Phosphorus Forum 2019

April 5, 2019
Barrett and O’Connor Washington Center
at Arizona State University
1800 I Street NW
Washington, DC,
phosphorusalliance.org
#PhosForum19

Made possible by the support of our members:

Founding/Current Members and Strategic Partners

Sustainable Phosphorus Alliance
Agenda

8:30 – 9:00 Welcome from Jim Elser
9:00 – 9:45 Keynote from Bruce Rittmann
9:45 – 10:00 Coffee sponsored by Ostara
10:00 – 10:30 Phosphorus Field-to-Watershed Modeling Task Force Report by Peter Vadas
10:30 – 11:00 Biosolids and Manure Task Force Report by Rebecca Muenich
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1:30 – 2:00 Algae Removal Program by James Gaspard
2:00 – 2:15 ReNEW Water Project by Patrick Dube
2:15 – 2:30 Closing comments from Jim Elser
2:30 – 3:00 Room open for networking
The Phosphorus Sustainability Challenge
The Demand Problem

Phosphorus consumption has increased... and it’s wreaking havoc on our waters

- 40% of lakes were in the “most disturbed” condition for total phosphorus (NLA 2012)
- 18.2% decline in the percentage of lakes with < 10 ppb P between 2007 and 2012
- 46% of US rivers and streams (by length) had “high” levels of phosphorus (NRSA, 2009)

Phosphorus is the most important pollutant of our most important natural resource and commodity.
The Supply Problem

“World resources of phosphate rock are more than 300 billion tons. There are no imminent shortages of phosphate rock.” – USGS, Mineral Commodity Summaries 2018

“The reserve/production ratio...is about 266, which is one of the largest among all mineral commodities.”
– Scholz and Wellmer, 2019

82% of global crude oil reserves here

71% of global phosphate rock reserves here
A Note on Recycling

Post-consumer functional recycling for 60 metals.

“rates tend to reflect the degree to which materials are used in large amounts in easily recoverable applications...or where high value is present.”
A Note on Recycling


“rates tend to reflect the degree to which materials are used in large amounts in easily recoverable applications...or where high value is present.”

Recycling phosphorus is critical, but let’s not pin all of our hopes on a circular economy for phosphorus.
The Circular Economy

“A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life.”

-- UK WRAP
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-- UK WRAP

Breaking news! Paper now infinitely recyclable!
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A conical economy is a circular economy that emphasizes reducing the consumptive footprint of the value chain (i.e. sustainable use and sustainable recycling).
The Sustainable Phosphorus Alliance is a members organization that serves as North America’s central forum and advocate for the sustainable use, recovery, and recycling of phosphorus in the food system.
There Is No P in CSR

Pivot Goals

The sustainability goals of the world’s largest and leading companies:
An initiative of Winston Eco-Strategies

Total Number of Goals: 3923
There Is No P in CSR

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GHG/Climate/Energy Goals: 1246
Deforestation/Paper Goals: 133
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## Activities

<table>
<thead>
<tr>
<th>Company</th>
<th>#CSR P Mentions</th>
<th>#CSR Nutrients Mentions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargill</td>
<td>0</td>
<td>0</td>
<td>Improve water quality through sustainable agriculture (nutrient focus)</td>
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<tr>
<td>ADM</td>
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<td>0</td>
<td>Waste-to-landfill reduction and sustainable agriculture</td>
</tr>
<tr>
<td>PepsiCo</td>
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<td>0</td>
<td>Sustainable agriculture (nutrient focus) and wastewater management</td>
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<td>Nestle</td>
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<td>0</td>
<td>Wetland restoration, sustainable agriculture, water stewardship</td>
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<td>Sysco</td>
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<td>2</td>
<td>Sustainable agriculture (fertilizer reduction) and recycling vegetative waste</td>
</tr>
<tr>
<td>JBS</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Introducing….

Psustainabilitychallenge.org
#phosphoruschallenge

Raise awareness about the issues and give credit to those addressing them.

Provide a public commitment platform for any organization.

Organize action networks to define sustainability and how to best measure and report it.
Who Needs to Get Involved?
How Does It Work?

- A framework has been built that includes a set of high level goals and specifications for commitment formation (see provided materials).

- Organizations submit commitments via web and we vet for compliance.

- Commitments are promoted.

- Action networks develop around “hot” issues.
How Are Commitments Framed?

**Challenge Rules**

1. Applicants must make either a new commitment or state an existing commitment that has yet to be achieved or publicized.

2. Commitments must exceed regulatory compliance requirements in pertinent jurisdiction(s).

3. Commitments must address at least one of the key phosphorus sustainability goals identified. Organizations may also petition to add additional goals, subject to review by Alliance staff.

4. Commitments must be SMART: Specific in aim, Measurable, Ambitious, Relevant to the Challenge goals, and Time-bound.

5. Commitments must include implementation, that is, commitments to R&D and innovation alone are ineligible. Implementation means that a technology or approach has reached market/rollout after pilot-scale or field trials.

6. Organizations must enter commitments about which progress can be reported on annually.

Sustainable Phosphorus Alliance
How Are Commitments Verified?

- Independent verification is acknowledged/encouraged but not mandated
- Commitments are public and misrepresentation will lead to expulsion
- Action networks may agree to a verification framework
How Is News Disseminated?

- Social Media: Twitter, LinkedIn
- Participant promotion: horn tooting via own marketing channels
- YOU! Peer promotion, especially by social media and word of mouth
Endgame: The Conical Economy for Phosphorus

Let’s get 100 Pivot Goals to address phosphorus pollution
Let’s take 5 minutes to read the Challenge Goals

Activities for each table (20 min)

Write a hypothetical commitment from either a governmental body or corporation that conforms to the specifications and discuss:

1. what challenges someone might face gaining internal buy-in from his/her organization and
2. how we might best help them make the case

Reports to room (20 min)
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How Are Commitments Framed?

1. Use phosphorus on landscapes, including cropland, more judiciously
2. Use phosphorus in animal feeding operations, including aquaculture, more judiciously
3. Sustainably re-use / recycle phosphorus
4. Remove phosphorus from human and animal waste streams
5. Reduce food system waste and recover its phosphorus
6. Recover phosphorus pollution from surface waters
7. Reduce and recover phosphorus wastes from industrial processes
8. Manage landscapes to contain and recover phosphorus
9. Promote human diets with lower phosphorus footprints
10. Improve the efficiency of phosphorus extraction from rock and conversion to products
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Biochar Now

Algae Removal Program

OMRI certified
USDA Bio-preferred
TSCA Listed
Biochar – Sized for water application
Biochar
Now

120X
Biochar
Now

1200X
Ag Nutrients Removed from Dirty Water Solutions
Using Biochar Now biochar
Independent Test Results

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Starting mg/L</th>
<th>% Adsorbed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>27</td>
<td>99.9%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>27</td>
<td>99.8%</td>
</tr>
<tr>
<td>Phosphate</td>
<td>284</td>
<td>86.6%</td>
</tr>
<tr>
<td>Ammonia</td>
<td>1.1</td>
<td>89.7%</td>
</tr>
<tr>
<td>Nitrate</td>
<td>52</td>
<td>64.3%</td>
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</table>

Solids Removed from a Dirty Water Solutions
Using Biochar Now biochar
Independent Test Results

<table>
<thead>
<tr>
<th>Solids</th>
<th>Starting mg/L</th>
<th>% Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>NTU*</td>
<td>68 NTU</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Non-soluble P</td>
<td>27</td>
</tr>
<tr>
<td>Solids</td>
<td>SS</td>
<td>506</td>
</tr>
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</table>

Water holding capacity = 5.6 x the weight of biochar
**Metals and Other Materials Removed from a Dirty Water Solutions Using Biochar Now biochar**

**Independent Test Results**

<table>
<thead>
<tr>
<th>Metals</th>
<th>Starting mg/L</th>
<th>% Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>638</td>
<td>100%</td>
</tr>
<tr>
<td>Arsenic</td>
<td>203</td>
<td>100%</td>
</tr>
<tr>
<td>Barium</td>
<td>0.17</td>
<td>66.0%</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.16</td>
<td>99.0%</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.015</td>
<td>100%</td>
</tr>
<tr>
<td>Chromium</td>
<td>166</td>
<td>100%</td>
</tr>
<tr>
<td>Cobalt</td>
<td>219</td>
<td>100%</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0</td>
<td>99.7%</td>
</tr>
<tr>
<td>Iron</td>
<td>66</td>
<td>99.6%</td>
</tr>
<tr>
<td>Lead</td>
<td>45</td>
<td>100%</td>
</tr>
<tr>
<td>Lithium</td>
<td>0.17</td>
<td>39.0%</td>
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<tr>
<td>Magnesium</td>
<td>3</td>
<td>69.2%</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>96</td>
<td>100%</td>
</tr>
<tr>
<td>Nickel</td>
<td>211</td>
<td>100%</td>
</tr>
<tr>
<td>Selenium</td>
<td>215</td>
<td>100%</td>
</tr>
<tr>
<td>Tin</td>
<td>0.17</td>
<td>100%</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.15</td>
<td>75.0%</td>
</tr>
<tr>
<td>Zinc</td>
<td>75</td>
<td>99.7%</td>
</tr>
</tbody>
</table>
Stops Algae Blooms

Before

After
Stops Algae Blooms

Before

After

Natural currents or pumps move contaminants-laden water through the biochar which removes the contaminants while also filtering out solids.
Float

Anchor

Flow-through mesh bags filled with biochar

Add more collection chains
Contaminant laden bags are removed
Flow-through mesh bags filled with biochar

Fresh replacement bags can be attached to remove more contaminants
Placing Filter socks in Dairy Lagoon with Floats
Croke Reservoir - Northglenn
Placement of Socks
Placement Day
Can easily configure filters to meet area shape or volume requirements
Remove Biochar Filters and sell into market to recoup costs

- Filters are now nutrient laden and the following slides outline benefits of biochar in agricultural.
- Marketing program is set up with local entities to make public aware of biochar benefits.
- Sell the biochar in local garden centers for home use and directly to large agricultural concerns and lawn care companies.
- Our current sales price in these markets allows for recapture of initial cost of biochar used to adsorb phosphorus and nitrates from water bodies and stop algae blooms.
Cornell Study

Control plot

Amazon River Basin
Native soil, maize corn, no fertilizer, no biochar
Cornell Study

NPK plot

Amazon River Basin
Native soil, maize corn, NPK fertilizer, no biochar
Cornell Study

Biochar with NPK

Amazon River Basin
Native soil, same NPK fertilizer, 10% biochar added

880% yield improvement over NPK-only plot
Biochar Increases Tree Root Growth

Root growth of honey locust seedlings growing in compacted soil after 18 months of no treatment (left) and an application of biochar top-dressing (right). Photo: Morton Arboretum Soil Science Laboratory
# Lawn & Landscape

Top 20 service companies (2016)

**2 of top 4 providers have approved our biochar for national rollout**

Top 100 provider market size is $8B

<table>
<thead>
<tr>
<th>2017 RANK</th>
<th>COMPANY</th>
<th>2016 RANK</th>
<th>2016 REVENUE</th>
<th>HEADQUARTERS</th>
<th>EMPLOYEES</th>
<th>% CHANGE FROM 2015</th>
<th>% CHANGE EXP. FOR 2017</th>
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<tr>
<td>1</td>
<td>BrightView</td>
<td>1</td>
<td>$2,200,000,000</td>
<td>Plymouth Meeting, Pa.</td>
<td>22,000</td>
<td>10%</td>
<td>N/A</td>
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<td>2</td>
<td>TruGreen Cos.</td>
<td>2</td>
<td>$1,377,054,000</td>
<td>Memphis, Tenn.</td>
<td>11,444</td>
<td>2%</td>
<td>7%</td>
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<td>3</td>
<td>The Davey Tree Expert Company</td>
<td>3</td>
<td>$645,878,000</td>
<td>Kent, Ohio</td>
<td>6,600</td>
<td>3%</td>
<td>5%</td>
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<td>4</td>
<td>Bartlett Tree Experts</td>
<td>5</td>
<td>$244,000,000</td>
<td>Stamford, Conn.</td>
<td>1,650</td>
<td>8%</td>
<td>10%</td>
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<tr>
<td>5</td>
<td>U.S. Lawns</td>
<td>7</td>
<td>$168,000,000</td>
<td>Orlando, Fla.</td>
<td>2,000</td>
<td>0%</td>
<td>5%</td>
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<td>6 (t)</td>
<td>LandCare</td>
<td>6</td>
<td>$160,000,000</td>
<td>Frederick, Md.</td>
<td>4,000</td>
<td>-10%</td>
<td>0%</td>
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<td>6 (t)</td>
<td>Five Seasons Property Management/Asplundh</td>
<td>6</td>
<td>$160,000,000</td>
<td>Philadelphia, Pa.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>8</td>
<td>Park West Companies</td>
<td>10</td>
<td>$150,745,000</td>
<td>Rancho Santa Margarita, Calif.</td>
<td>1,615</td>
<td>18%</td>
<td>14%</td>
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<td>9</td>
<td>Ruppert Landscape</td>
<td>12</td>
<td>$149,000,000</td>
<td>Laytontowne, Md.</td>
<td>1,275</td>
<td>21%</td>
<td>5%</td>
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<td>10</td>
<td>Wood Man</td>
<td>9</td>
<td>$148,825,830</td>
<td>Messiguaqua, Ontario</td>
<td>4,050</td>
<td>4%</td>
<td>10%</td>
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<td>11</td>
<td>Ferrandino &amp; Son</td>
<td>8</td>
<td>$145,000,000</td>
<td>Farmingdale, N.Y.</td>
<td>350</td>
<td>-3%</td>
<td>7%</td>
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<td>12</td>
<td>Yellowstone Landscape</td>
<td>13</td>
<td>$137,500,000</td>
<td>Bun nell, Fla.</td>
<td>1,900</td>
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<td>10%</td>
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<td>1,500</td>
<td>5%</td>
<td>15%</td>
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<td>14</td>
<td>Lawn Doctor</td>
<td>15</td>
<td>$112,000,000</td>
<td>Holmde, N.J.</td>
<td>1,350</td>
<td>7%</td>
<td>5%</td>
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<td>15</td>
<td>Ambus</td>
<td>14</td>
<td>$106,261,790</td>
<td>Reading, Pa.</td>
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<td>Mossey Services</td>
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<td>$74,892,678</td>
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<td>8%</td>
<td>15%</td>
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<td>MainScape</td>
<td>18</td>
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<td>Fishers, Ind.</td>
<td>1,000</td>
<td>4%</td>
<td>0%</td>
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<td>20</td>
<td>The Grounds Guys</td>
<td>22</td>
<td>$72,460,000</td>
<td>Weeke, Texes</td>
<td>600</td>
<td>25%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Disease Combative Potential

Vinca and Gardenia inoculated with Phytophthora

Control  Compost  Biochar
Biochar Retains Toxins and Helps Restore Sterile Soils
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ReNEW Water Project: Resource Recovery in the US

Sustainable Phosphorus Alliance Forum 2019
Patrick Dube, PhD
Wastewater treatment plants are **NOT waste** disposal facilities, but rather water **resource recovery** facilities that produce **clean water**, **recover nutrients** (such as phosphorus and nitrogen), and have the potential to reduce the nation’s dependence upon fossil fuel through the production and use of **renewable energy**.
WEF’s Mission

• Objective 4: Establish the conditions that promote accelerated development and implementation of innovative technologies and approaches in the water sector

• Goal 4a: Drive an increase in resource recovery in the water sector
Mass Balance Approach

\[
\frac{\text{total mass of resource recovered by WRRF}}{\text{total mass of resource that is received and treated at the WRRF}} = \% \text{ Recovered}
\]
Establishing Resource Recovery Baseline

**Project Team**
- Carollo
- Stantec
- University of Colorado Boulder

**Supporting Organizations**
- Water Research Foundation
- WaterReuse
- NACWA
- ACWA
- Réseau Environnement
Data Mining + WRRF Survey → Baseline
BASELINE RECOVERY RATES

- **Water (H₂O)**: 7% recovery
  - 803 billion gallons/year

- **Energy (E)**: 41% recovery
  - 350 megawatts/year

- **Nitrogen (N)**: 11% recovery
  - 172,400 dry metric tons/year

- **Phosphorus (P)**: 21% recovery
  - 68,220 dry metric tons/year

- **Bio (Bi)**: 51% recovery
  - 3.4 million dry metric tons/year
U.S. Survey Responses

LEGEND

<table>
<thead>
<tr>
<th>Flow Capacity (mgd)</th>
<th>Facility Count</th>
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</thead>
<tbody>
<tr>
<td>0 ≤ x ≤ 5</td>
<td>9</td>
</tr>
<tr>
<td>5 &lt; x ≤ 20</td>
<td>32</td>
</tr>
<tr>
<td>20 &lt; x ≤ 50</td>
<td>18</td>
</tr>
<tr>
<td>x &gt; 50</td>
<td>50</td>
</tr>
</tbody>
</table>
Figure 17  Definition of Recovered and Not Recovered Phosphorus Mass Streams in this Study
Aggregated phosphorus mass flows by end use in the U.S.
Figure 16  Annual Phosphorus Load in Wastewater Influent by State
Figure 18  Wastewater Treated with Phosphorus Removal by State
Figure 19  Percent Wastewater by State Treated with and without Phosphorus Removal
Figure 20  Recovered and Not Recovered Phosphorus by State as a Percentage
Figure 21  Phosphorus Recovery and Total Recovery Potential by State
Figure 22  National Distribution of Wastewater Derived Phosphorus
Figure 23  Wastewater Derived Phosphorus End Use by State (Recovered fractions shown as solid bar segments, not-recovered fractions with white fill)
Figure 25  Mass Balance Check between Phosphorus Entering WRRFs and the Sum of all Phosphorus End Uses by State (recovered and not recovered)
Path Forward

- Announce ReNEW Water Goals for 2030 based on established baseline – Fall 2018
- Collection of data for first biannual report – 2018-2020
- Publication of first biannual report WEFTEC 2020
- Biannual Reports WEFTEC 2020-2030
THANK YOU!

pdube@wef.org

www.wef.org

www.weftec.org
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• Objective 4: Establish the conditions that promote accelerated development and implementation of innovative technologies and approaches in the water sector

• Goal 4a: Drive an increase in resource recovery in the water sector
SDG 6: Ensure availability and sustainable management of water and sanitation for all

6 CLEAN WATER AND SANITATION
The Utility of the Future Today

- *The* program launched in 2016
  - Designed by utility partners, with input from staff from the partnering organizations

- It is a recognition program – not a competition

- Applicants are evaluated based on program criteria, not against each other

- The application is compact and streamlined, to limit the burden on applicants
ReNEW
WATER PROJECT
H₂O Water
E Energy
N Nitrogen
P Phosphorus
Bio Biosolids
Mass Balance Approach

\[
\text{total mass of resource recovered by WRRF} = \frac{\text{total mass of resource that is received and treated at the WRRF}}{\% \text{ Recovered}}
\]
Establishing Resource Recovery Baseline

**Project Team**
- carollo
- Stantec
- University of Colorado Boulder

**Supporting Organizations**
- The Water Research Foundation
- WaterReuse
- NACWA
- ACWA
- Réseau Environnement
Data Mining + WRRF Survey → Baseline
U.S. Survey Responses

LEGEND

<table>
<thead>
<tr>
<th>Flow Capacity (mgd)</th>
<th>Facility Count</th>
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<tr>
<td>0 ≤ x ≤ 5</td>
<td>9</td>
</tr>
<tr>
<td>5 &lt; x ≤ 20</td>
<td>32</td>
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<tr>
<td>20 &lt; x ≤ 50</td>
<td>18</td>
</tr>
<tr>
<td>x &gt; 50</td>
<td>50</td>
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</table>
Baseline Recovery Rates

- **Water (H₂O)**: 7% recovery rate, 803 billion gallons/year
- **Energy (E)**: 41% recovery rate, 350 megawatts/year
- **Nitrogen (N)**: 11% recovery rate, 172,400 dry metric tons/year
- **Phosphorus (P)**: 21% recovery rate, 68,220 dry metric tons/year
- **Bio** (Biosolids): 51% recovery rate, 3.4 million dry metric tons/year
Definition of Recovered and Not Recovered Phosphorus Mass Streams in this Study
Aggregated phosphorus mass flows by end use in the U.S.

- 319,000 Metric Tons per Year of Phosphorus
- 68,000 Metric Tons per Year Recovered
  - 21% Domestic Wastewater Influent
  - 19% Beneficial Use of Biosolids
  - 1% Fertilizer Production
  - 23% Biosolids Non-Beneficial Use
- 251,000 Metric Tons per Year Not Recovered
  - 79%
- 22,700 Metric Tons per Year Other Not Recovered
  - 7%
- 154,400 Metric Tons per Year Effluent Discharge
  - 48%
- 5,000 Metric Tons per Year Irrigation
  - 1%
- 60,700 Metric Tons per Year Beneficial Use of Biosolids
Distribution of Phosphorus End Uses by Facility Size for Survey Participants
Distribution of Phosphorus End Uses for all Survey Participants
Annual Phosphorus Load in Wastewater Influent by State
Wastewater Treated with Phosphorus Removal by State
Percent Wastewater by State Treated with and without Phosphorus Removal
Recovered and Not Recovered Phosphorus by State as a Percentage

Recovered:
- Urine source separation
- Water reused for irrigation
- Biosolids applied to land application
- Fertilizer production (struvite, etc.) from biosolids

Not recovered:
- Effluent discharged to surface or groundwater
- Potable reuse
Phosphorus Recovery and Total Recovery Potential by State
Wastewater Derived Phosphorus End Use by State

(Recovered fractions shown as solid bar segments, not-recovered fractions with white fill)
Current Status of Struvite Recovery by U.S. State

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Installation Country</th>
<th>Installation Location</th>
<th>ADAP Current, mgd</th>
<th>lbs P recovered as fertilizer per year</th>
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</table>

Total 5,499,332

0.8% of the total recoverable P available!
Path Forward

• Announce ReNEW Water Goals for 2030 based on established baseline
• Collection of data for first biannual report – 2018-2020
• Publication of first biannual report WEFTEC 2020
• Biannual Reports WEFTEC 2020-2030
THANK YOU!

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www.wef.org

www.weftec.org
Thanks for coming!