Assessing the Performance of Innovative Technologies for Treatment and Resource Recovery

Charles B. Bott, PhD, PE, BCEE
Director of Water Technology and Research
Hampton Roads Sanitation District
Hampton Roads Sanitation District

- Created in 1940
- Serves 1.7 million people
- Includes 17 jurisdictions – 3,100 square miles
- 9 major plants, 4 small plants
- Capacity of 249 MGD
The Challenges for HRSD

• ~$750M in Nutrient Removal Upgrades by 2021

• Biosolids – strong reliance on old Multiple Hearth Incinerators

• ~$2B in Consent Decreed Mandated Upgrades to Reduce Sanitary Sewer Overflows over 20 years

• ~$1B Indirect Potable Reuse Initiative - Aquifer Replenishment at ~120 MGD by 2030
HRSD Rates are Increasing Dramatically

Ted Henifin, HRSD General Manager:
“If the business case is good, and the risk has been reasonably managed, we must innovate our way out of this predicament. Rapid implementation of emerging technology is critical, and occasional failure is inevitable. We must accept some risk – we can’t afford not to.”
Technology Implementation at HRSD is Driven by:

• MINIMIZING Resource Utilization:
  – Energy
  – Chemicals
  – Labor (operations, maintenance, instrumentation...)
  – Concrete, footprint, land area

• MAXIMIZING Resource Recovery (business case must be good)
  – Water
  – P
  – CH
  – biogas (electricity, CNG, etc)
  – Heat
  – Hydraulic energy
  – Chemicals of interest (maybe)
  – Biosolids (N, P, organics)
  – Etc, etc, etc

Intensification
Nitrogen Removal Technologies - Conventional

- Conventional Technologies

<table>
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<tr>
<th>Footprint</th>
<th>Life Cycle Cost / Kg N Removed</th>
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<tr>
<td>Compact</td>
<td>Low</td>
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<tr>
<td>Medium</td>
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<td>High</td>
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- MBRs
- Granular
- BAFs
- IFAS
- MLE + Post Denit
- Activated Sludge
- Lagoons

(slide from Beverley Stinson, AECOMM)
Nitrogen Removal - Intensified

![Graph showing the relationship between Footprint and Life Cycle Cost for various nitrogen removal technologies. The graph compares Conventional Technologies and Disruptive Technologies. The technologies include MBRs, BAFs, Granular Deammonification, IFAS, SANI Process, Suspended Growth Deammonification, MLE + Post Denit, Activated Sludge, and Lagoons.](slide from Beverley Stinson, AECOMM)
New Technology Evaluation

• Business case – must be reasonable for non-regulatory projects (capital is always limited)

• Travel to see new technologies is critical

• Pilot test, only if needed

• R&D participation manages risk of new technology

• Learn from the experience of others (even outside the US)
Business Case Analysis at HRSD

• Financial modeling
  – Completely in-house
  – Buy-in across departments
  – Team effort between Ops/R&D, Engineering, and Finance
  – Opportunity costs are carefully considered
  – TBL not quantified explicitly but considered

• Jay Bernas, PE, MBA – Director of Finance
One-Step Sidestream Deammonification

- **SBR + Hydrocyclone Granular Sludge (DEMON)**
  - Strass, Austria
  - World Water Works, Inc.

- **Upflow Granular Sludge (CANON/ANAMMOX)**
  - Olburgen, Netherlands
  - Paques (NL)

- **Biofilm process (MBBR-style)**
  - ANITA Mox – Malmo, Sweden
    - AnoxKaldnes – Kruger - Veolia
  - Deammon -- Hattingen, Germany & Stockholm
    - Purac

Partial Nitritation and Anammox - combined in a single reactor
DEMON at HRSD York River (15 MGD)
Implementation of DEMON at York River
AnitaMox at HRSD James River (20 MGD)
AnitaMox Sidestream Deammonification MBBR
Granular Sludge Research

Principal Investigator
Belinda Sturm (University of Kansas)

Technical Co-Lead
Haydée De Clippeleir (DC Water)

Technical Advisory Committee
James Barnard (Black & Veatch), Joe Husband (Arcadis), Dave Kinnear (HDR), Wendell Khunjar & Ron Latimer (Hazen&Sawyer), Dwight Houweling (CH2M HILL)

James River, VA
Charles Bott (HRSD)
Jose Jimenez
Pusker Regmi (Brown & Caldwell)
External selection
Cyclones at Full-scale
4-stage Bardenpho-IFAS
1.5-4 d SRT

Ejby Mølle, Denmark
Per Nielsen (VCS-Denmark)
Tim Constantine (CH2M HILL)
External selection
Cyclones at Full-scale
MLE Oxidation Ditch
20-30 d SRT

Blue Plains, DC
Sudhir Murthy
Ahmed Al-Omari (DC Water)
Beverly Stinson (AECOM)
External selection
Screens at Pilot-scale
PFR
< 2 d SRT

Tomahawk Creek, KS
Susan Pekarek (Johnson County Wastewater)
Andrew Shaw (Black & Veatch)
Internal selection
Bench-scale with screens
SBR & PFR
10-20 d SRT

Strass, Austria
Martin Hell (AIZ Waterboard)
Bernhard Wett (ARAConsult)
Sabine Podmirseg (University of Innsbruck)
External selection
Cyclones at Full-scale
MLE Oxidation Ditch
10 d SRT

Other Participating Utilities for Sampling & Conceptual Design Phase
Sampling Coordinator: Belinda Sturm (Univ Kansas); Modeling Coordinator: Joe Husband (Arcadis)
Municipal Water Reclamation District of Greater Chicago, Others Pending
inDense® Implementation at James River

Diagram of wastewater treatment processes:
- Influent
- Primary Clarifier
- IFAS (Integrated Fixed Film Activated Sludge)
- Centrifuge
- Anaerobic Digestion
- Secondary Clarifier
- Overflow
- WAS (Wastewater Sludge)
- GT (Granular Sludge床)
- Centrate
- Primary Sludge
- NRCY (Nitrification Reactor)
- Underflow
- ANITA™ Mox
- Centrifuge
- Biosolids
Hydrocyclone Installation
Nansemond Plant Process Flow Diagram

Nansemond Treatment Plant

Preliminary Treatment
Solids Settle to Bottom

Secondary Treatment
Biological Nutrient Removal (5-Stage + 5-Stage Configuration)

Tertiary Treatment
Disinfection

Discharge to James River

Sodium Hypochlorite

Sodium Bicarbonate

Septage
Raw Influent

Screens

Vortex Grid Separator

Organic Waste

Solids (50%)

Treated Centrate Recycle

Super Sacs

OSTARA

Slow Release Swine Slaught

Fertilizer Poultry 5-23-9 10% Mg

Seaweed 8% F - Body Temperature

Concentrate

Concentrate Equalization Tanks

Centrifuge

Solid Hauled Offsite to Incineration

Incinerator

RAS
Primary Solids

SWF
Primary Solids

Membrane

Carbon

NRCY

Carbon

Ferric

Sodium Hypochlorite

Sodium Bicarbonate

H2O

Most Bacteria Settle Out

H2O

H2O

H2O

H2O

H2O
Struvite Recovery Facility

Sorting, product Storage and bagging

Dewatering and Drying

3 - 500 kg/day fluidized bed reactors
# Struvite Recovery - Business Case Review

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<th>Option 1</th>
<th>Option 2</th>
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<td>Original Ostara Cost Estimate</td>
<td>Ostara CY 2013 Actual Costs</td>
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<tr>
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<td>(349,100)</td>
<td>(501,900)</td>
<td>(400,000)</td>
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Ammonia Based Aeration Control

Ammonia
Dissolved Oxygen

Zone 1
Zone 2
Zone 3

NH4 Controller
DO Controller

Ammonia
Dissolved Oxygen
Fermentation and WASSTRIP Evaluation for Nansemond Plant

Diagram of treatment processes:
- Primary Clarifier
- Primary Sludge
- Fermenter
- Thickener
- Biogas
- Anaerobic Digestor
- Dewatering Centrifuge
- Biosolids
- Treated Sidestream from OSTARA (80-90% Orthophosphate Removal, 10-20% Ammonia Removal, typ.)
- Biological Nutrient Removal
- Anaerobic Zone
- Anoxic Zone
- Aerobic Zone
- Rec-Aeration Zone
- Secondary Clarifier
- UV Disinfection
- To Surface Discharge
- External Mg$^{2+}$ NaOH
- OSTARA Process
- Treated Sidestream
- Dryer
- CrystalGreen: Slow Release Struvite Fertilizer

Chemical compounds:
- P & Mg$^{2+}$
- NH$_4^+$
Primary Sludge and FOG Fermentation
Short-Cut Nitrogen Removal Processes:
Mainstream Nitrite Shunt & Deammonification
Funding from EPA through grant to WERF
Drivers for Mainstream Shortcut N Removal

• Eliminate External Carbon

• Energy
  – decreases aeration demand for N removal
  – decreases aerobic COD oxidation
  – diverts wastewater carbon to anaerobic digestion

• Intensification
  – carbon diversion = much smaller aeration tank volume required
Challenges

Management of populations

1. NOB out-selection (max. AerAOB rates)
2. Anammox retention
Step 1 - Addition of A-Stage
- Controls C:N
- Maximizes C Recovery

Step 2 - B-Stage
- Advanced aeration controls (e.g. AvN)
- SRT control
- Addition of mainstream anammox retention

Step 1 - Existing PST would be converted to A-Stage ST

Step 3 - Bioaugmentation of AOB and anammox to mainstream
AvN Control at Boat Harbor – Maximizes TN Removal & Minimizes Resource Utilization
AvN Control – Eliminates Caustic Addition
Final Thoughts...

• R&D program guides technology implementation
• And technology implementation guides R&D
• Technology testing/development:
  – Increases maturity
  – Provides experience
• University partnerships and graduate students are a HUGE resource
• New technology is implemented when:
  – Regulations drive it
  – Business case is clear
  – Maturity is reasonable (plug-and-play not required - perhaps not so for smaller utilities)
Questions?

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  – 757-460-4228