CIVIL & ENVIRONMENTAL ENGINEERING
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The Resource Recovery Facility of the Future is Adaptable

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Does Anyone Know How to Construct a Facility That Implements This Vision?

Vision

Aarhus Vand has drawn up the following vision statement for Aarhus ReWater:

To build the world's most resource-efficient wastewater treatment plant.

- Since the Answer is No, We Can:
  - Just Do What We've Done Before
  - Think Differently

Aarhus ReWater

aarhusvand

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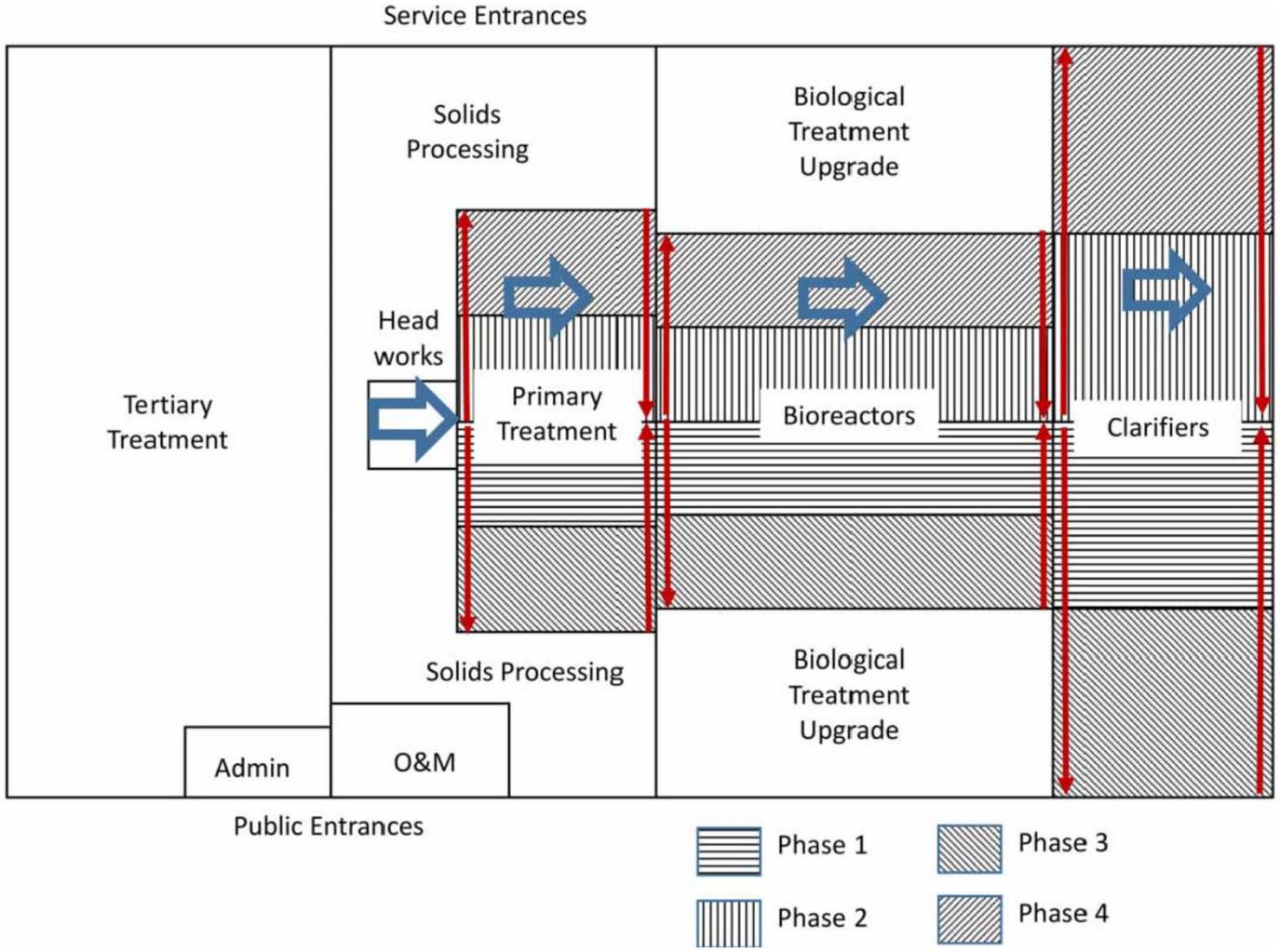
Used Water Treatment Has Traditionally Focused on Removal of Constituents

Bulk Organics	Nutrients	Disinfection	Trace Constituents
• Primary Treatment • High-Rate Aerobic Biological Treatment • Direct Anaerobic Treatment • In-Main Biological Treatment	• Biological and Chemical P-Removal to 0.01 to 0.1 mg/L • Heterotrophic and Autotrophic TN Removal to 1–3 mg/L	• Filtration • UV • Ozone • Advanced Oxidation • Chlorine	• Membranes • Ozone • BAC • Advanced Oxidation • Electro-Chemical Processes

Daigger, *Wat. Pract. & Tech.*, **12**(1), 156-165, 2017

The Building Block Approach Has Served Us Well in the Past



Daigger, *Wat. Pract. & Tech.*, **12**(1), 156-165, 2017

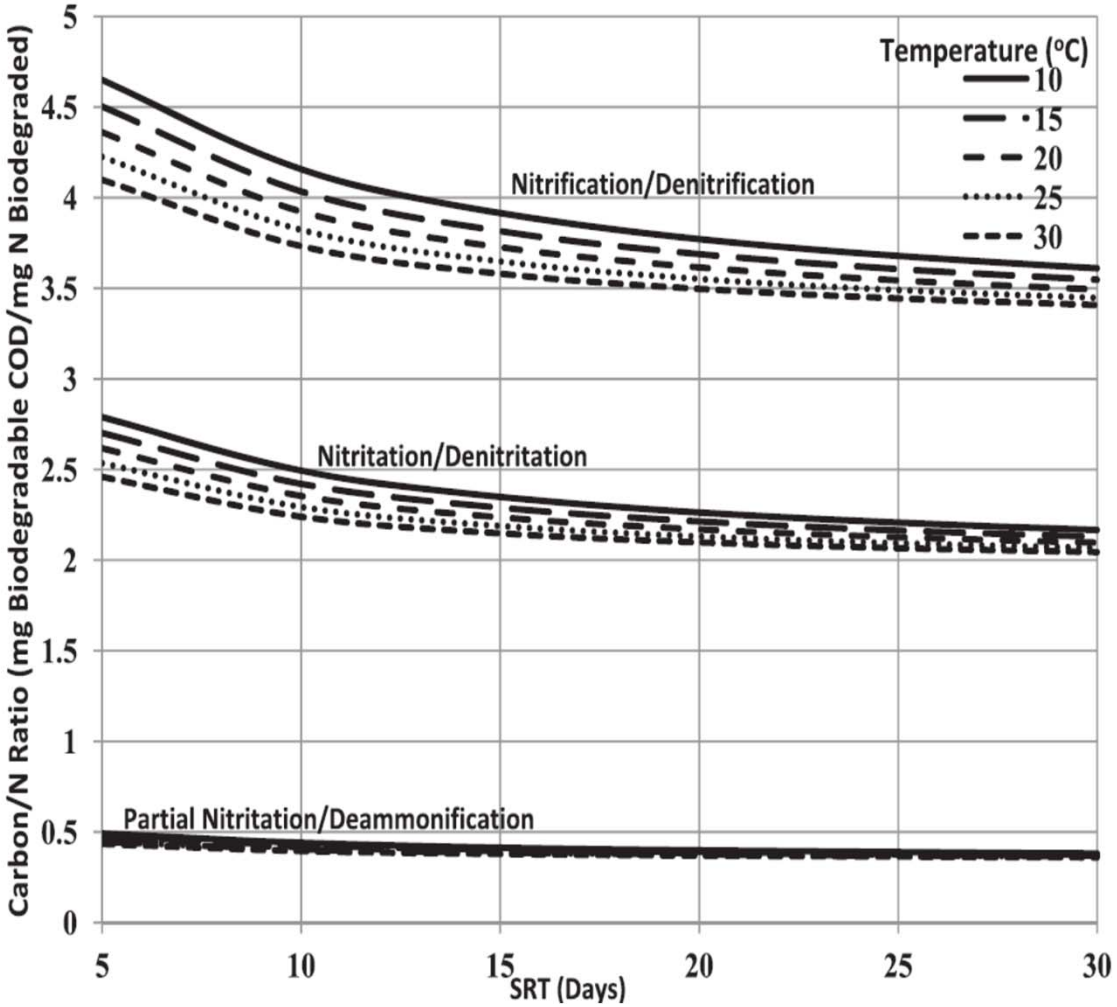
Structures are Most Long-Lasting With Conventional Approach

Item	Useful Life (Years)	Comment
Structures	50-100	Lifetime of Concrete Structures (Including Rehab)
Mechanical Equipment	15-40	Rotating Equipment
Electrical Equipment	10-20	Determined by Obsolescence
Treatment Technology	10-20	Determined by Effluent Standards and Evolution of Technology
I&C Technology	5-15	Determined by Obsolescence

Daigger, *Wat. Sci. & Tech.*, **63**(3), 516-526, 2011.

Carbon Diversion is Required to Achieve Oxygen Savings From Short-Cut Nitrogen Removal and Anammox

- As Long as Influent Biodegradable Organic Matter is the Carbon Source for Denitrifcation:
  - $NH_3 \rightarrow N_2$
  - Valence Change: $-3 \rightarrow 0 = +3$
  - Net Oxygen Required 1.714 mg O_2/mg NH_3-N
  - Biodegradable Organic Matter in Excess of That Needed for Denitrification Must Still be Oxidized



Daigger, G. T., *WER*, **86**(2), 204-209, 2014.

Mainstream Anammox Fundamentally Changes WRRF Carbon Flow and Energy Use/Production

Traditional Approach

- Sufficient Influent Carbon Used for Biological Nitrogen Removal
- Biological and Chemical Phosphorus Removal
- Insufficient Carbon to Anaerobic Digestion (Even with Sludge Hydrolysis) to Achieve Energy Neutrality

Emerging Approach

- Reduced Carbon Requirement for Biological Nitrogen Removal Allows Increased Influent Carbon Capture
- Diversion of More Carbon to Anaerobic Digestion Reduces Aeration and Increases Biogas
- Biological and Chemical Phosphorus Removal

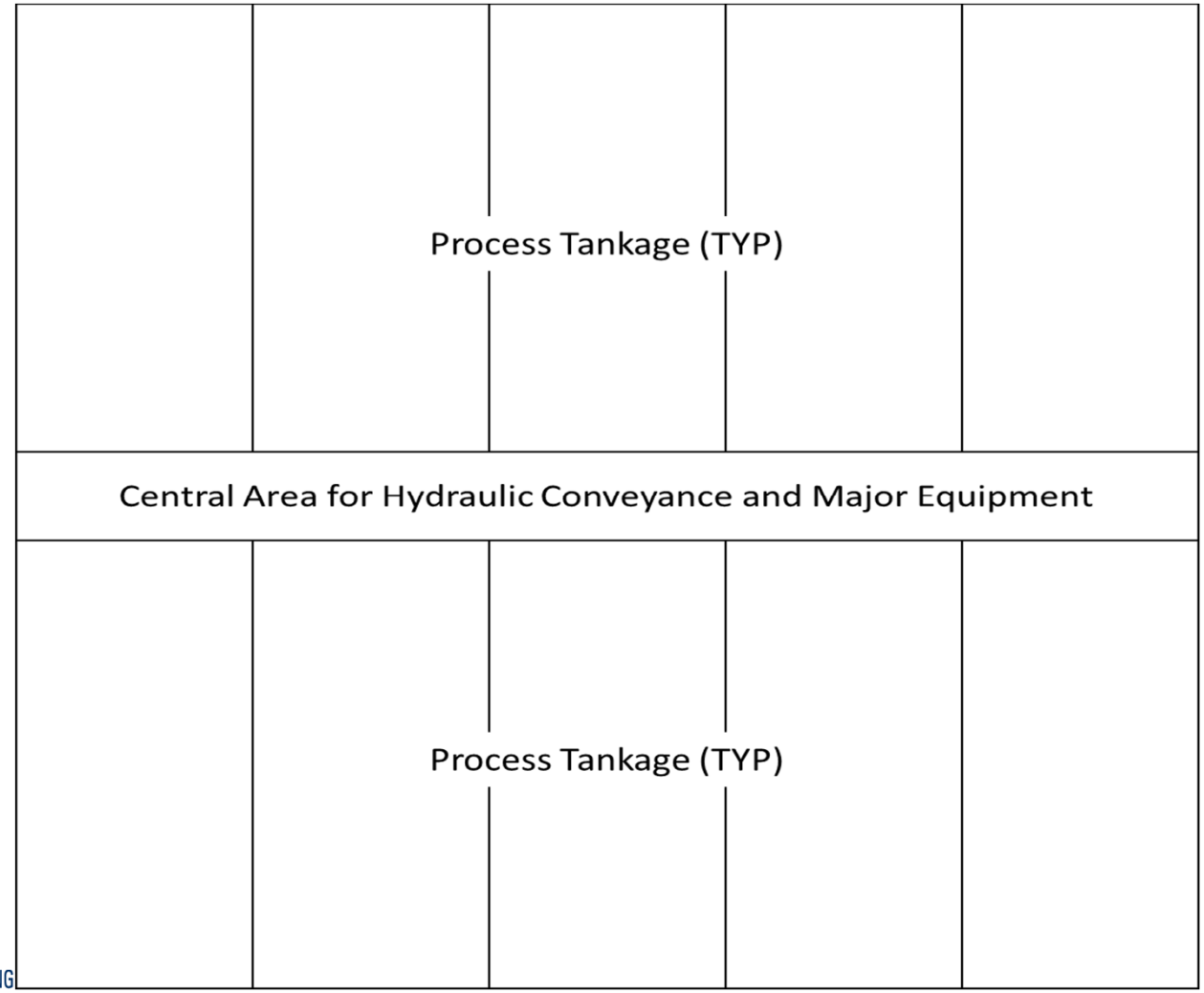
Numerous Carbon Capture and Nutrient Removal Options Exist

Primary Treatment	Biological Treatment	Phosphorus Removal	Liquid-Solids Separation
Conventional	High-Rate Aerobic	Biological	Clarifiers
Chemically Enhanced Primary Treatment (CEPT)	Low-Rate Aerobic	Chemical	Dissolved Air Flotation (DAF)
Dissolved Air Flotation (DAF)	Anaerobic		Membranes
Filters			

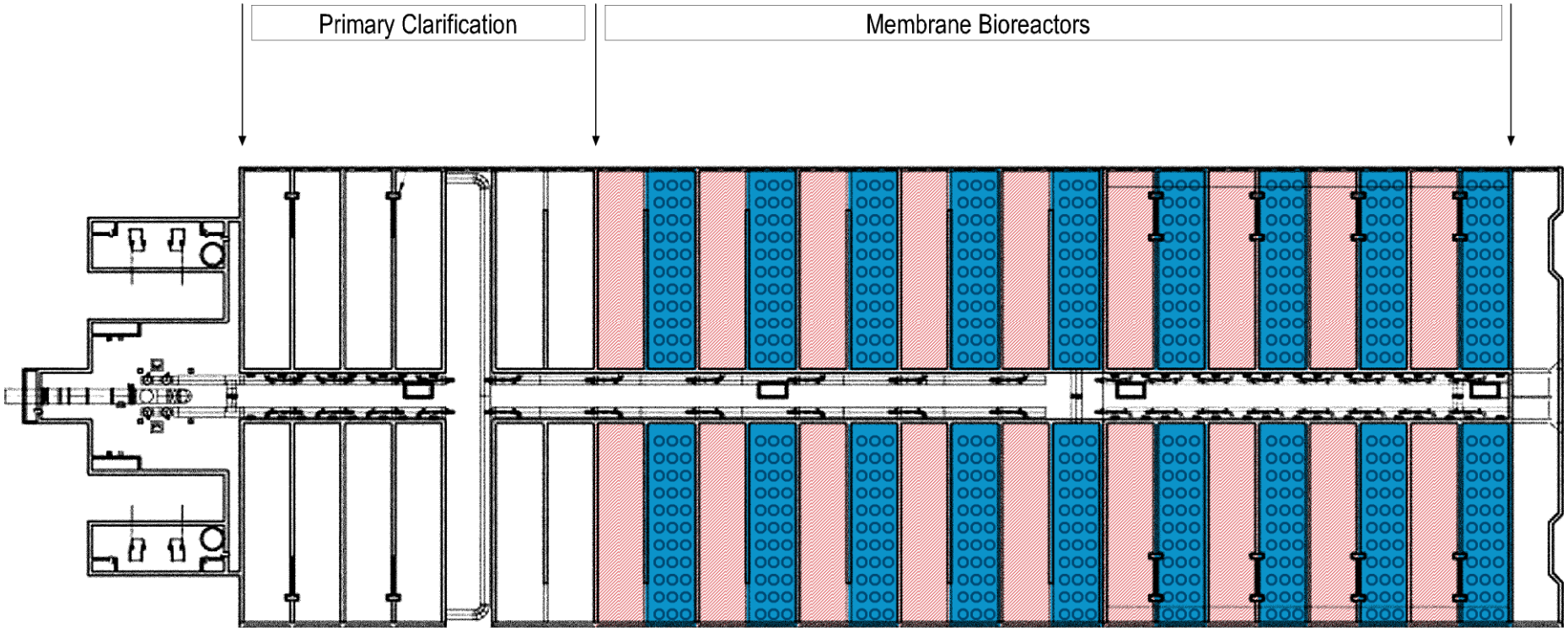
And, They Dramatically Affect Plant Layout and Tank Requirements

Primary Treatment	Biological Treatment	Nutrient Removal	Sludge Stabilization
Conventional (or DAF or Filters)	High-Rate	Biological Nitrogen and (Chemical) Phosphorus Removal	Anaerobic Digestion
Conventional (or DAF or Filters)	Biological Phosphorus Removal	Biological Nitrogen Removal	Anaerobic Digestion
CEPT	High-Rate	Biological Nitrogen Removal	Anaerobic Digestion
None	High-Rate	Biological Nitrogen and (Chemical) Phosphorus Removal	Anaerobic Digestion
None	Biological Phosphorus Removal	Biological Nitrogen Removal	Anaerobic Digestion
None	Anaerobic Treatment	Biological Nitrogen and Phosphorus Removal	None
None	Anaerobic Treatment	Biological Nitrogen and Chemical Phosphorus Removal	None

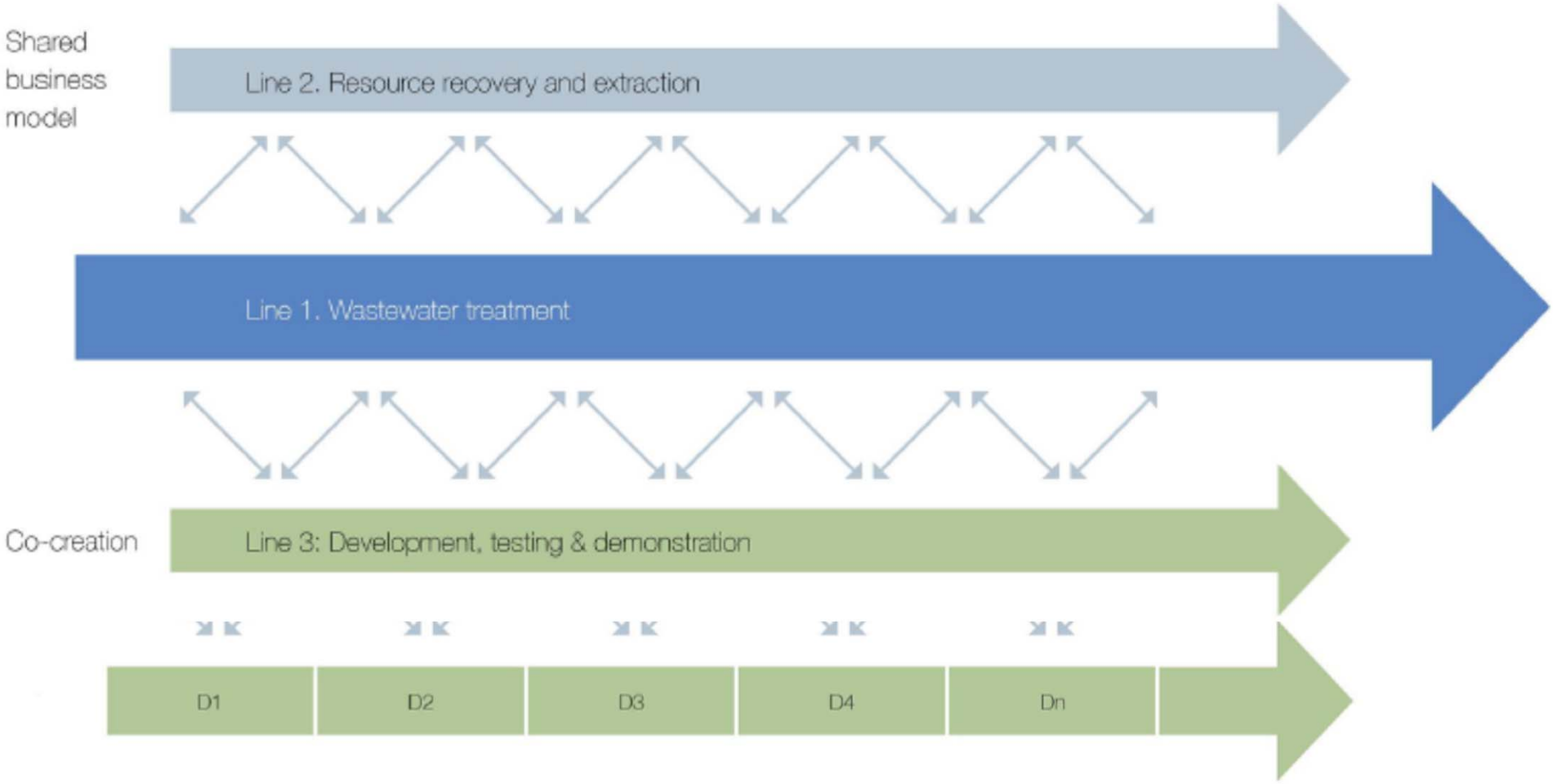
One Approach is to Not Dedicate Tankage to Specific Locations in the Hydraulic Profile



Flexible Tankage Concept Successfully Applied to Changi WRP in Singapore



Aarhus ReWater is Envisioned to be a Process (Not Just a Facility) Which Unfolds Over its Lifetime



Will the Aarhus ReWater Facility be:

- Modular?
- With Multi-Use Tankage?
- With Tankage That Can be Assembled and Reassembled?
- Constructed with New Materials (Other Than Concrete)?
- With an In-Situ Test Train?
- With Space for Testing and Partner Facilities?

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