Metropolitan Water Reclamation District of Greater Chicago

Welcome to the July Edition of the 2021 M&R Seminar Series

NOTES FOR SEMINAR ATTENDEES

- All attendees' audio lines have been muted to minimize background noise.
- A question and answer session will follow the presentation.
- Please use the "Chat" feature to ask a question via text to "All Panelists".
- The presentation slides will be posted on the MWRD website after the seminar.
- This seminar has been approved from the ISPE for one PDH, and pending approval from the IEPA for one TCH. Certificates will only be issued to participants who attend the entire presentation.

GLEN T. DAIGGER, PhD, PE, BCEE, DMASCE, DISTINGUISHED FELLOW IWA, FELLOW WEF NAE

Dr. Daigger is currently Professor of Engineering Practice at the University of Michigan and President and Founder of One Water Solutions, LLC, a water engineering and innovation firm. He previously served as Senior Vice President and Chief Technology Officer for CH2M HILL (now Jacobs) where he was employed for 35 years, as well as Professor and Chair of Environmental Systems Engineering at Clemson University. Actively engaged in the water profession through major projects, and as author or co-author of more than 200 technical papers, five books, and several technical manuals, he contributes to significantly advance practice within the water profession. He has advised many of the major cites of the world, including New York, Los Angles, San Francisco, Detroit, Singapore, Hong Kong, Istanbul, and Beijing. Deeply involved in professional activities, he is a Past President of the International Water Association (IWA). The recipient of numerous awards, including the Kappe, Freese, and Feng lectures and the Harrison Prescott Eddy, Morgan, and the Gascoigne Awards, and the Pohland Medal, he is a Distinguished Member of the American Society of Civil Engineers (ASCE), a Distinguished Fellow of IWA, and a Fellow of the Water Environment Federation (WEF). A member of a number of professional societies, Dr. Daigger is also a member of the U.S. National Academy of Engineers and the Chinese Academy of Engineering.

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Urban Water Management for the 21st Century

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Distinguished Fellow, IWA
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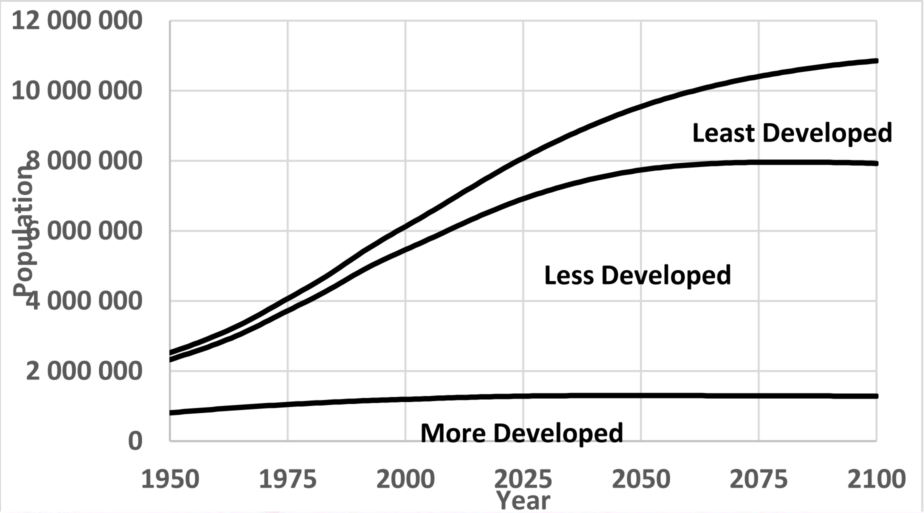
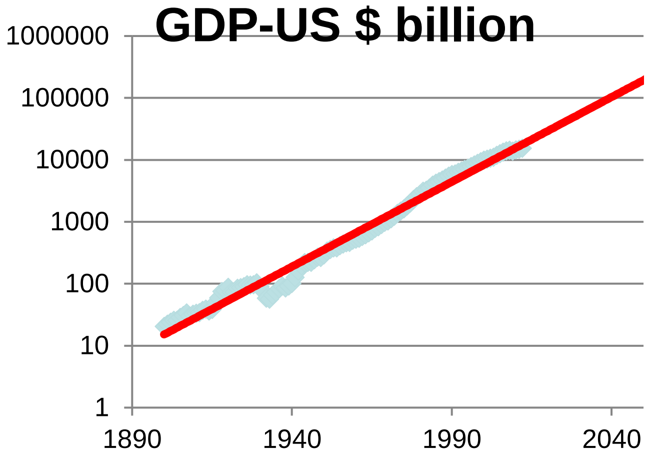
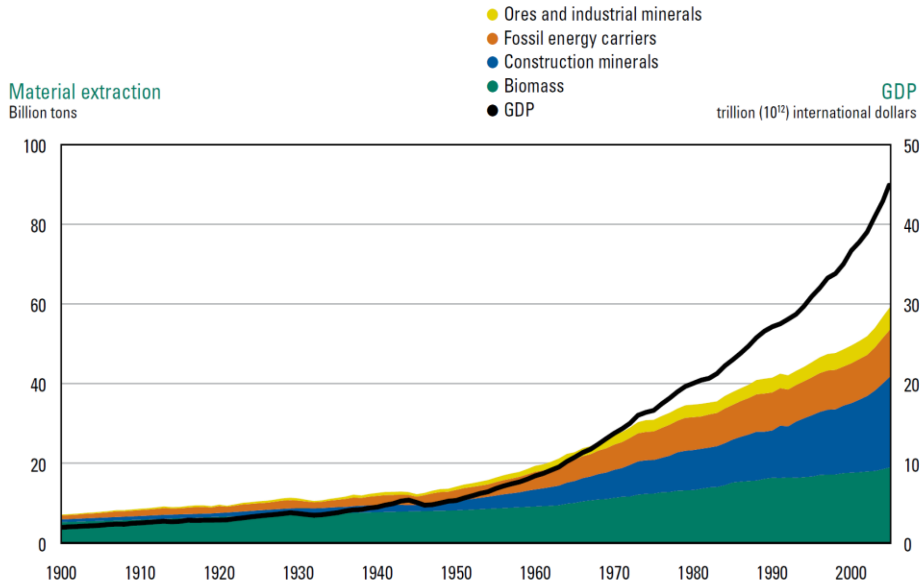
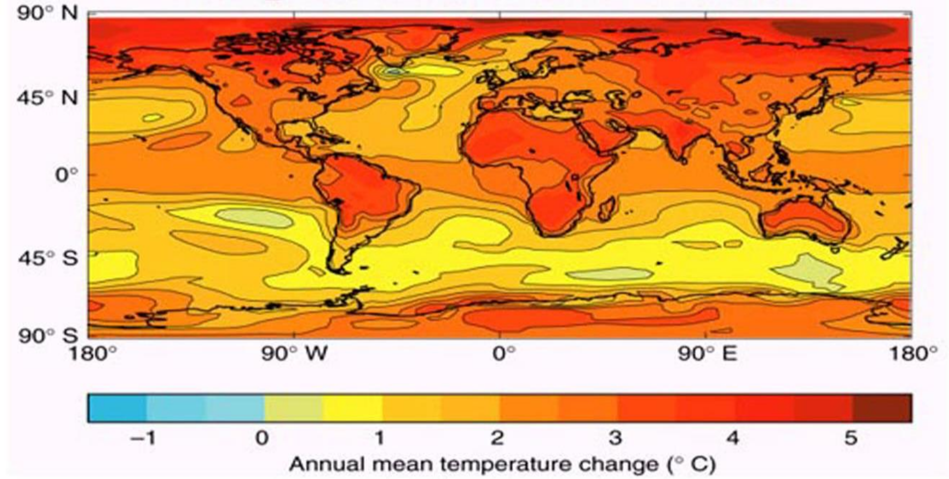
Metropolitan Water Reclamation District of Greater Chicago
Monitoring and Research Department 2021 Seminar Series
July 30, 2021

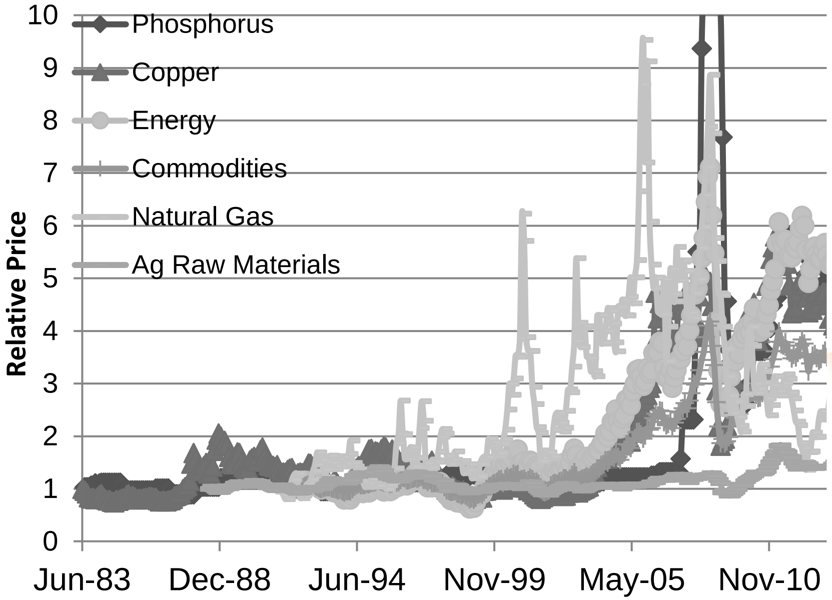
Drivers and Responses to Change are Inter-Related and Complex

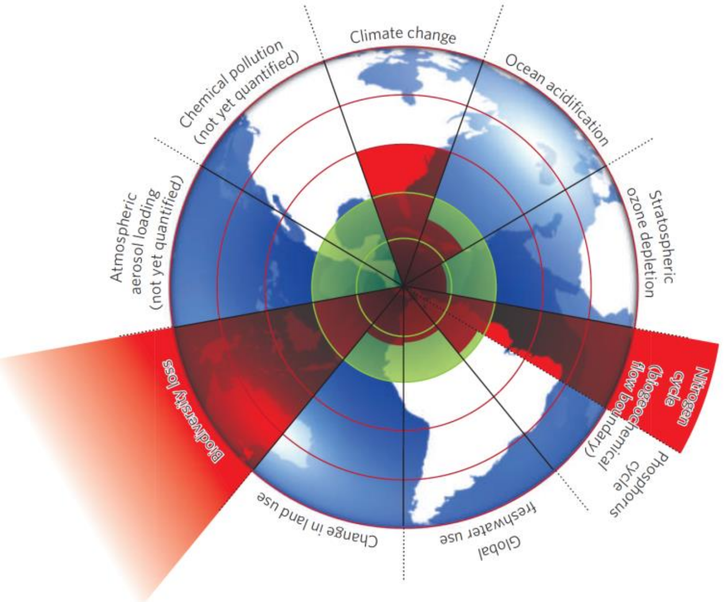












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We are in the Midst of One of the Most Significant Transitions in the History of the Water Profession

Item	Past	Future
Water Supply	Remote	Local
Optimization Function	Infrastructure Cost	Water Use, Energy, Materials, Labor
System Components	Separate Drinking Water, Rainwater, and Used Water Systems	Integrated, Multipurpose Systems
System Configuration	Centralized Treatment	Hybrid (Centralized and Distributed) Systems
Institutions	Single Purpose Utilities	Integrated, Water Cycle Utilities
Financing	Volume Based	Service Based
System Planning	"Plumb up" the Planned City	Integrated with City Planning

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The Water Profession Must Address Three Principal Priorities

1. Change Water Management to Avoid Water Stress
2. Become More Resource Efficient
3. Extend Human Right to Water and Sanitation to All

1. We Must Fundamentally Change Our Approach to Water Management to Avoid Stress

- Water Supplies Provided by Portfolio of:
  - Efficiency
  - Storage:
    - Surface
    - Aquifer Storage and Recovery
  - Local Water Capture:
    - Rainwater Harvesting
    - Restoring Local Ecosystems
  - Reclamation and Reuse
  - Desalination

- Flooding Addressed by Combination of:
  - Conventional Measures:
    - Drainage
    - Dikes and Levees
  - Rainwater Capture
  - Green Infrastructure
  - Spatial Planning and Implementation

Eliminating Biases May Lead to Different Solutions

	Traditional Approach	Revised Approach
Water Supply	What are the Available Surface and Ground Water Sources?	What are the Available Sources of Reuse Water?
Wastewater Management	What are the Applicable Discharge Requirements?	How Can the Effluent be Best Reuse?

Built and Natural Infrastructure Increasingly Being Integrated to Create Multiple Benefits

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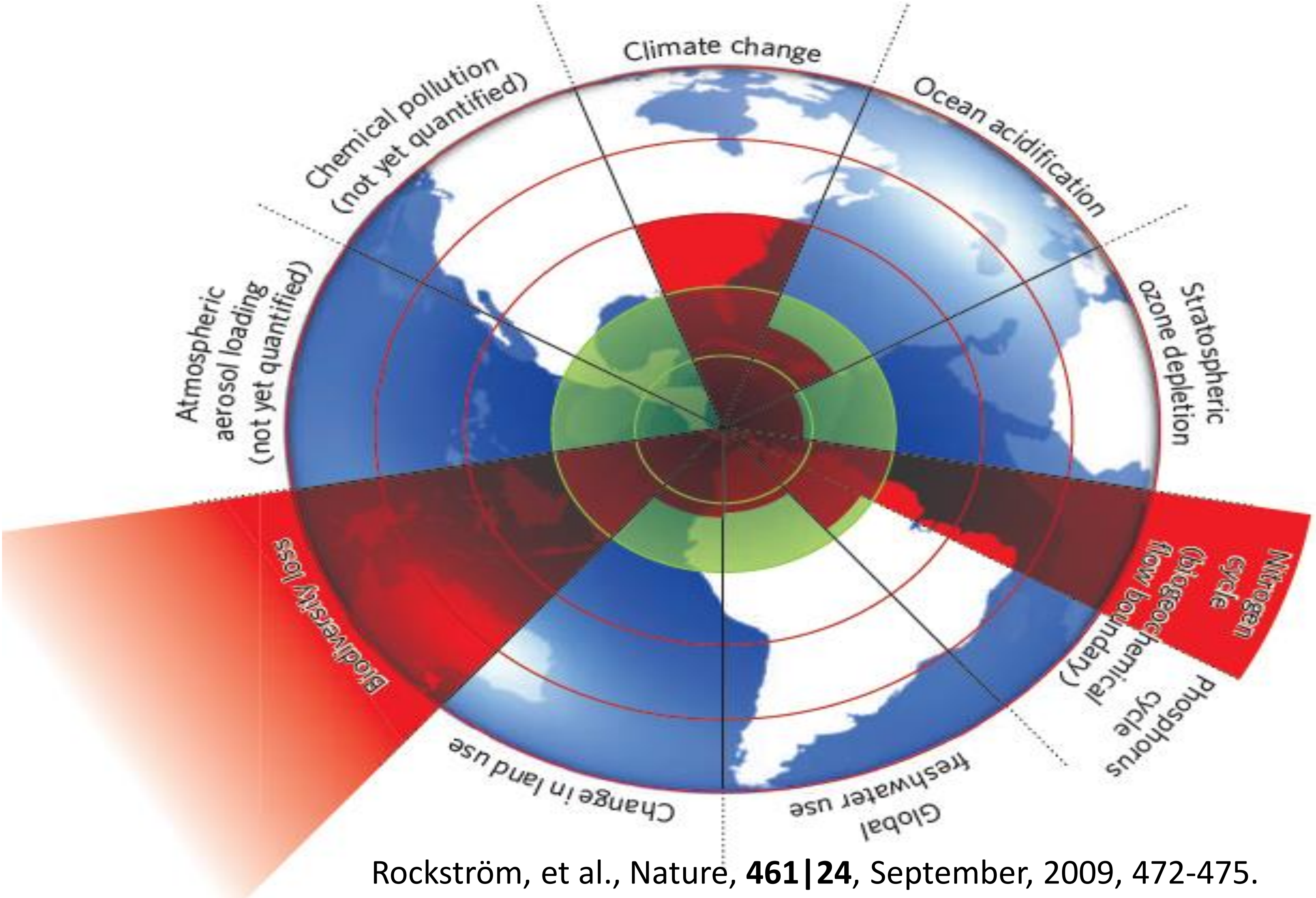
2. Water Management Must Become Much More Resource Efficient to Sustain Into the Future

- Biodiversity Loss
- Nutrients
  - Nitrogen
  - Phosphorus
- Climate Change
- Chemical Pollution (Not Yet Quantified)



Rockström, et al., Nature, **461|24**, September, 2009, 472-475.

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We Know How to Achieve These Priorities

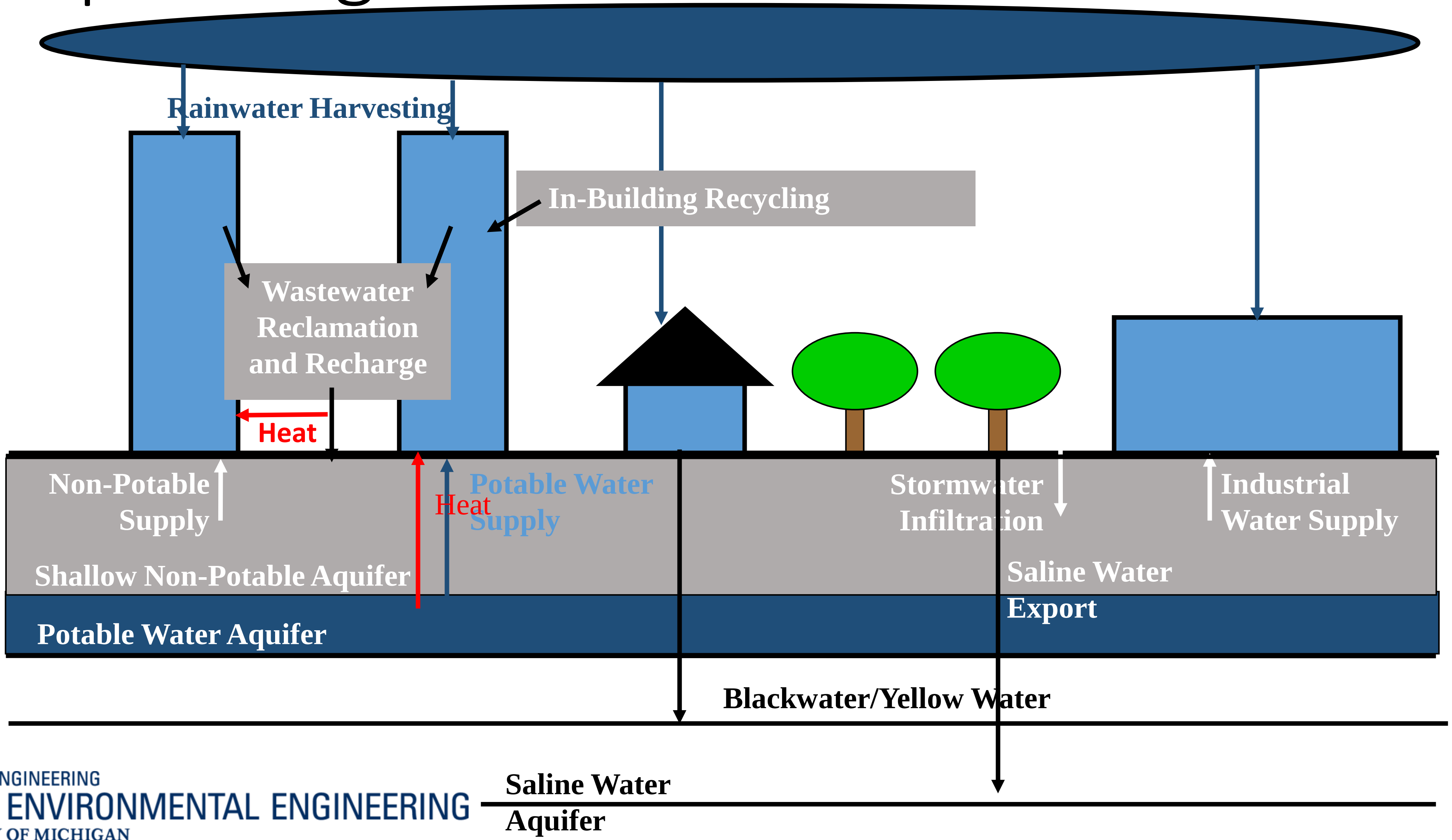
Consider All Available Options and Select the Best Ones for Each Case

- Water Conservation
- Distributed Stormwater Management
  - Low Impact Development
  - Rainwater Harvesting
- Distributed Water Treatment
- Water Reclamation and Recycling
- Heat Recovery
- Organic Management for Energy Production
- Nutrient Recovery
- Source Separation
- Desalination

Combine Options Into an Integrated System Which Captures Inherent Synergies

Component	Centralized	Decentralized/Hybrid
Stormwater	–	Permeable Pavements, Green Roofs, Rain Gardens, etc.
Water Conservation	Wide Variety of Technologies, Along with Behavior Changes	
Treatment	Treatment for Potable Use and Reuse (Direct and In-Direct)	Treatment for Potable Use and Non-Potable Reuse
Energy Management	Anaerobic Digestion, Thermal, Microbial Fuel Cells	Capture Heat Energy, Microbial Fuel Cells
Nutrient Recovery	Land Application of Biosolids, Struvite Precipitation	Urine Separation
Source Separation	Treatment of Kitchen, Black and Yellow Water	Supply Potable and Non-Potable; Treatment of Kitchen, Black, and Yellow Water

Let’s Look at an Example Integrated System Incorporating Most of These Tools



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And, Adapt to Changing Realities Over Time!

3. The Human Right to Water and Sanitation Must be Extended to All

On 28 July 2010, through Resolution 64/292, the United Nations General Assembly explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights. The Resolution calls upon States and international organisations to provide financial resources, help capacity-building and technology transfer to help countries, in particular developing countries, to provide safe, clean, accessible and affordable drinking water and sanitation for all.

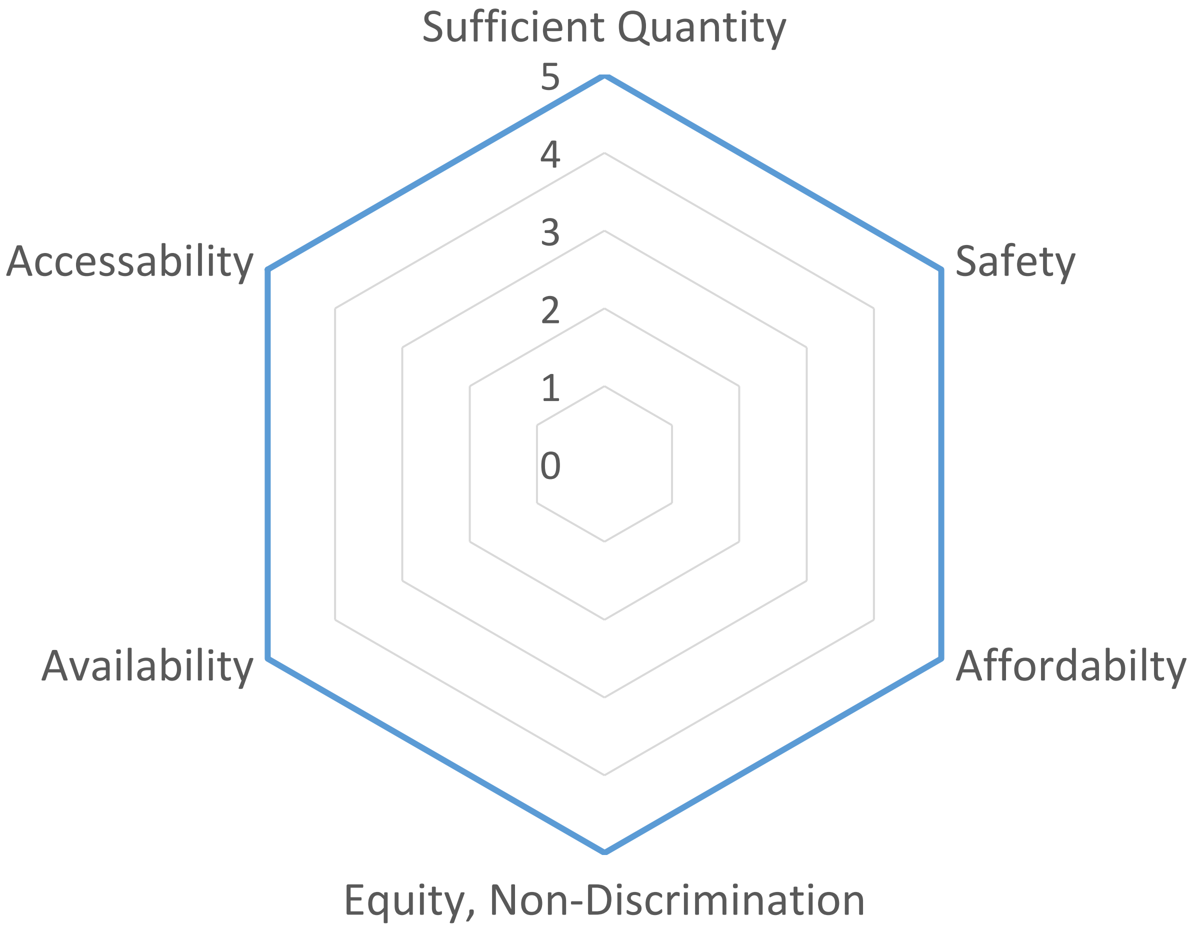
Resolution A/RES/64/292. United Nations General Assembly, July 2010

Approximately Half of the Human Population Lacks Safe Water, and Less Than 20 % of Wastewater is Treated

- ~3 Billion Without Water at Home or in the Vicinity (45 %)
- ~ 4 Billion Without continuous Access to Water (60%)

- ~4.5 Billion With No Sewerage (70 %)
- ~ 5.5 Billion With No Treatment (80%)

Compliance with Human Right Evaluated Using Six Criteria Evaluated on Relevant Scales



IWA, Manual of the Human Rights to Safe Drinking Water and Sanitation for Practitioners, 2016

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Water and Resource Recovery Facility (WRRF) of the Future Must:

- Produce Product Water Which:
  - Matches Water Quality Standards of Receiving Water Bodies
  - Meets “Fit for Purpose” Water Reuse Standards
- Process Increased Peak Wet Weather Flows
- Recover a Wide Varity of Products:
  - Energy
  - Nutrients
  - Organics
  - Other Materials
- Adapt to Evolving Roles in the Overall System:
  - Water and Resource Recovery
  - Resource Recovery with “Upstream” Water Recovery

"Legacy Systems" Must be Dealt With In Existing Urban Areas

- Centralized Systems Serve Existing Development
- Distributed Elements Aggressively Incorporated Into New Developments and Redevelopment
  - Allows System to be Converted Over Time
- Existing Water Distribution and Wastewater Collection System Provides Necessary Capacity as Urban Density Increases
  - Avoids Need for System Expansion
  - May be "Downsized" Over Time and "Re-Purposed"
- Centralized Plant Transitions From "Wastewater" to "Organic Matter" Processing Facility

Let’s Talk About Four Items of Potential Interest to MWRDGC

- Decarbonization of the Electric Supply
- Hybrid Systems
- Nutrients
- Flooding

How Might Decarbonization of the Electric Supply Affect MWRDGC?

- Northern Europe (Denmark and Germany for Instance) is Rapidly Transitioning Their Electric Supply to Renewables
  - Principally Wind and Solar
  - Unit Cost of Electricity Production Declining Due to Technology Improvements So Rate Charged by Utilities is Becoming Dominated by Transmission Costs
  - Utilities Rethinking Economics of CHP as the Actual Value of the Electricity Produced is the Fact That it Avoids Transmission
    - Meaning Value of Electricity Declines
    - Note, These Utilities Monetize Heat Through Sale to District Heating Systems
  - Decarbonization of Electric Supply Significantly Lowers Carbon Footprint
    - But, N_2O Emissions Become Bigger and Bigger Proportion of the Remaining Footprint
- Implications?
  - Begin Planning for Uses of Biogas Other Than CHP
  - Assess N_2O Emissions and Assess Reduction Options

Experience with Distributed Systems in Developed Metropolitan Areas

- Provide Reclaimed Water Supply at Source of Demand
  - "Sewer Mining"
  - City and County of San Francisco Public Utilities Commission (SFPUC)
    - Mandates Building-Scale Water Reuse for New Buildings 250,000 sf (Being Revised Down to 100,000 sf)
    - Administrative and Permitting Process Collaboratively Developed
- Minimize Disruption as Urban Area Densifies
  - Cost of Treatment Can be Higher as it Avoids Cost and Disruption of Increasing Water Supply and Wastewater Collection Infrastructure
- MWRDGC Policy?
- New York City Example

Let’s Look at A Real World Example in a Surprising Location

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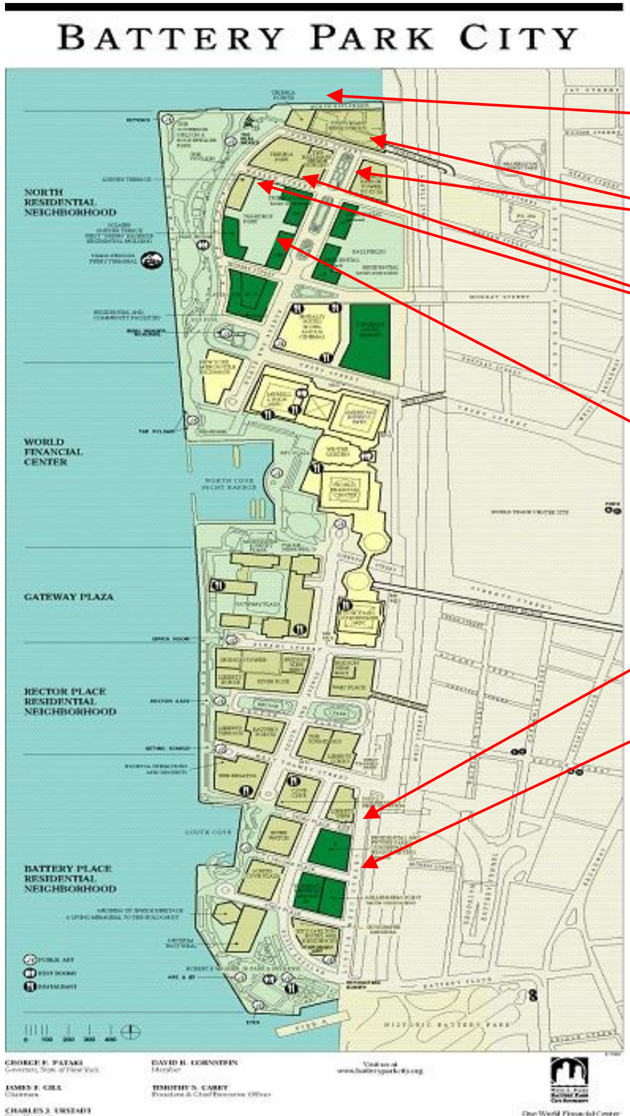
Water Resources Managed On-Site to Mimic Natural Condition

Water Reclamation Plant Located in Building Basement

Financial and Environmental Success of Solaire Lead to Several Additional Installations



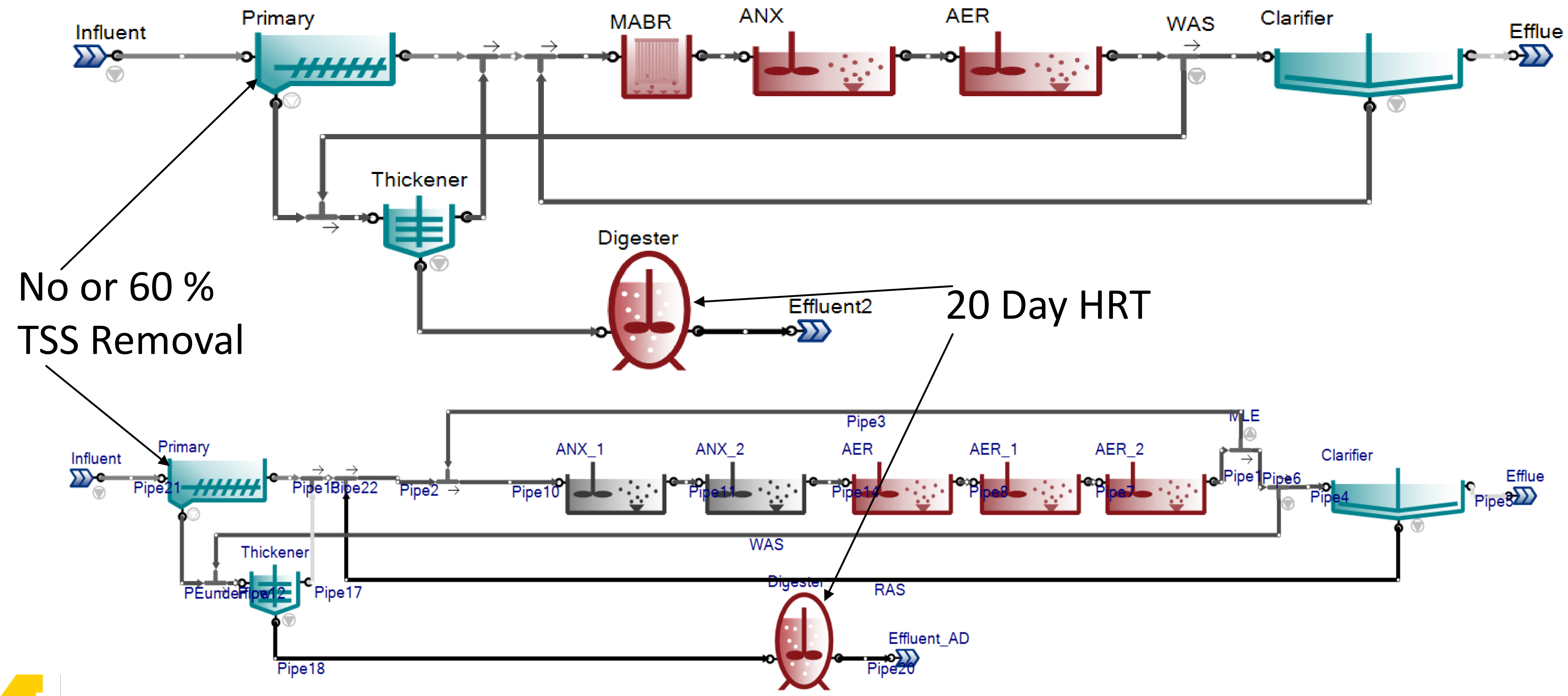
Integrated Water Reuse Systems

- Site 19B – Tribeca Green
- Site 23 – 24 Millstein Properties
- Site 18A and 18 B- The Solaire and The Verdesian
- Site 16-17 – Riverhouse
- Site 3 – Albanese Development
- Site 2 – Millennium Point
- The Helena – 57th Street – Durst Development
- One Bryant Park – 45th Street Durst Development – Bank of America

Advances in Nutrient Removal and Recovery Continue

- Removal
  - Phosphorus
    - Activated Sludge Fermentation, Especially Side-Stream, Emerging
      - Provides Reliable Source of VFA's
  - Nitrogen
    - Anammox Research Progressing, but Still Limited at Full-Scale (Strass, Changi, Xi'an)
    - Two Options for Nitrite Generation
      - Partial Nitritation
      - Partial Denitrification
    - Hybrid MABR
- Recovery
  - Land Application Still Most Proven Method
  - Capabilities of Struvite-Based Systems Becoming Better Characterized
  - Still No Attractive Nitrogen Recovery Options Emerging

Improved Nitrogen Removal at Lower SRT and Increased Carbon Capture for Hybrid Process



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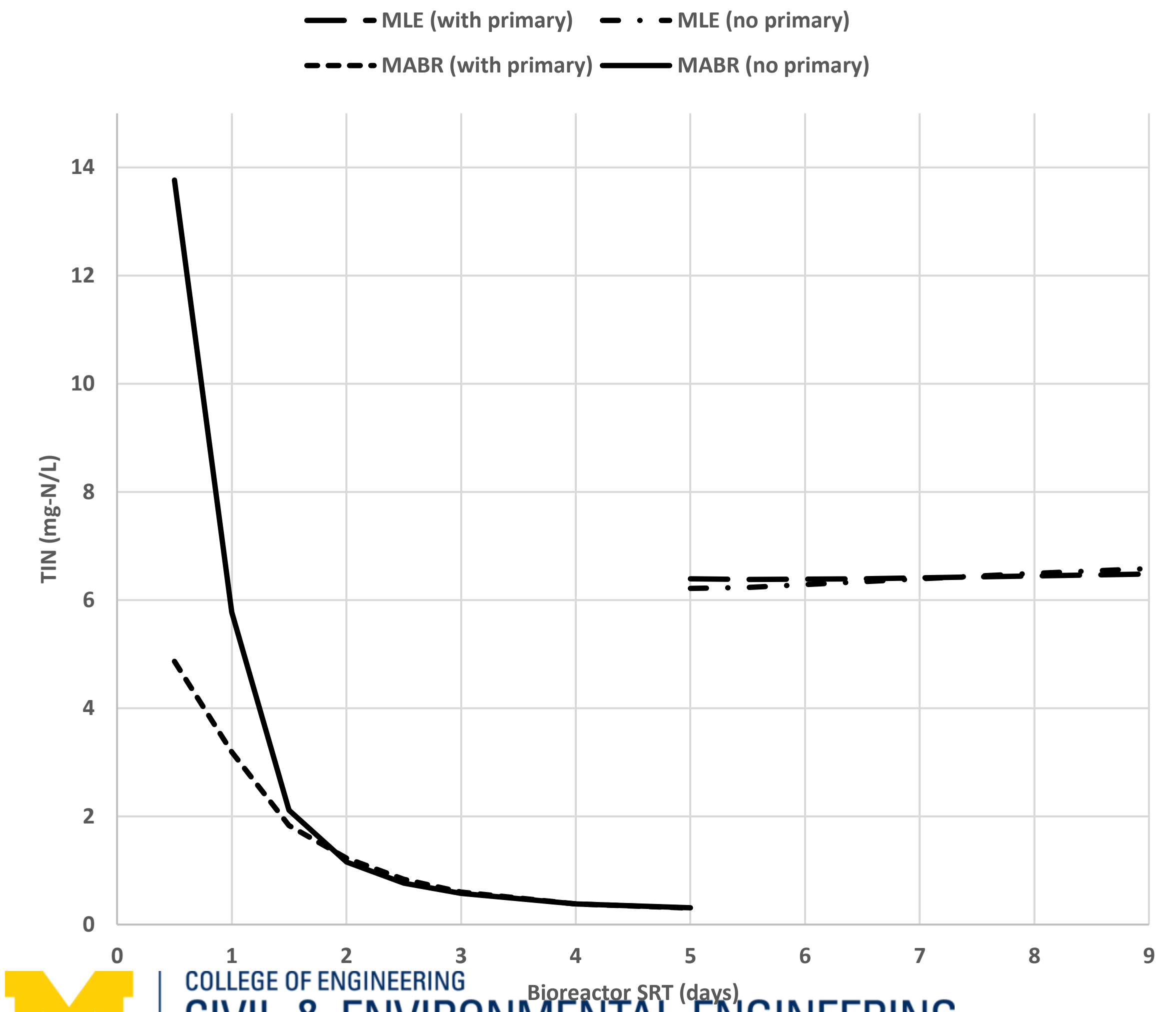

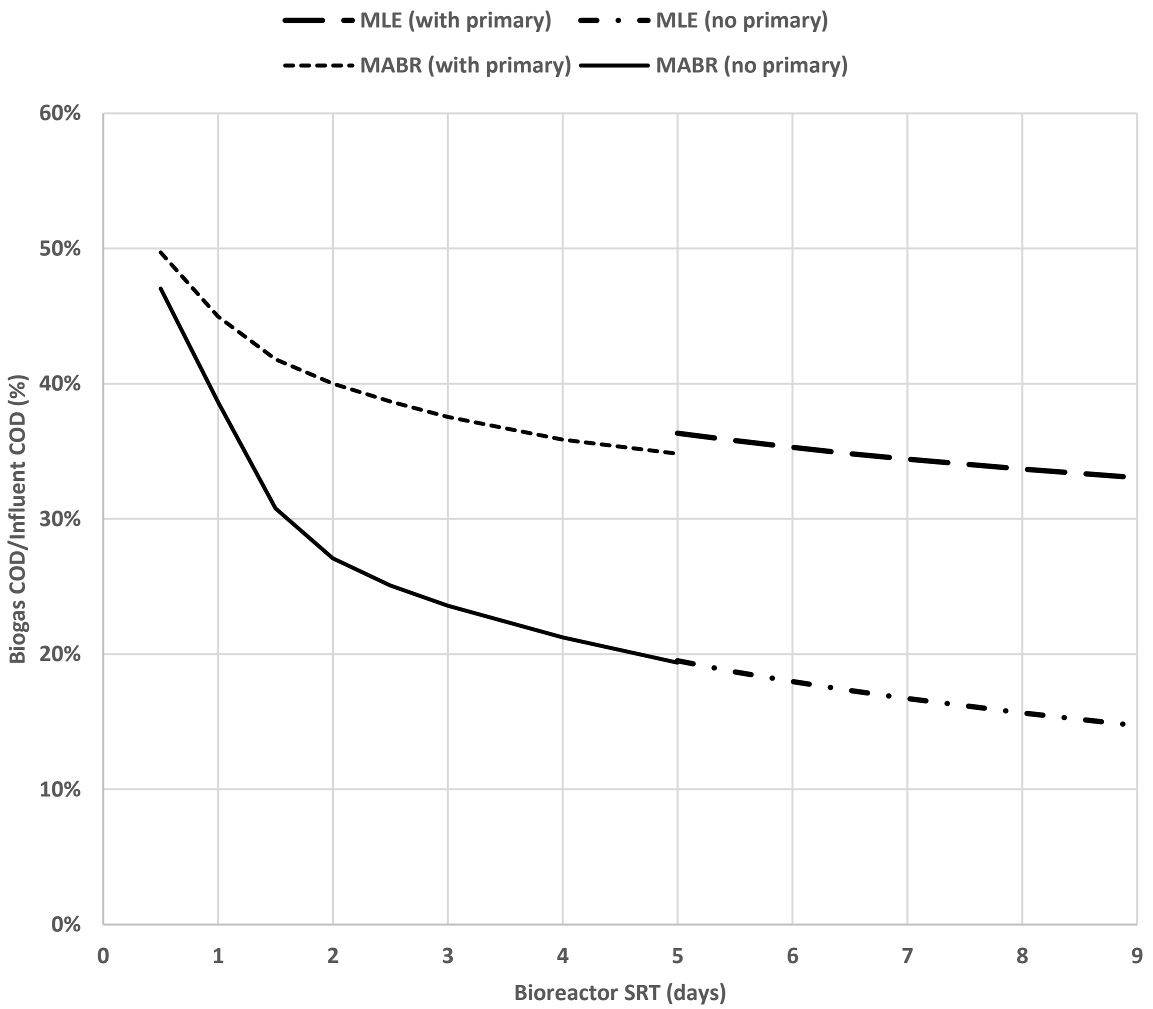

Hybrid MABR Gives Lower Effluent TIN, Less Energy, and Smaller Bioreactor

Item	COD/N = 11.3 mg COD/mg N				COD/N = 6.7 mg COD/mg N			
	Hybrid MABR		MLE		Hybrid MLE		MLE	
	w/ Pri	w/out Pri	w/ Pri	w/out Pri	w/ Pri	w/out Pri	w/ Pri	w/out PRI
Susp. Growth SRT (Days)	2.5	2.5	5	5	5	5	5	5
Effluent TIN (mg-N/L)	0.8	0.8	6.4	6.2	1.2	5.3	25.4	20.9
MLR (%)	-	-	400	400	-	-	400	400
AOR/COD (mg/mg)								
MABR	0.18	0.19	-	-	0.30	0.33	-	-
Conventional	0.10	0.21	0.42	0.57	0.09	0.21	0.67	0.80
Total	0.28	0.40	0.42	0/57	0.39	0.54	0.67	0.80
Biogas/Influent COD (%)	38.7	25.1	36.3	19.4	38.3	24.2	37.0	19.8
Bioreactor Volume (m^3)	4,520	7,620	7,150	12,700	4,600	8,000	4,340	7,540

Climate Change is Rewriting "The Book" on Wet Weather Management

- Changing Weather Patterns
  - Storm Frequency and Intensity Increasing
  - Dry (Drought) Periods In Between Increasing in Frequency and Duration
- Green Infrastructure
  - Potential for Multiple Benefits But Not Always Realized
  - Location-Specific
  - Need to Achieve Sufficient Coverage to Produce Benefit
  - Effective in Low-Intensity Storms But Can be Overwhelmed in Intense Storms
- Need Integrated Approach

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