Adaptive Master Planning to Manage PFAS in Biosolids

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Jacobs Residuals Resource Recovery Global Technology Leader

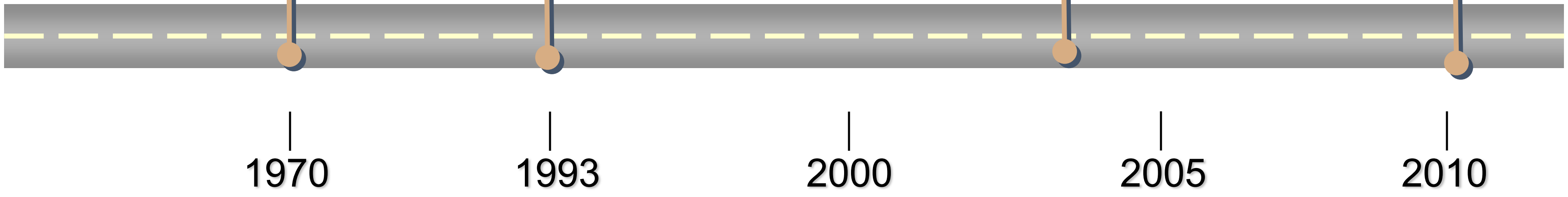
Our Changing View of Biosolids Management

Sludge Disposal

Biosolids Beneficial Use

Bioenergy

Resource Recovery



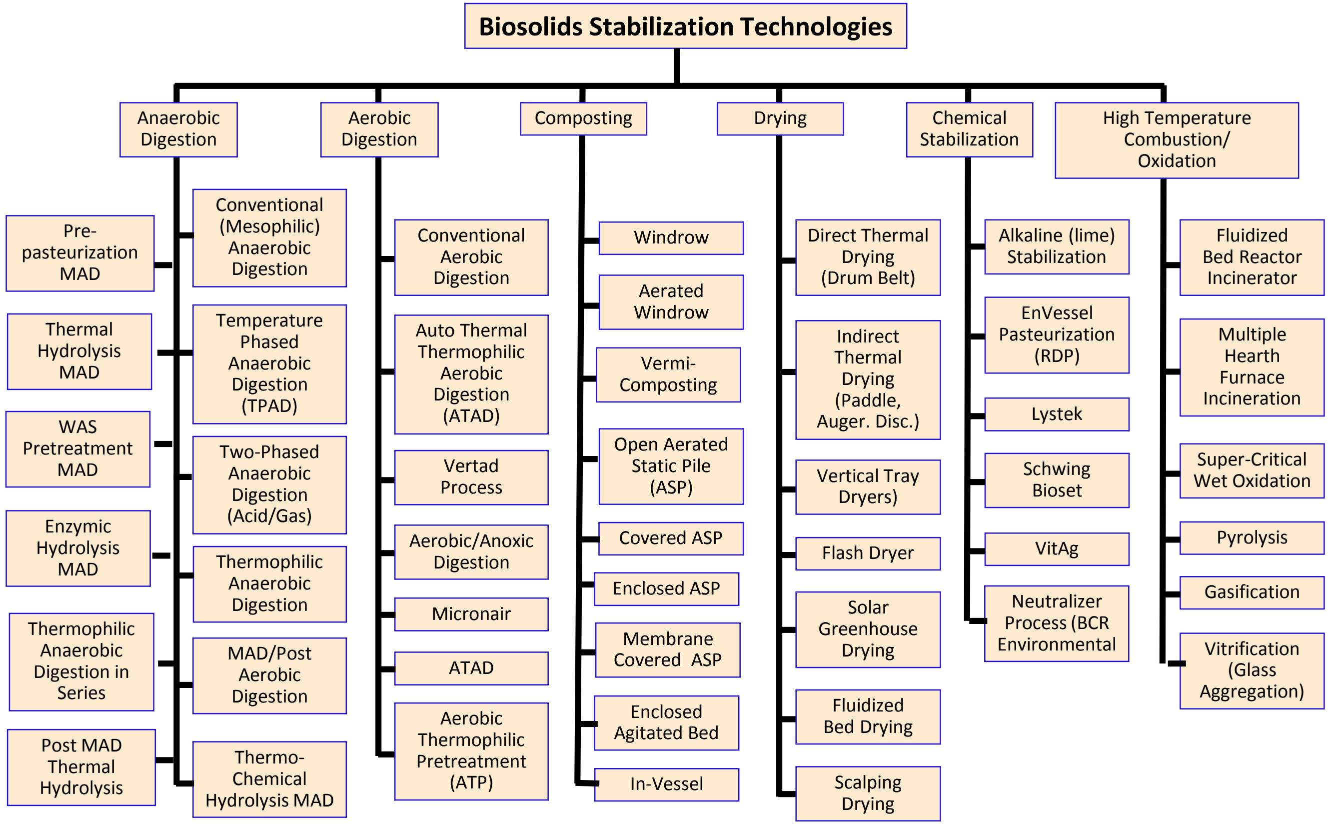
From *Charting the Future of Biosolids Management, a State-of-the-Industry Review* (2010)

Future Trends in Biosolids Management

- What are the trends?
  - Improved quality due to regulatory and public concerns
    - Class B to Class A
    - Research into eliminating trace constituents of concern
  - Side Stream Treatment and Nutrient Recovery
  - Energy efficiency/optimization
    - Advanced anaerobic digestion
      - Thermal hydrolysis/Micro hydrolysis
    - Co-Digestion (FOG and HSW) to generate more biogas
      - Biogas for driving CHP and biogas upgrading
    - Whole plant optimization
      - Carbon redirection
  - Interest in non-land-based alternatives and future technology development
    - Pyrolysis
    - Gasification
    - Hydrothermal liquefaction
    - Supercritical water oxidation
  - How to manage PFAS

There are Dozens of Technology Options
How Do We Sort Through Them All?

NEWEA
WORKING FOR WATER QUALITY



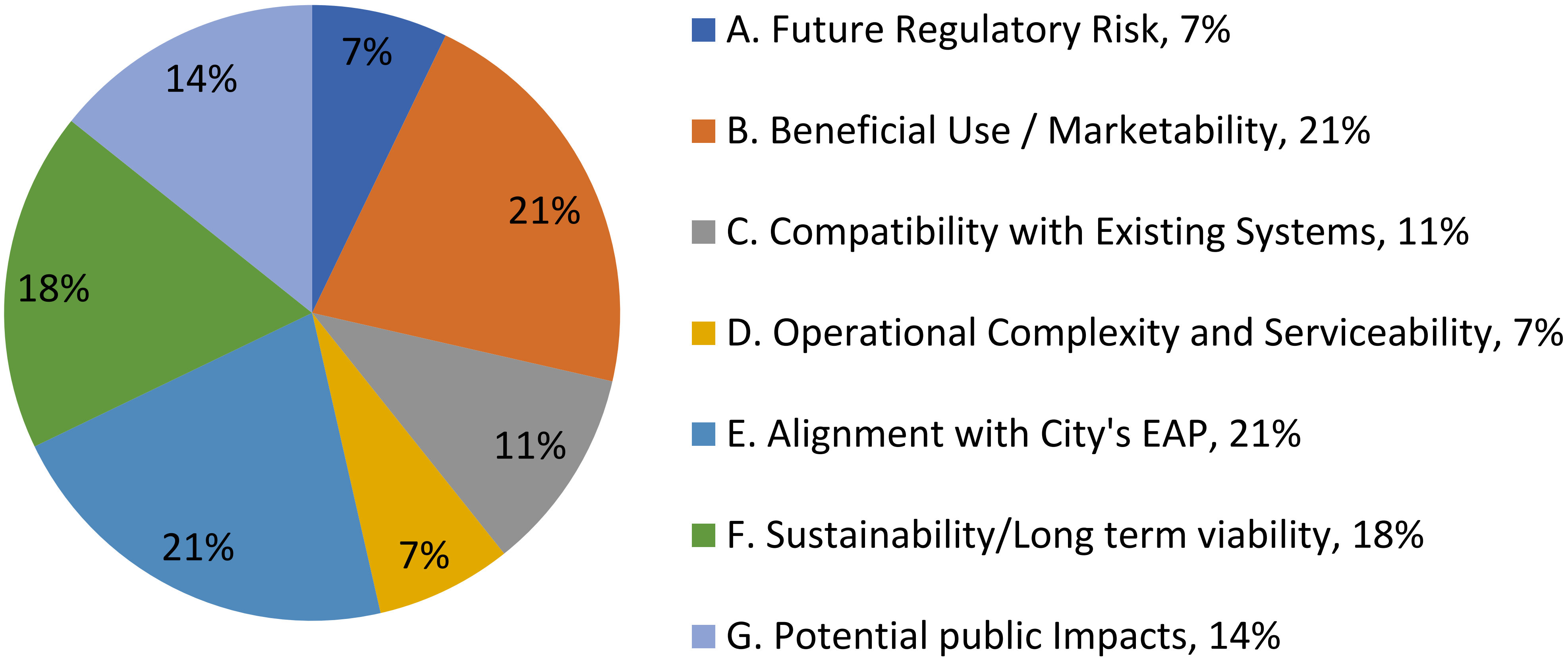
Identifying Appropriate Technology Solutions – Non-Monetary Criteria Development

Screening criteria are selected and weighted to ensure most cost-effective and sustainable process - Example

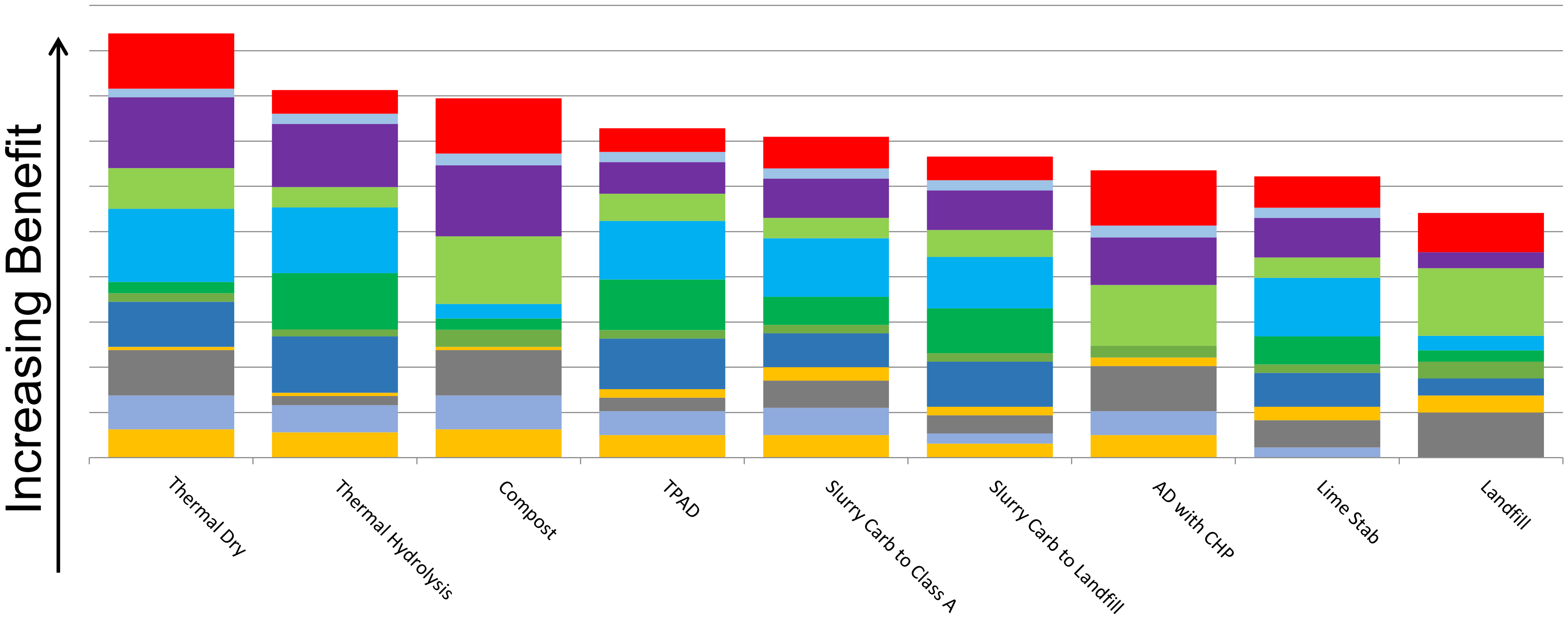
- Best Option
  - Social Performance
    - Public Health / Quality of Life
    - Values and Beliefs
    - Cultural Resources
    - Public Involvement
    - Aesthetics
    - Community Development
  - Economic Performance
    - Affordability
    - Ability to Finance
    - Ability to Maintain
    - Ability to Sustain
    - Economic Development
  - Environmental Performance
    - Surface Water Quality and Quantity
    - Ground Water Quality and Quantity
    - Aquatic Eco-Systems
    - Land Eco-Systems
    - Soil Quality
    - Air Quality
    - Energy Use
  - Technical Performance
    - Knowledge Base
    - Site Impacts
    - Implementation

Example of Non-Monetary Criteria Weighting

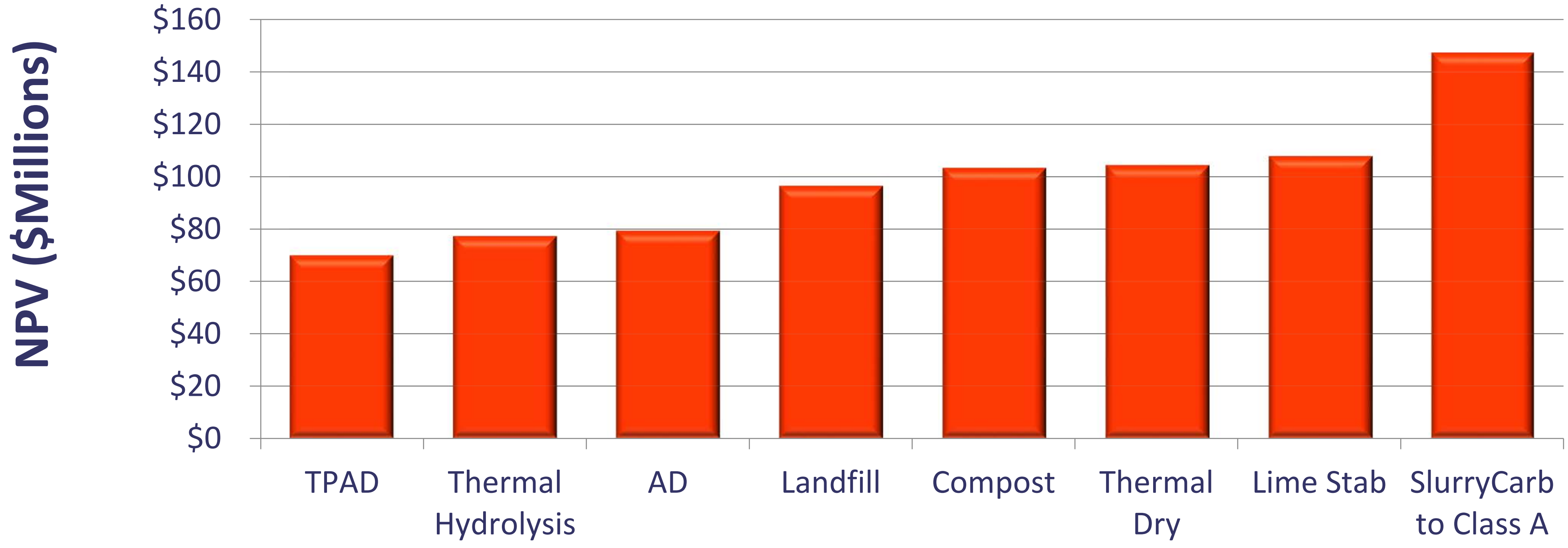
- Forced-weighting results



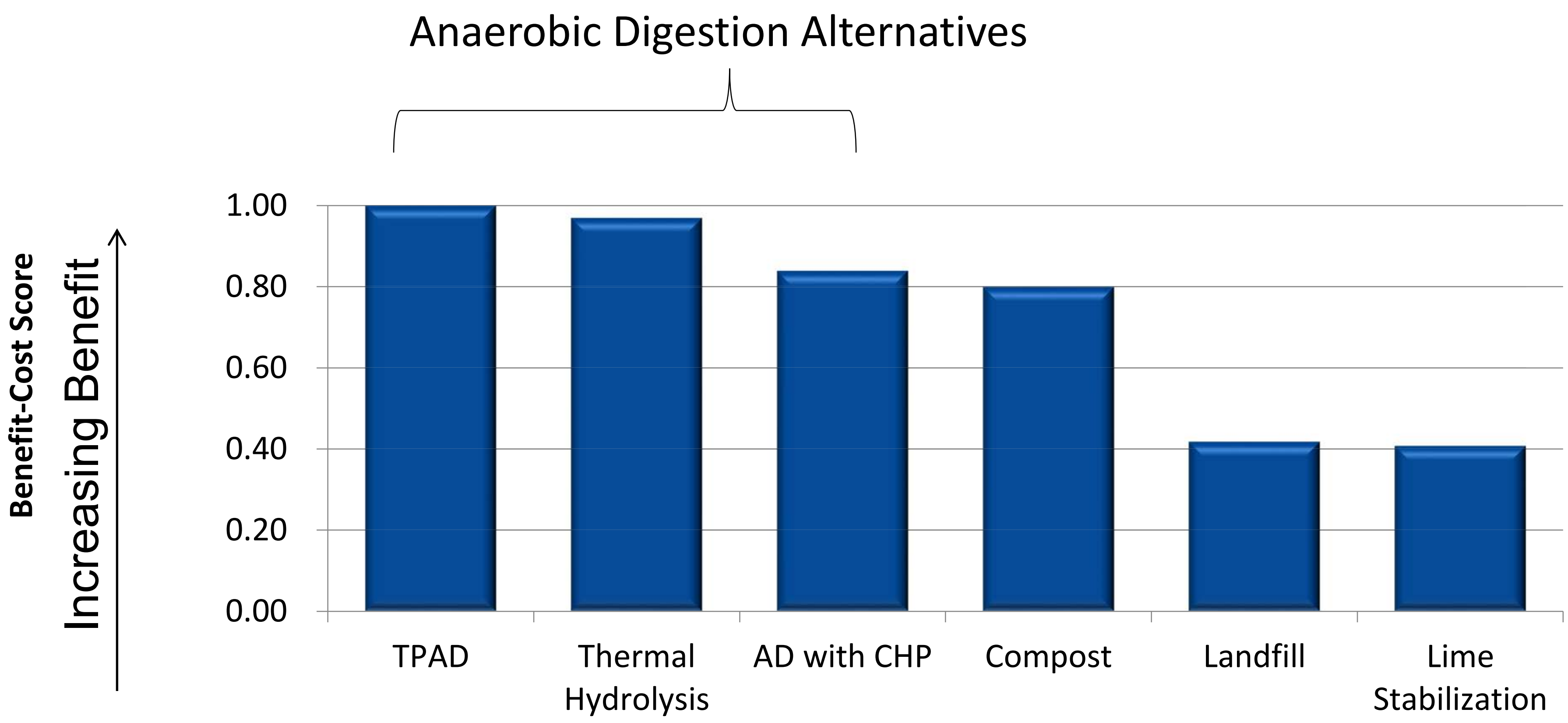
Example of Benefit Scores for a Utility



Example of Comparative Net Present Value Results



Example of Relative Benefit-Cost Results

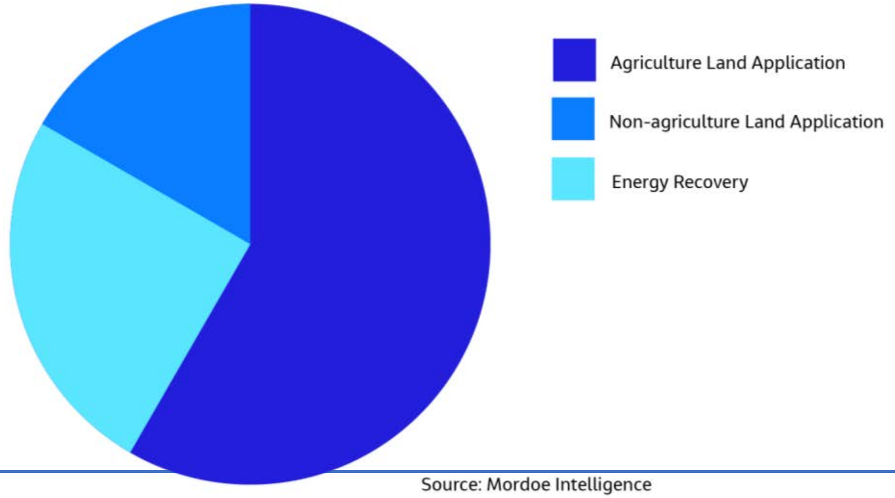


PFAS in Biosolids – Why should we care?

- Land application makes up 60% of the global biosolids market
- In the US, half of the 7.2 M dry tons per year of WWTP biosolids are land applied.
- The US biosolids land application market is valued at $600M/year and growing 4% per year or more

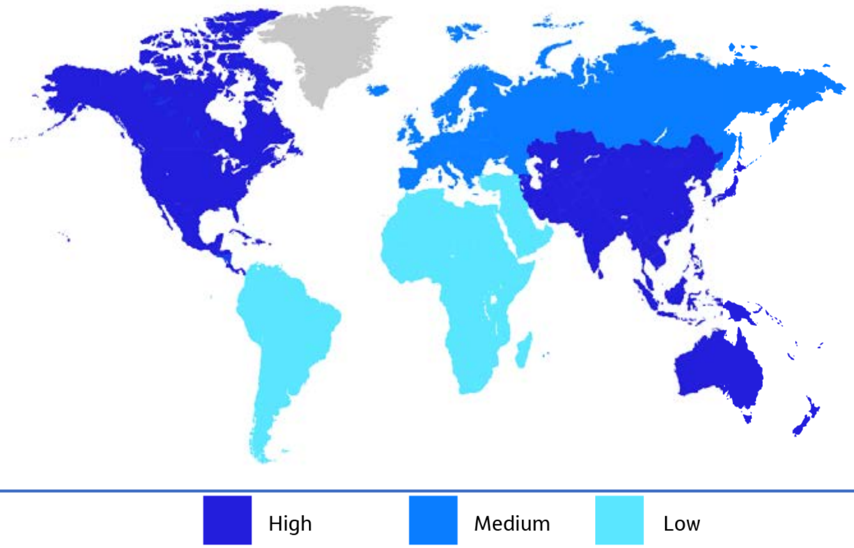
- Problems with landfills is forcing even more biosolids to land application
- What are the concerns?
  - Surface water, ground water, plant uptake
- Obvious regulatory development
- More importantly, what do farmers think?

Biosolids Market, Volume (%), by Application, Global 2018



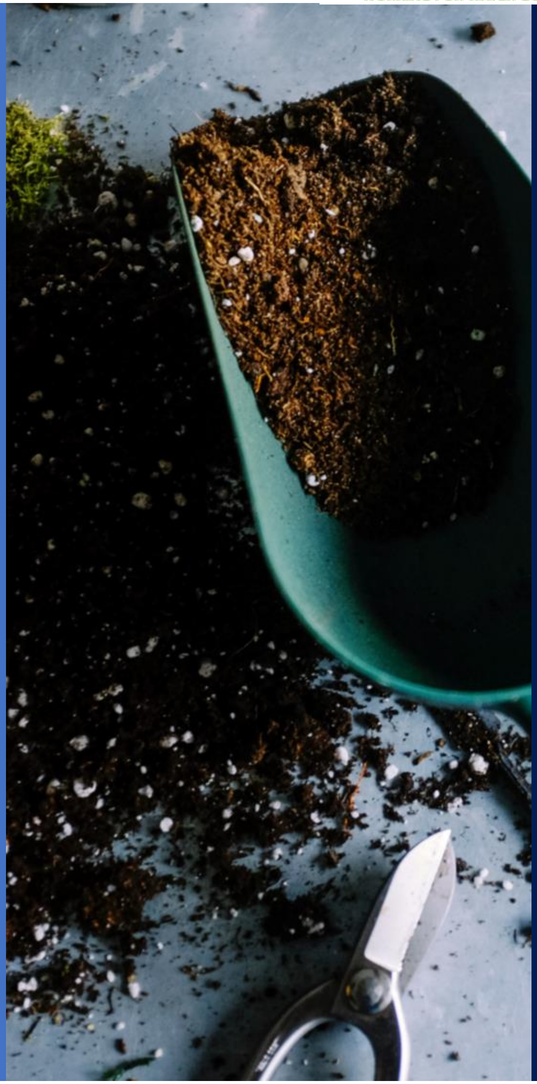
Source: Mordoe Intelligence

Biosolids Market – Growth Rate by Region, 2019-2024

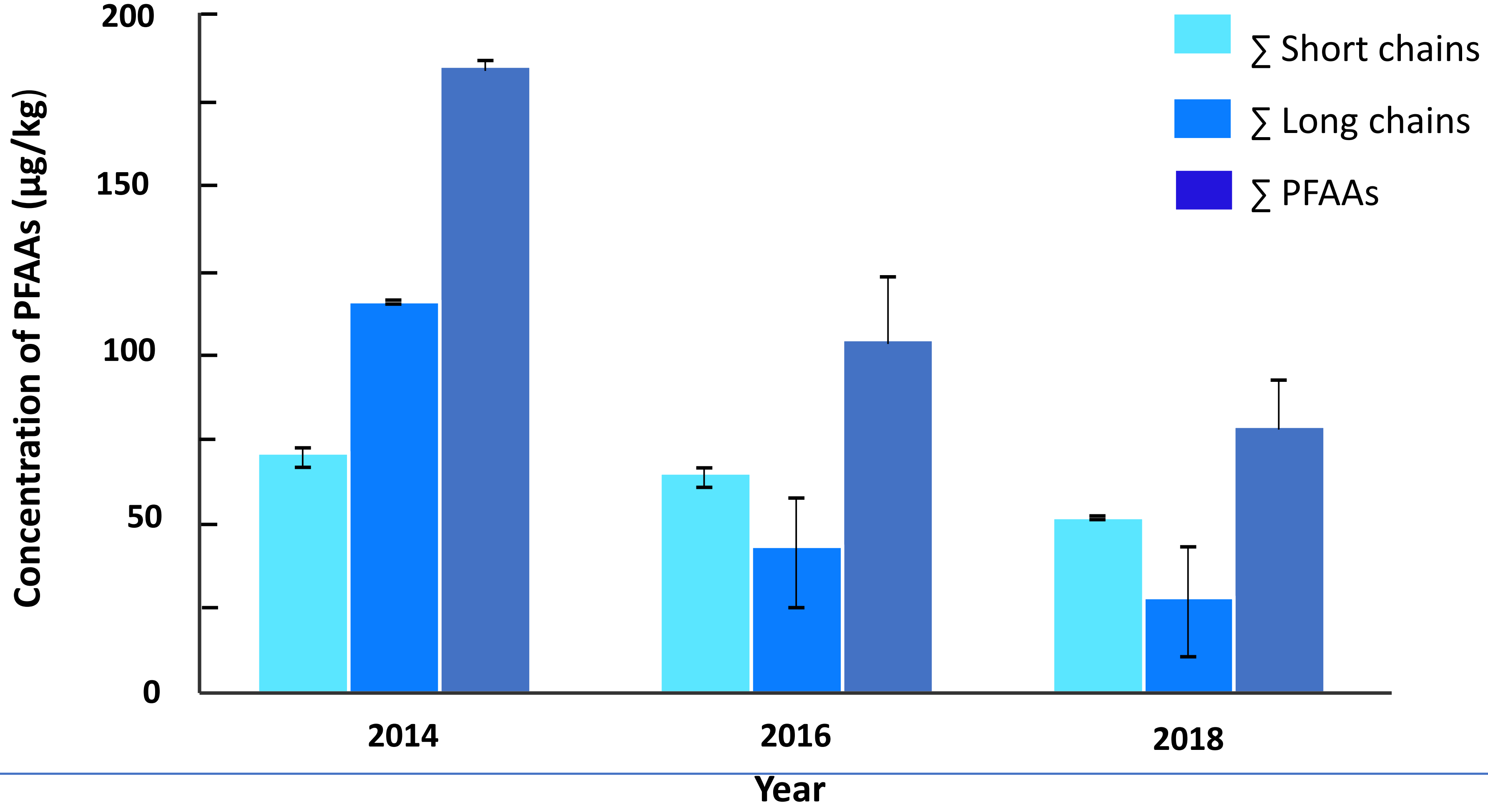


Implications of PFAS on biosolids land application

- PFOS and PFOA concentrations are decreasing
- EPA is working through risk analysis process for PFAS
- Some states will issue guidance recommendations on land application of biosolids based on concentration levels. MI has already done so, and WI has draft guidance
- Most data on PFAS impact in field studies has been gathered on industrially impacted biosolids. Very little data on impact (leachability, plant uptake, etc.) in US of PFAS from non-industrially or non AFFF impacted biosolids/soils
- Studies are being done to evaluate various biosolids process impacts including composting, incineration and pyrolysis. Jacobs and others are gathering more data this year.
- So what do we know?

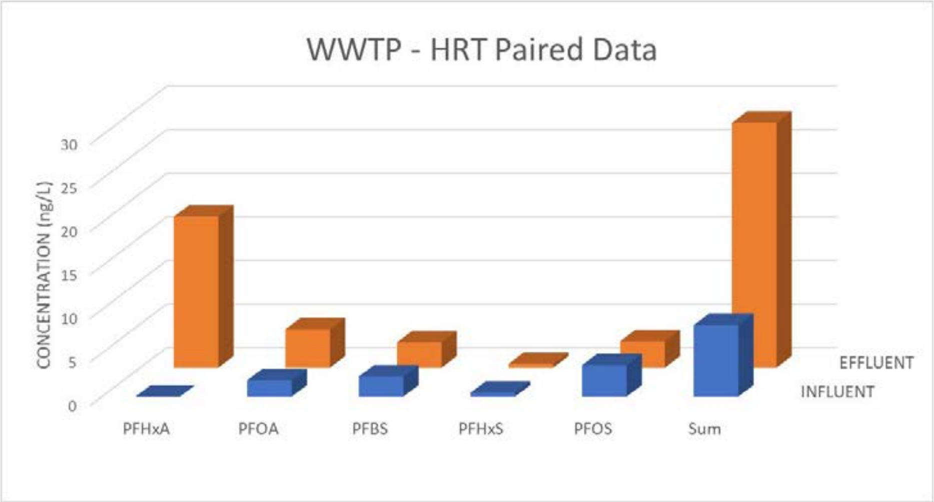


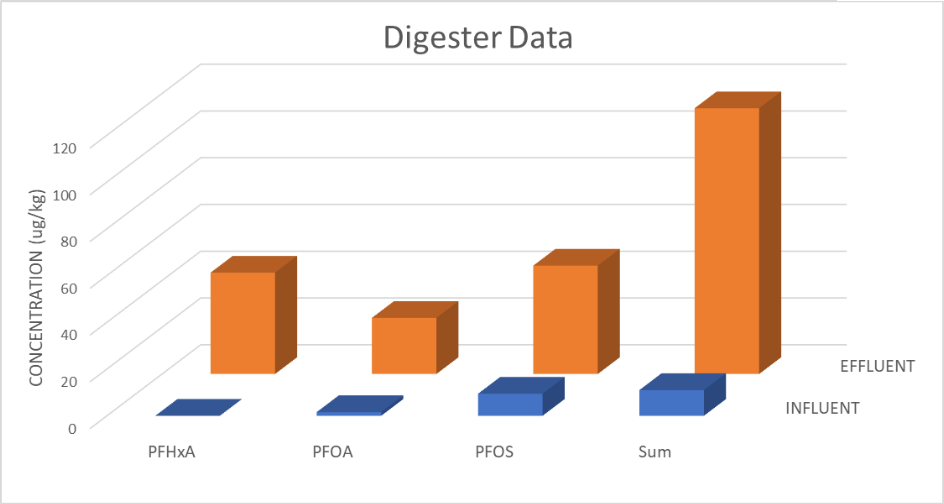
PFAA concentrations in biosolids have dropped as PFOS and PFOA were phased out of production in the US (one dried biosolids case study)



PFAS Precursor Transformation

Example Plant: Confirmed no Landfill or Industrial Contributions





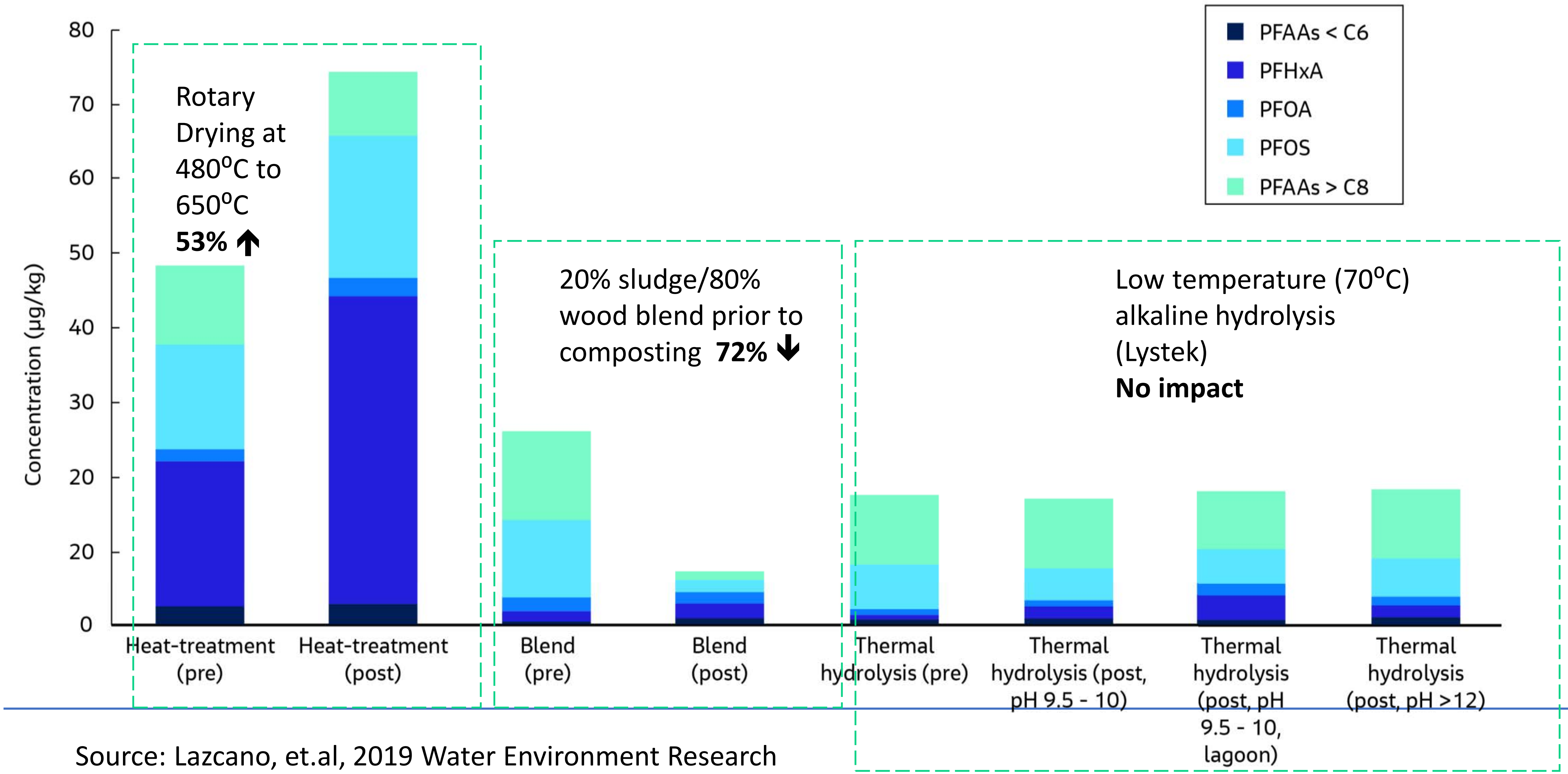
(PFBS and PFHxS not detected)

- 3 days of influent and effluent grab sampling
  - Morning, afternoon, night
- Effluent data timed according to hydraulic residence time (HRT)
- Measured PFAS pass through WWTP with limited/no reduction
- Precursors discharged to WWTP cause PFAS increase across aeration

- 100% WAS treated through ATAD system
- Increase across digestion from precursor conversion and/or changes in % solids
- PFAS also leaves plant through biosolids

Data Source: Jacobs, 2020

Impact of thermal drying, blending with bulking agent, and chemical/thermal hydrolysis treatment (not THP)



Source: Lazcano, et.al, 2019 Water Environment Research

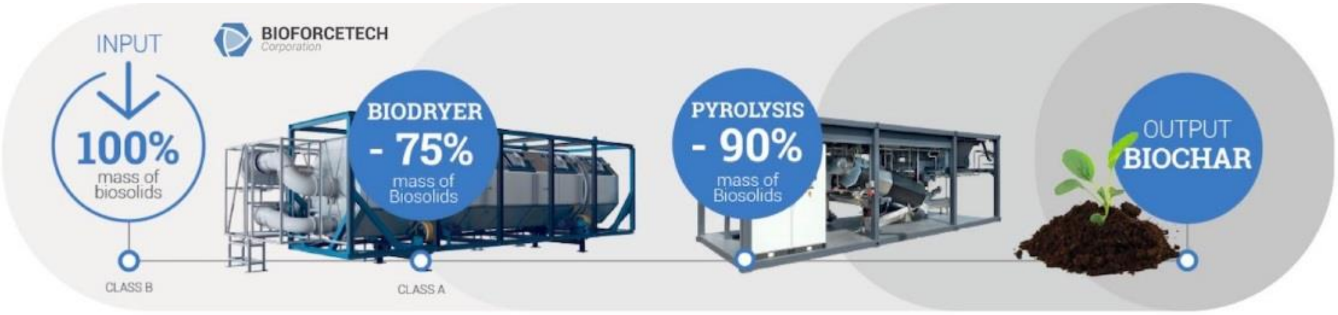
Pyrolysis - Biochar from BioForceTech Corp.

- One set of samples 2019, confirmed in duplicate in 2020
- Pyrolysis at 1100ºF (600ºC)
- We know soil sampling needs to be above 1000ºC for destruction of PFAS

Compound Name	Dry Biosolids (ng/g)	Biochar (ng/g)
PFBA	7.03	Not Detected
3:3 FTCA	ND	Not Detected
PFPeA	5.94	Not Detected
PFBS	2.3	Not Detected
4:2 FTS	ND	Not Detected
PFHxA	33.7	Not Detected
PFPeS	ND	Not Detected
HFPO-DA	ND	Not Detected
5:3		
PF		
AD		
PF		
6:		
PFOA	89.1	Not Detected
PFHpS	ND	Not Detected
7:3 FTCA	40	Not Detected
PFNA	5.3	Not Detected
PFOSA	ND	Not Detected
PFOS	26.3	Not Detected
9Cl-PF3ONS	ND	Not Detected
PFDA	11.3	Not Detected
8:2 FTS	5.68	Not Detected
PFNS	ND	Not Detected
MeFOSAA	23.5	Not Detected
EtFOSAA	19.6	Not Detected
PFUnA	3.39	Not Detected
PFDS	ND	Not Detected
11Cl-PF3OUdS	ND	Not Detected
10:2 FTS	ND	Not Detected
PFDoA	5.85	Not Detected
MeFOSA	ND	Not Detected
PFTrDA	ND	Not Detected
PFTeDA	2.44	Not Detected
EtFOSA	ND	Not Detected
PFHxDA	ND	Not Detected
PFODA	ND	Not Detected
MeFOSE	17.1	Not Detected
EtFOSE	ND	Not Detected

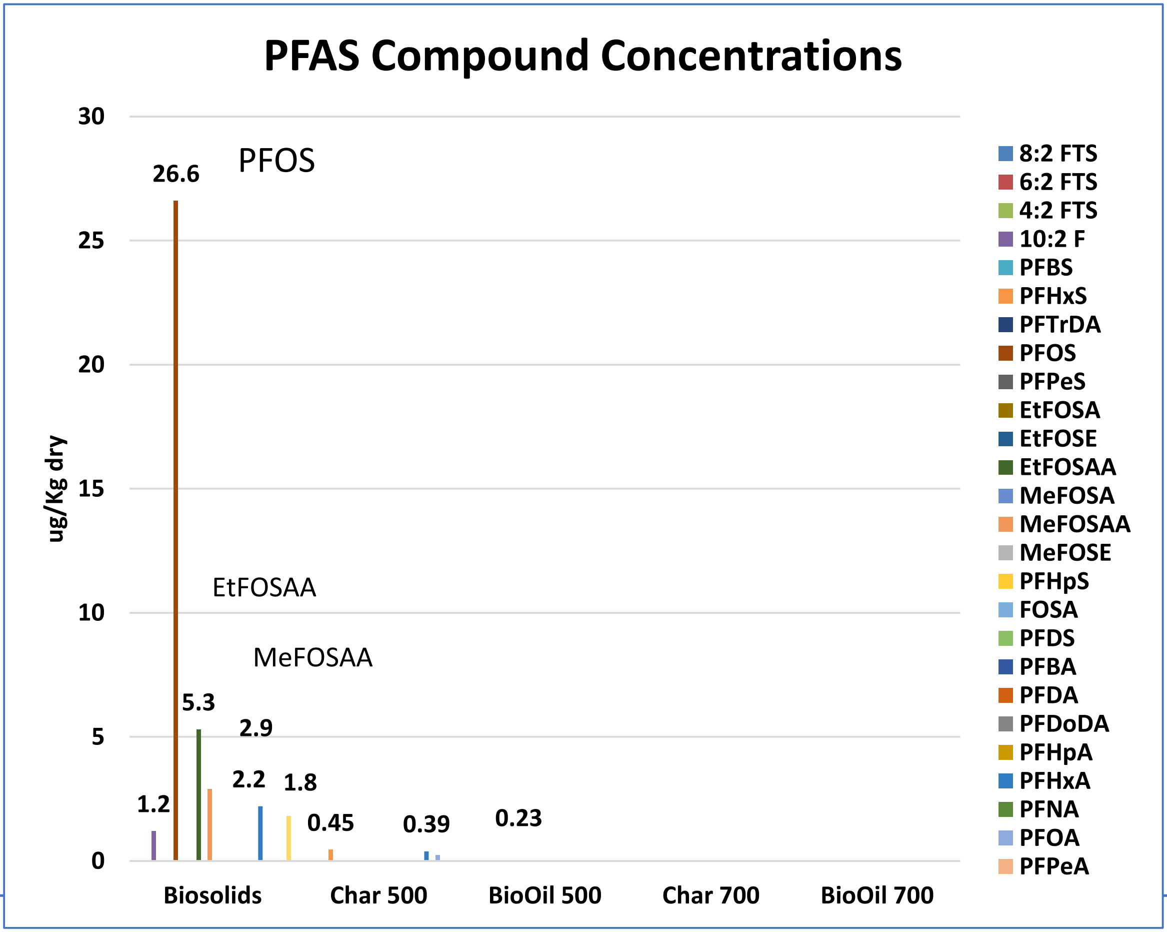
PFOA =89.1 & PFOS = 26.3

All ND @ 2ppb

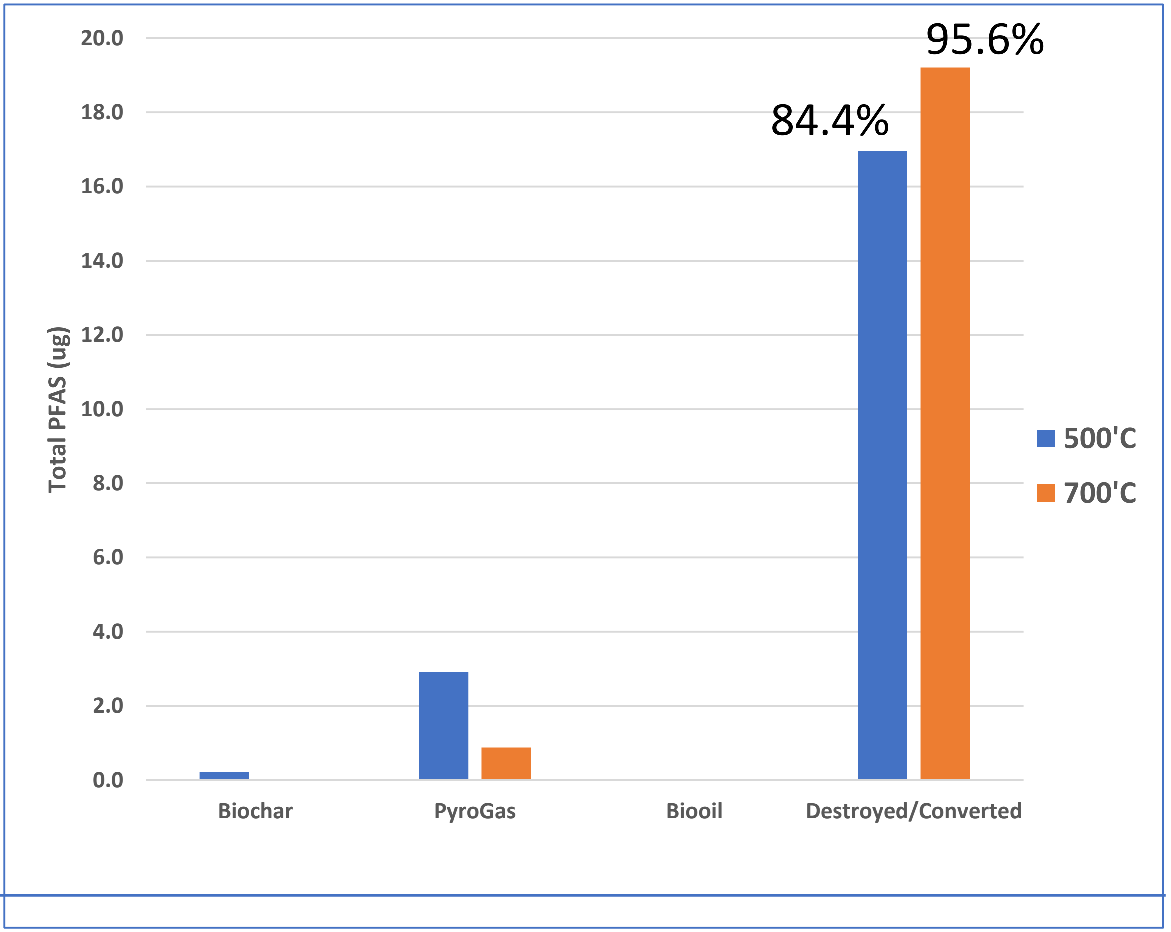


Source: BioForceTech, 2019, retested and confirmed 2020

PFAS Testing Results Before and After Pyrolysis

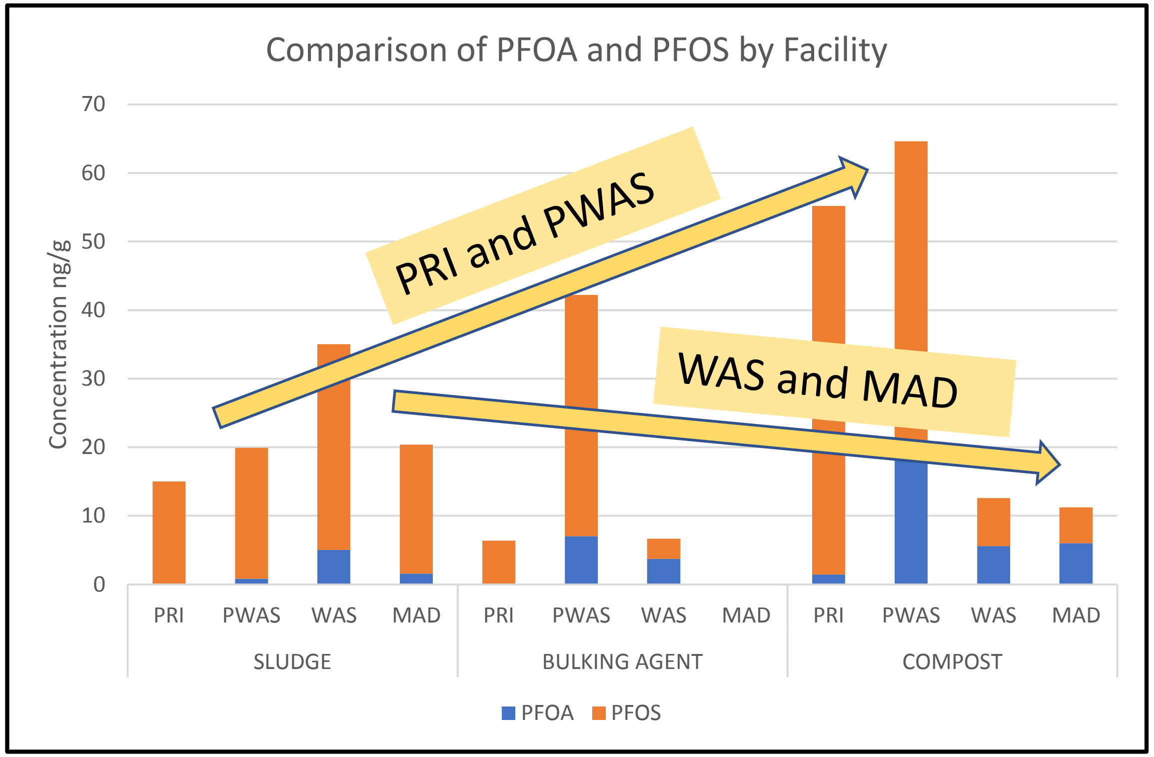


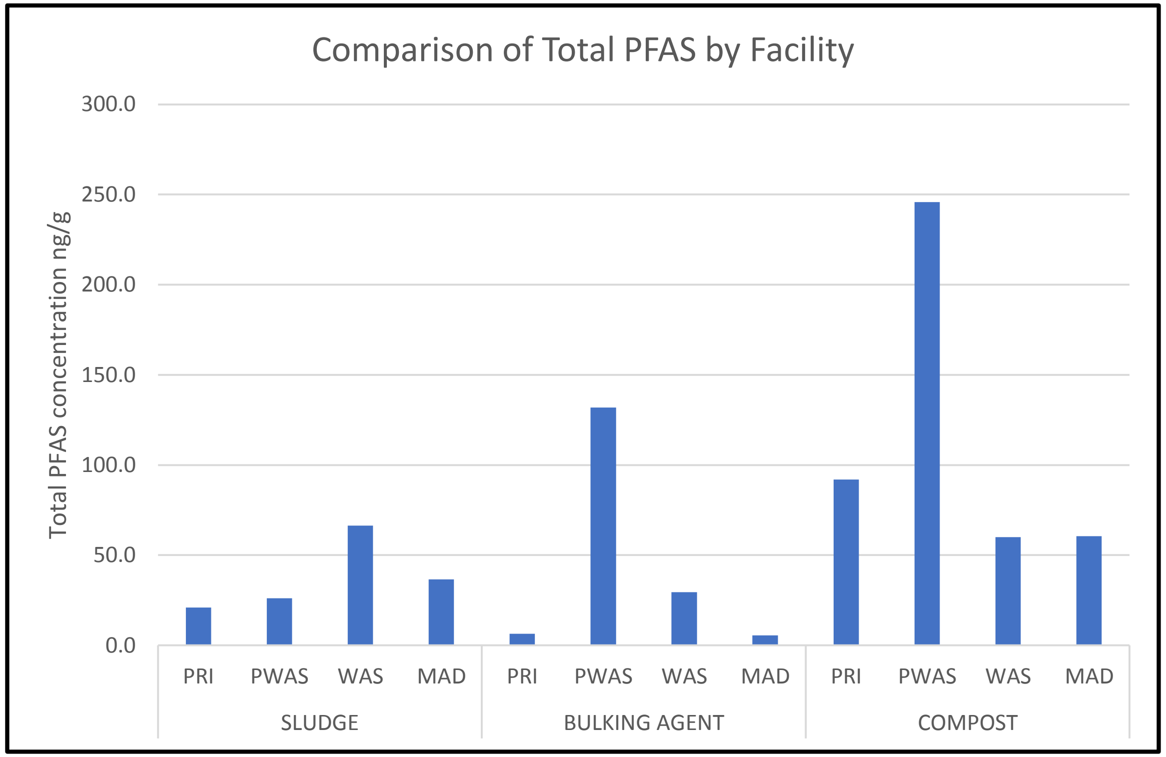
PFAS Mass and % Reductions out of 20 ug PFAS in biosolids



Source: Jacobs, WEF RBC 2021

PFOA, PFOS and Total PFAS in 4 Composts by Sludge Type

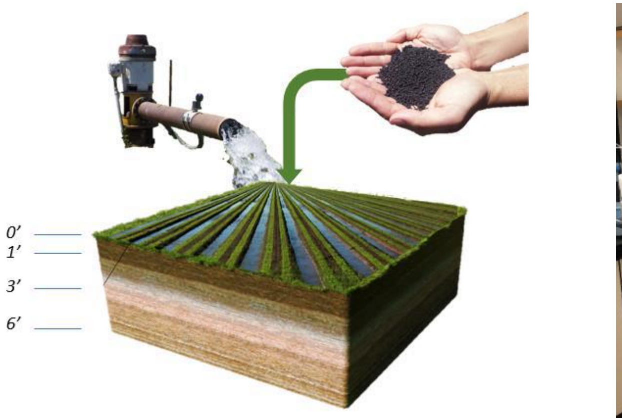




Appears to be more precursor transformation of primary sludge vs. waste activated sludge or digested sludge

Source: Jacobs, USCC 2021

So What's the Impact of Biosolids Processes on PFAS?



- Limited data....but...
  - Digestion may change precursors, but does not reduce overall PFAS levels
  - Short duration thermal drying appears to increase PFAS concentrations
  - Addition of bulking agent (composting) can dilute PFAS concentrations
  - Pyrolysis (and longer duration desorption) can eliminate PFAS
- Research on non-industrially impacted biosolids is progressing
  - Dr. Linda Lee at Purdue and others doing much research in this area
- Studies are being initiated to evaluate process impacts
  - Look for more data to be published soon

Biosolids PFAS Management Summary Thoughts…

- Follow studies and regulation development
- It is important to update biosolids management plans
- It is important to develop flexible biosolids programs that can be modified as regulations and/or public demand require
- Consider testing biosolids to understand PFAS levels
- Look upstream for industries that may use PFAS (SIC search)
- Prepare for questions from the public as they will come
- Fact sheets are available from several sources
  - https://www.nacwa.org/advocacy-analysis/campaigns/pfas
  - https://pfas-1.itrcweb.org/
  - Jacobs PFAS fact sheet

Summary thoughts for Adaptive Biosolids Management

- Leadership must articulate a vision for the future – ***be bold!***
- Consider non-traditional approaches to bridge gaps – ***dare to disrupt!***
- Staff must be involved, empowered, motivated, and accountable – ***seek buy in!***
- Know where are you starting from – ***develop a baseline!***
- Implement changes incrementally, reassess frequently, and have a contingent plan that is adaptable – ***no regrets!***
- Involve the community you serve – ***communicate!***
- Learn from others; share results – ***collaborate!***

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Thank You!

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