtain maximum TIN removal during Nitrite shunt and feed optimal Nox/NH4 ratio to anammox MBBR

Rethink Conventional Wisdom for Short Cut in Nitrogen in Activated Sludge Systems

- ~~Long SRTs~~ **Shorter SRTs**
- ~~Low Dissolved Oxygen~~ **Higher Dissolved O2**
- ~~Continuous Low DO~~ **Transient Anoxia**

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Integrated Management of Animal Manure Wastes

STAR_N3R14

Ryan Ziels & H. David Stensel
Civil and Environmental Engineering
University of Washington

Craig Fear
Washington State University

Ali Saleh
Tarleton State University

Project Objectives

- **Demonstrate feasibility** of using low cost/chemical ammonia stripping to recover ammonia from wastewater and manure
- **Provide** recovered ammonia as **fertilizer**
  - Previously ammonia stripping of animal waste has been prohibitively expensive
  - Requires techno-economic evaluation in regard performance, capital costs, operating costs and co-product revenues

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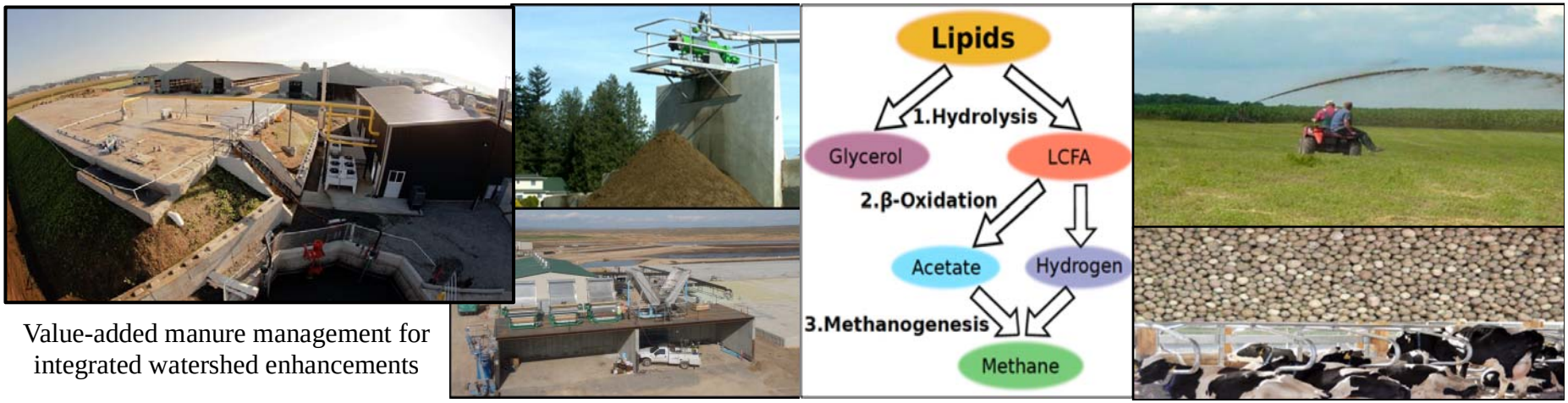
Thrust Areas:

1: Co-digestion of FOG with Manure Anaerobic Digestion

2: Low-Input Ammonia Stripping with Bio-fertilizer Recovery

3: Evaluation of Systems Approach to Manure Management



Value-added manure management for integrated watershed enhancements

Demonstration Sites

- Dairy cow facilities
  - Washington State: Yakima Basin, Central Washington
    - over 60 dairies and nearly 100,000 dairy cows
    - strong agricultural zone, using irrigation to produce numerous valuable row crops on sandy soil
    - excess nitrate levels in well water, led to new interest in manure management.
  - Wisconsin
- Poultry operation
  - Ohio

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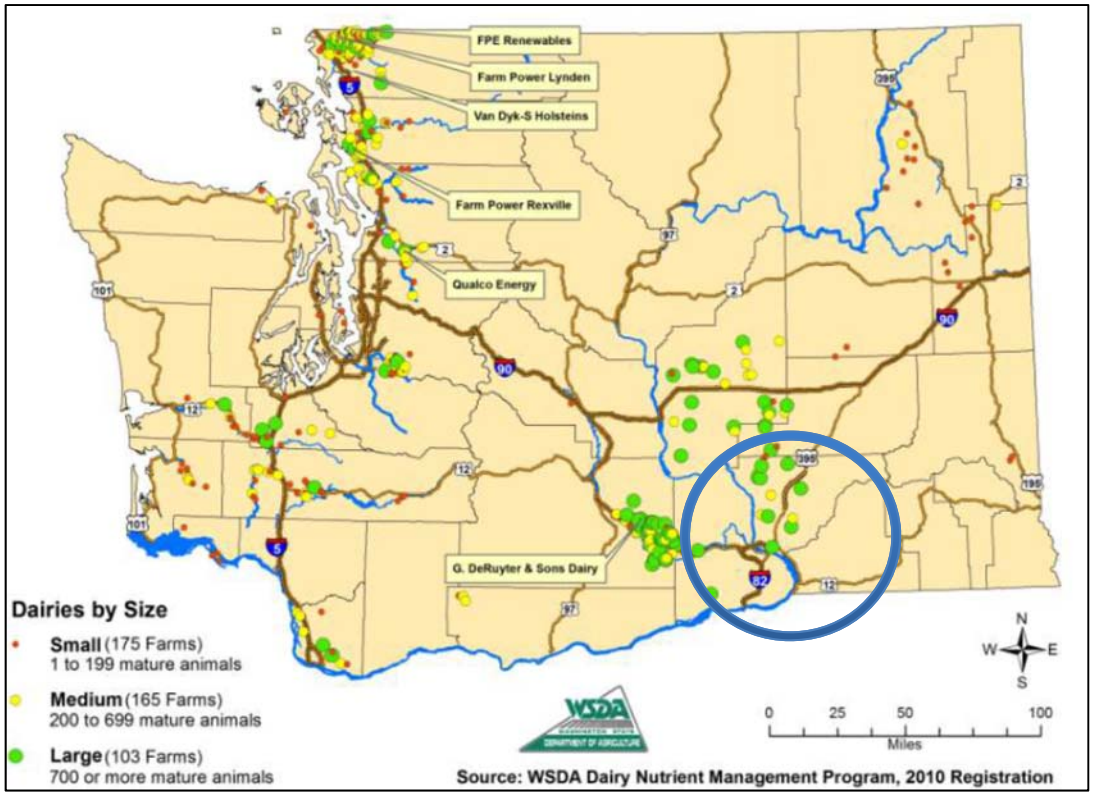
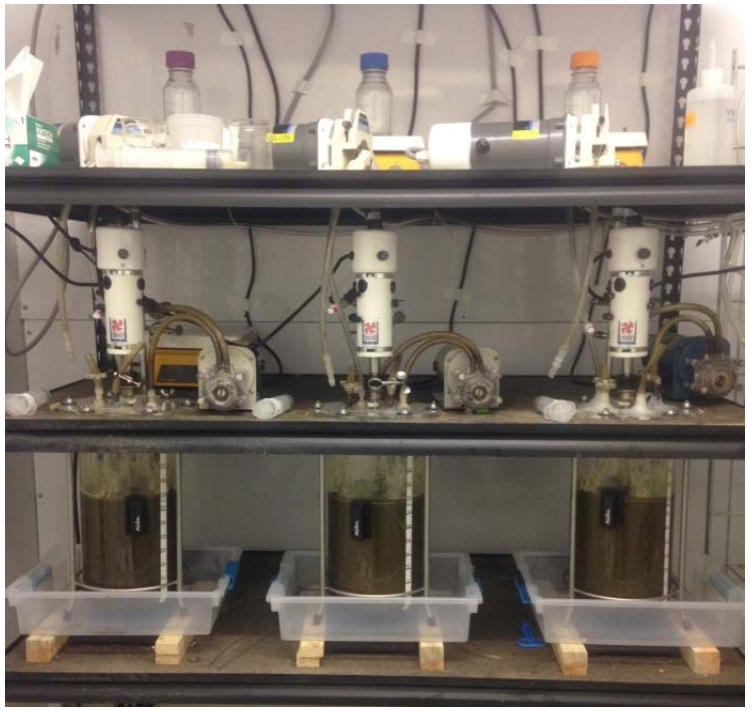
Apply Knowledge Gained to Modeling of Watersheds for Determination of Best Practice Impacts

- **Characterize** wastewater **effluents** after various scenarios of digestion & nutrient recovery
- Use field and sub-watershed models and nutrient tracking tools to **compare different technology best practices to impacts on field** and sub-watershed management
- Incorporate **these modeling outputs with known techno-economic data** to further inform on viability of best practices



Current Status

- Dual **models under-development** and being calibrated for use in this objective
- One-day **workshop at Pullman** on farm-based nutrient, model assessment/impacts now
- Potential for **increased levels of methane production** with co-digestion of FOG in manure anaerobic digesters



UW Current Status:
Lab-scale Anaerobic Bioreactors

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Enhanced Removal of Nutrients from Urban Runoff with Novel Unit-Process Capture, Treatment, and Recharge Systems

STAR_N4R14

Principal Investigators:

David L. Sedlak – University of California, Berkeley

Richard G. Luthy – Stanford University

Water Research Foundation
advancing the science of water

ReNUWIt
Re-inventing the Nation's URBAN WATER INFRASTRUCTURE

Objectives of Research

- **Guidance** on designing and operating systems to control nutrient releases to surface waters.
- **Quantitative models** for predicting and enhancing nutrient removal in unit-process stormwater treatment and recharge systems under conditions representative of regions where most nutrient releases occur in a small number of precipitation events.
- **Impact assessments** of different urban runoff treatment schemes at the watershed scale.
- **Evaluation of treatment systems design** with community acceptance and sustainability.

People

Principal Investigators:
David L. Sedlak – University of California, Berkeley
Richard G. Luthy – Stanford University

Stanford:
Alexandria Boehm (Associate Professor)
Greg LeFevre (postdoc)
Brian Halaburka (PhD candidate)
Jordyn Wolfand (PhD student)

UC Berkeley:
Marc Planes (postdoc)
Joe Charbonnet (PhD candidate)

Colorado School of Mines:
Chris Higgins (Associate Professor)
Bridget Ulrich (PhD candidate)

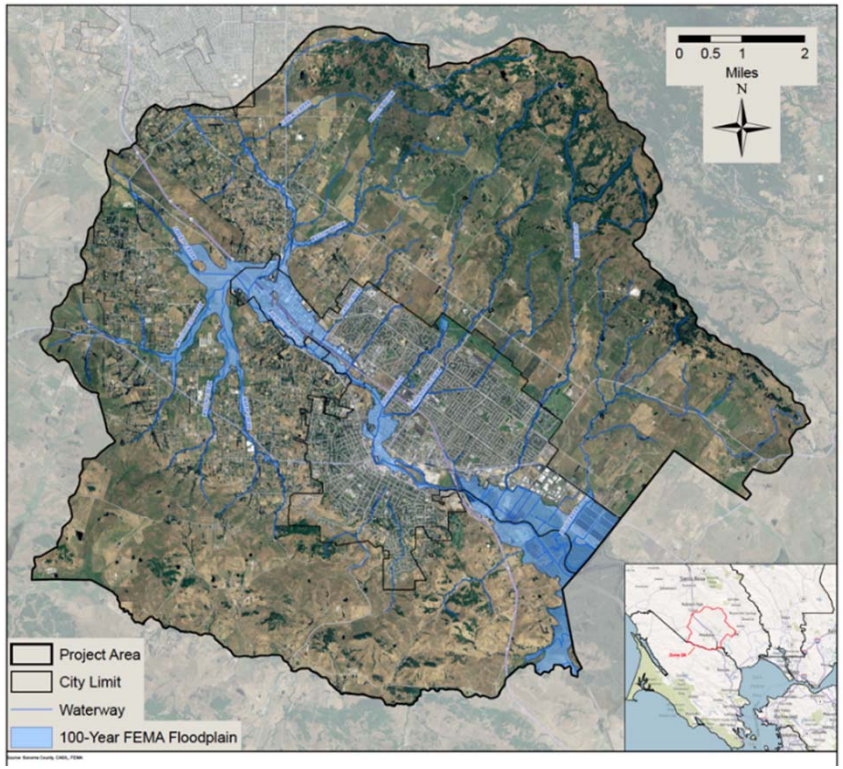
Sonoma County Water Agency:
Kent Gylfe (Principal Engineer)
Jay Jaspers (Chief Engineer + Director of Groundwater Management)
Mike Thompson (Assistant General Manager)

Securing our Future by Investing in our Water Resources, Environment & Community

Sonoma County

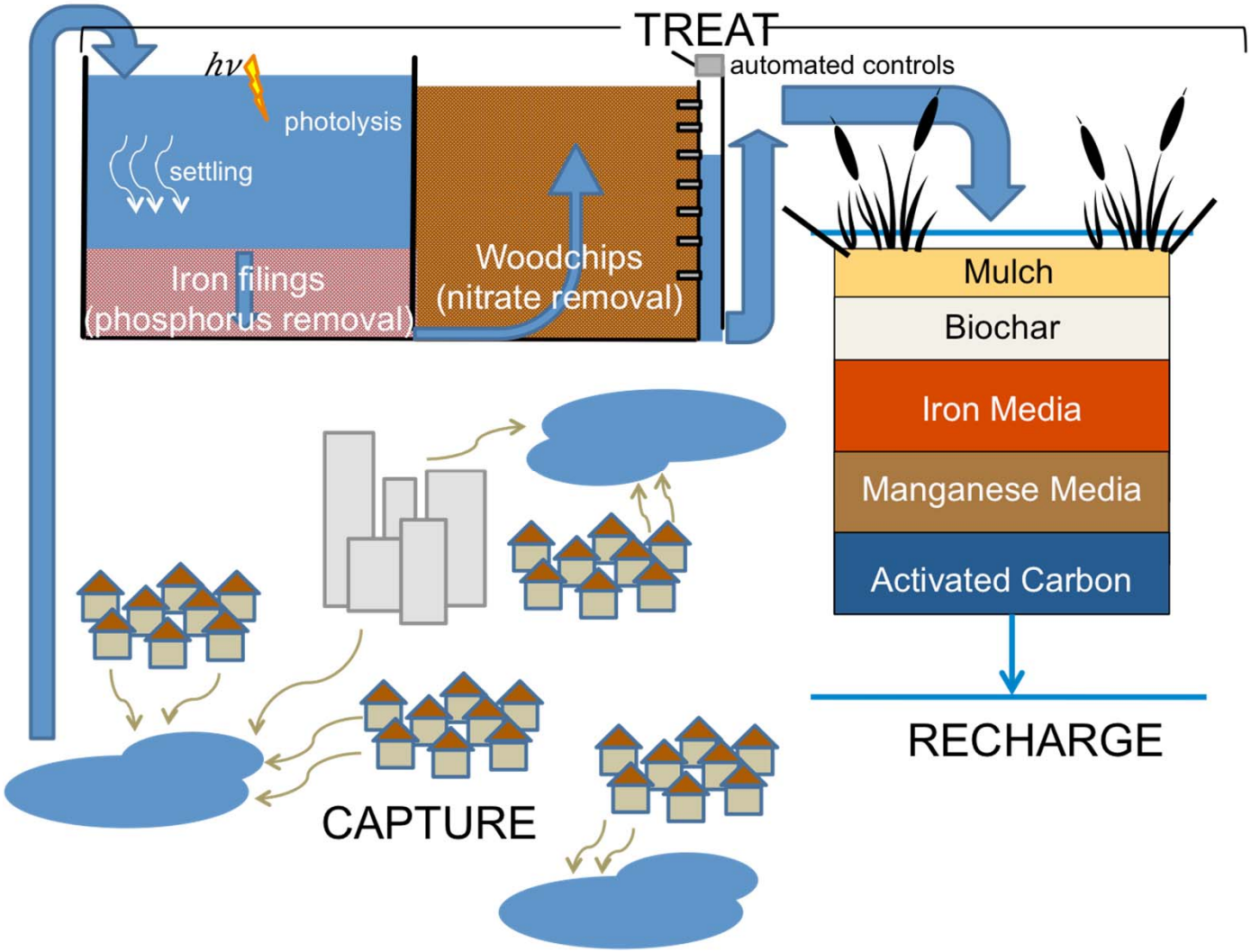
Stormwater management priorities

- **Two main objectives**: flood hazard reduction & groundwater recharge
- **Systems-level view:** integrated land use planning and public acceptance.
- **Muliti-benefit projects:** community benefits, maintain open space, ecosystem functions
- **Reduce nutrient load to Bay**



Contaminant removal

How would all this work? What's the right design?



Innovation

- Show the potential for **adapting LID** to combine stormwater capture, denitrifying bioreactors, and bioinfiltration systems,
- Extend the **use of denitrifying bioreactors**—a technology developed and proven to be useful in other applications—to conditions encountered **in urban runoff**.
- **Augment ongoing research** on novel geomedia designed for removal of trace organic contaminants and waterborne pathogens to assess their **potential use for nutrient removal.**
- **Use sensors** and automated controls for better control of system operations and **more precise estimates** of the mass of **nutrients** being **removed** under field conditions.

Developing a Consolidated Resource for Agricultural BMP Performance

Population of a New National Database

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

NATIONAL CORN GROWERS ASSOCIATION

Project Team
Jane Clary and Jonathan Jones, P.E.,
Wright Water Engineers
Eric Strecker, P.E. and Marc Leisenring, P.E.,
Geosyntec consultants

WRIGHT WATER ENGINEERS, INC.

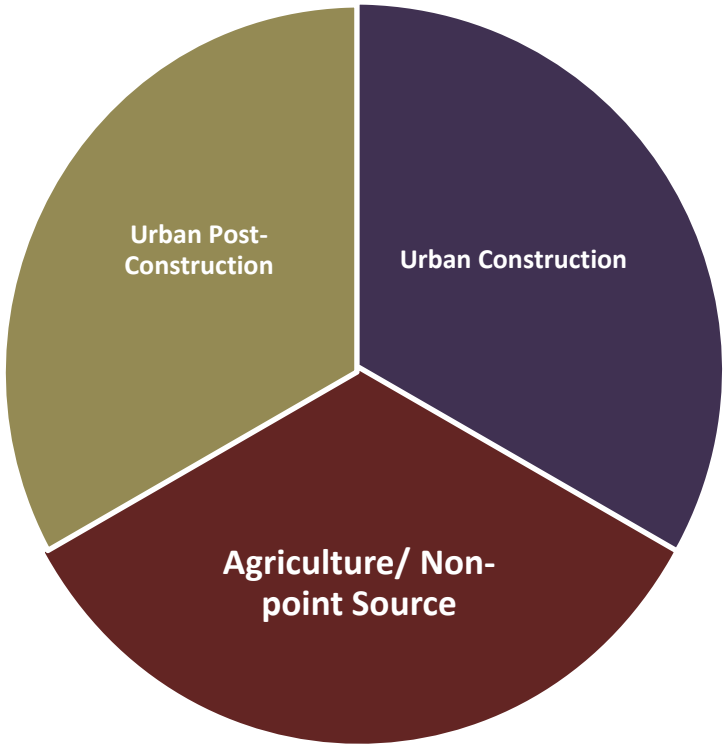
Geosyntec consultants
engineers | scientists | innovators

the Agricultural BMP Database

A nationwide agricultural BMP monitoring/reporting protocols and performance database

Modeled on and integral to the existing International Stormwater BMP Database (www.bmpdatabase.org)

"Part of the pie" in addressing watershed-scale water quality issues



Industrial Waste Streams Research - 2016

- R &D of commercial extractive nutrient recovery technologies to the agricultural and industrial sectors.
- Accelerate production of nutrient products with high resale potential.
- Further demonstrate and field test viability of extractive nutrient recovery
- Significantly leverage investments by the municipal wastewater treatment sector
- Build upon ongoing WERF research project NTRY1R12 which currently includes 18 locations, mostly wastewater treatment facilities) to include agricultural and industrial waste streams.
- WERF will issue a competitive RFP

Evaluating the social, economic and environmental costs, benefits and acceptance

Collaborate w/Johnson Foundation at Wingspread to host meeting of key stakeholders

Review research results and advise on new nutrients research needs.

Set the stage for future investment by WERF and the greater water quality community in this type of research.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Thank You!


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