A Novel Method to Quantify Biosolid Drying Properties

Vanessa Borkowski, P.E.

November 2, 2023

Stantec

Acknowledgements

Stantec: Rafael (Rocky) Iboleon & Dian Zhang

Virginia Tech: Yitao Li & Drew Wang

Agenda

- **Introduction**
  - Background on MSD, THP, and Thermal Drying
  - Purpose of Pilot Testing
  - Hypothesis/Goals
- **Methodology**
  - Experimental Design
  - Pilot Dewatering and THP Units
  - Dewatering, Optimal Polymer Dose, and friability methods
  - Biological Methane Production (BMP)
- **Results and Discussion**
  - BMP and Yield
  - Capillary Suction time (CST)
  - Cake Dryness
  - Drying Properties/Fragility
- **Q&A**

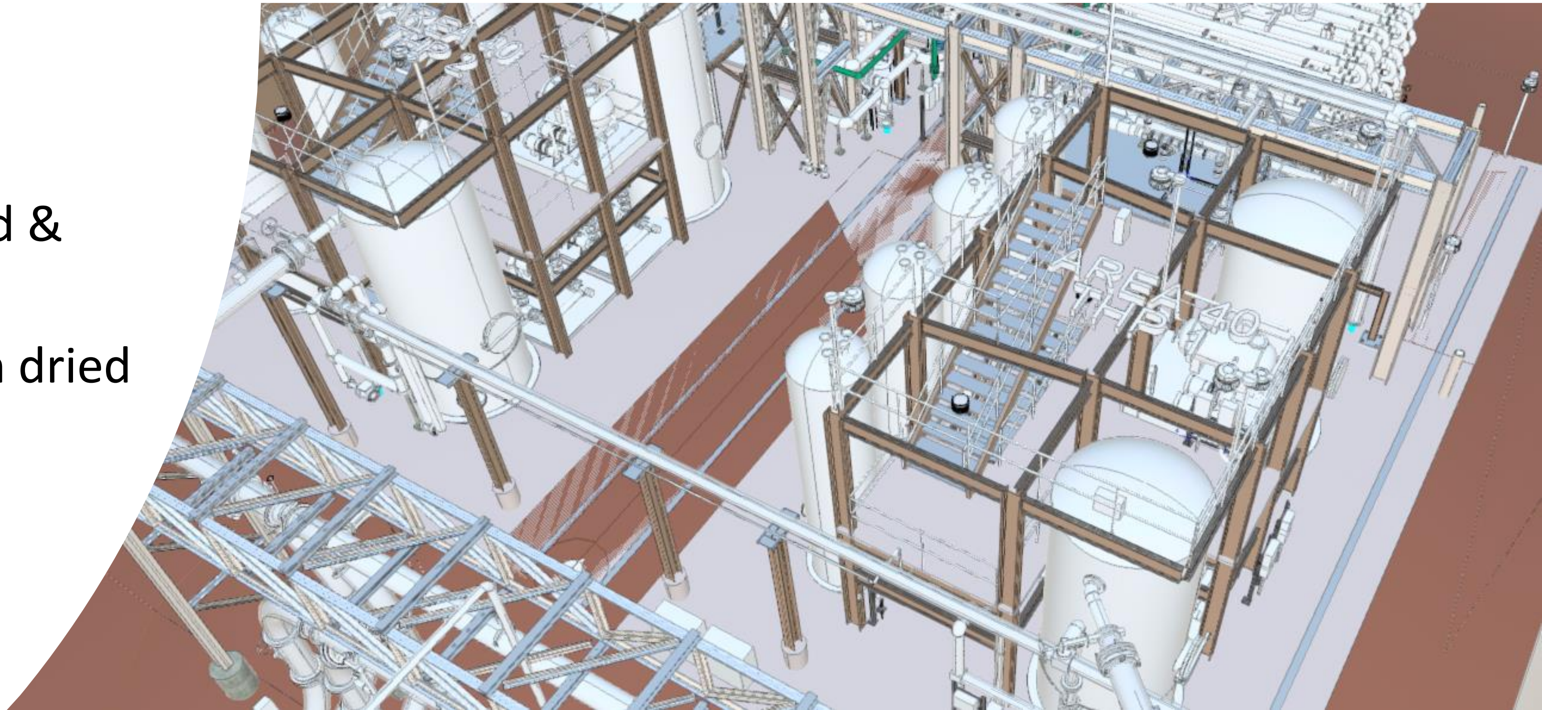
Introduction

Background on Jefferson/Louisville Metropolitan Sanitation District (MSD)

- Morris Forman Water Quality Treatment Center(MFWQTRC): Kentucky's largest treatment center
- Designed:
  - Dry weather flow 120 MGD
  - Wet weather flow 350 MGD
  - Produces ~70-80 tons of biosolids per day
- Manages solids processing for Regional Wastewater Treatment Facilities in Metro Louisville
  - Imported Waste activated sludge (IWAS) from Derek R. Guthrie Water Quality Treatment Center (DRGWQTC)

Purpose of Pilot Project

- Louisville MSD seeks bench-scale study → THP's impact on **digestion, dewatering, and drying** on sludge in preliminary design
- Evaluated Biosolids for anomalies like:
  - Low VSR
  - Odor
  - Poor dewaterability
- THP enhances dewaterability → Over-dried & friable cake
- Bench study aims to verify THP's impact on dried pellet friability with controlled variables

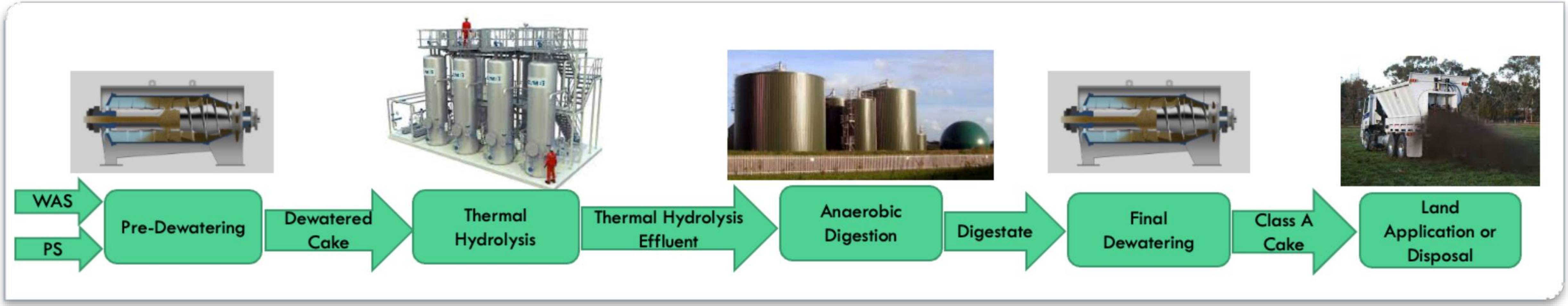


Introduction to Thermal Hydrolysis Pretreatment Process

- Uses high temperature and pressure to degrade the composition of organic material
- Process acts like a "Pressure Cooker"
- Enables maximum efficiency of digester units (up to 4X)
- Produces high-quality Class A biosolids

Benefits to Facilities by Adding Thermal Hydrolysis treatment

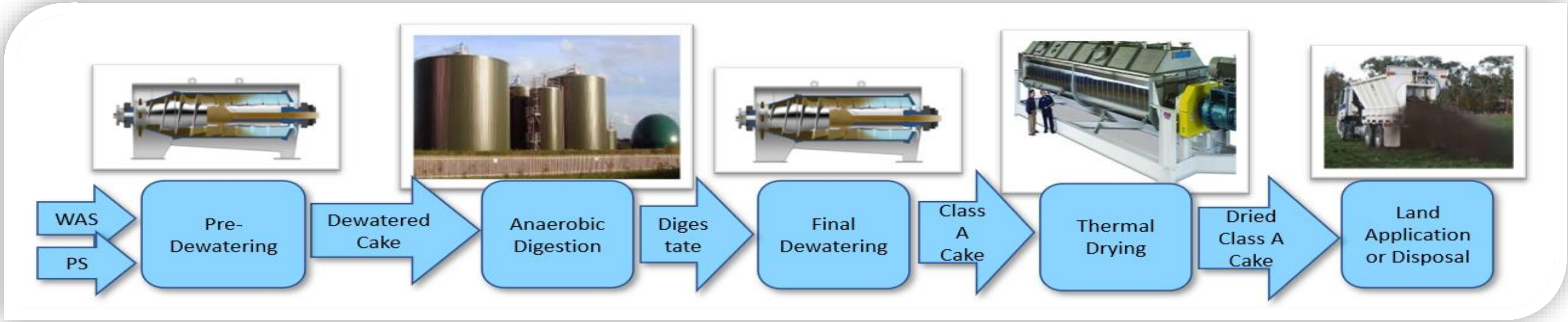
Diminished Viscosity	Double TS influent content (i.e., 8-10%) pumped and mixed
Pathogen Sterilization	Generate Class A Biosolids
Higher Digestibility	Decreased solids retention time (i.e., from 30 to 15 days)
Enhanced Dewaterability	Less biosolids production and lower water content
Maximized Digester Utilization	ADs can handle up to 4 times the TS loading rate



Example Train for Thermal Hydrolysis Pretreatment

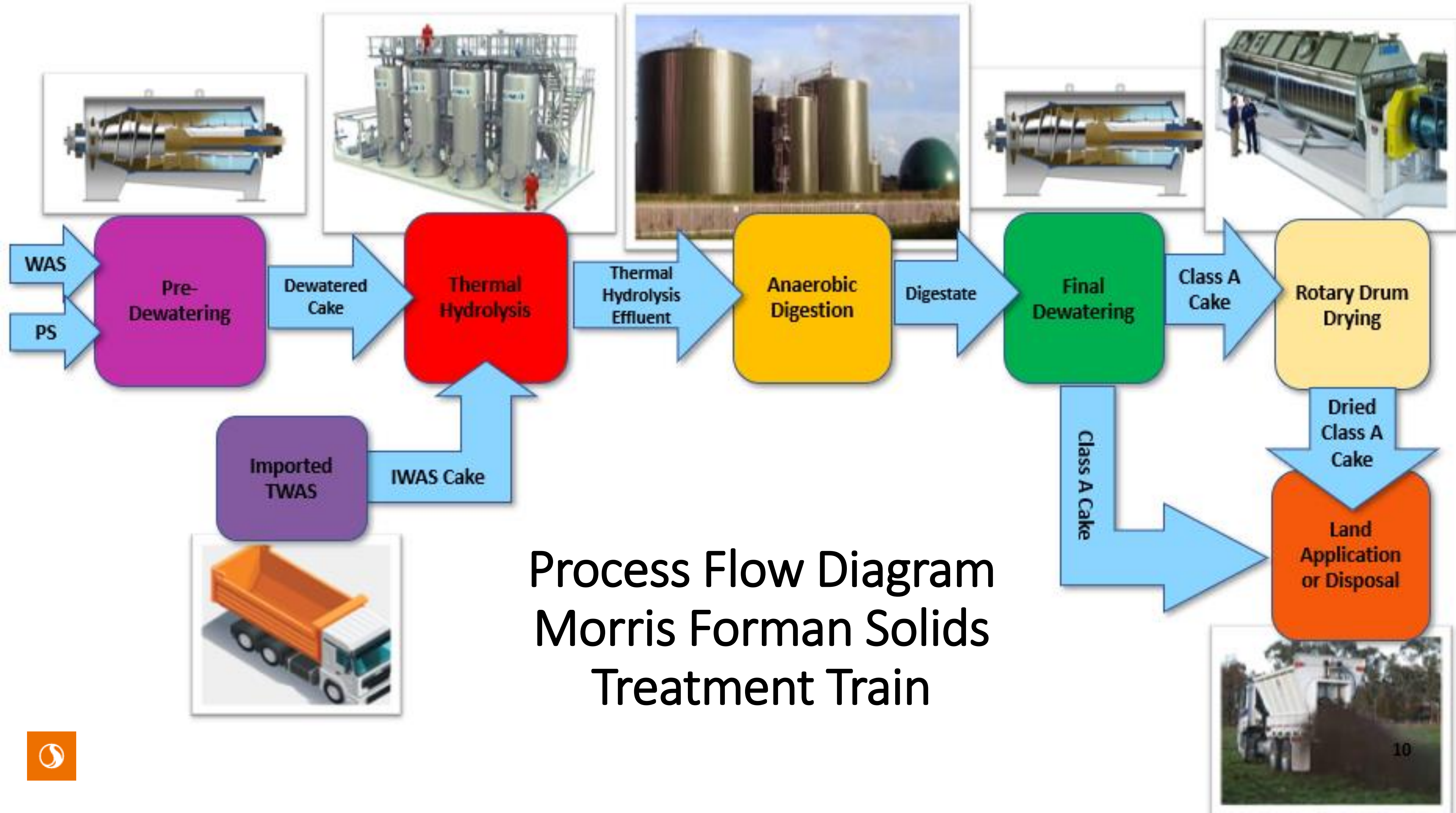
Benefits to Facilities by Adding Thermal Drying

Mass/Volume Reduction	15-30+%TS → 90+% dry solids (4-5-fold decrease)
Pathogen Sterilization	Produces stable and marketable Class A Biosolids
Decreased Hauling Cost	Less material to move for land application or landfill disposal
Small Footprint	Compact compared to other stabilization technologies



Example Train For Thermal Drying

Process Flow Diagram Morris Forman Solids Treatment Train



Hypothesis/Goals

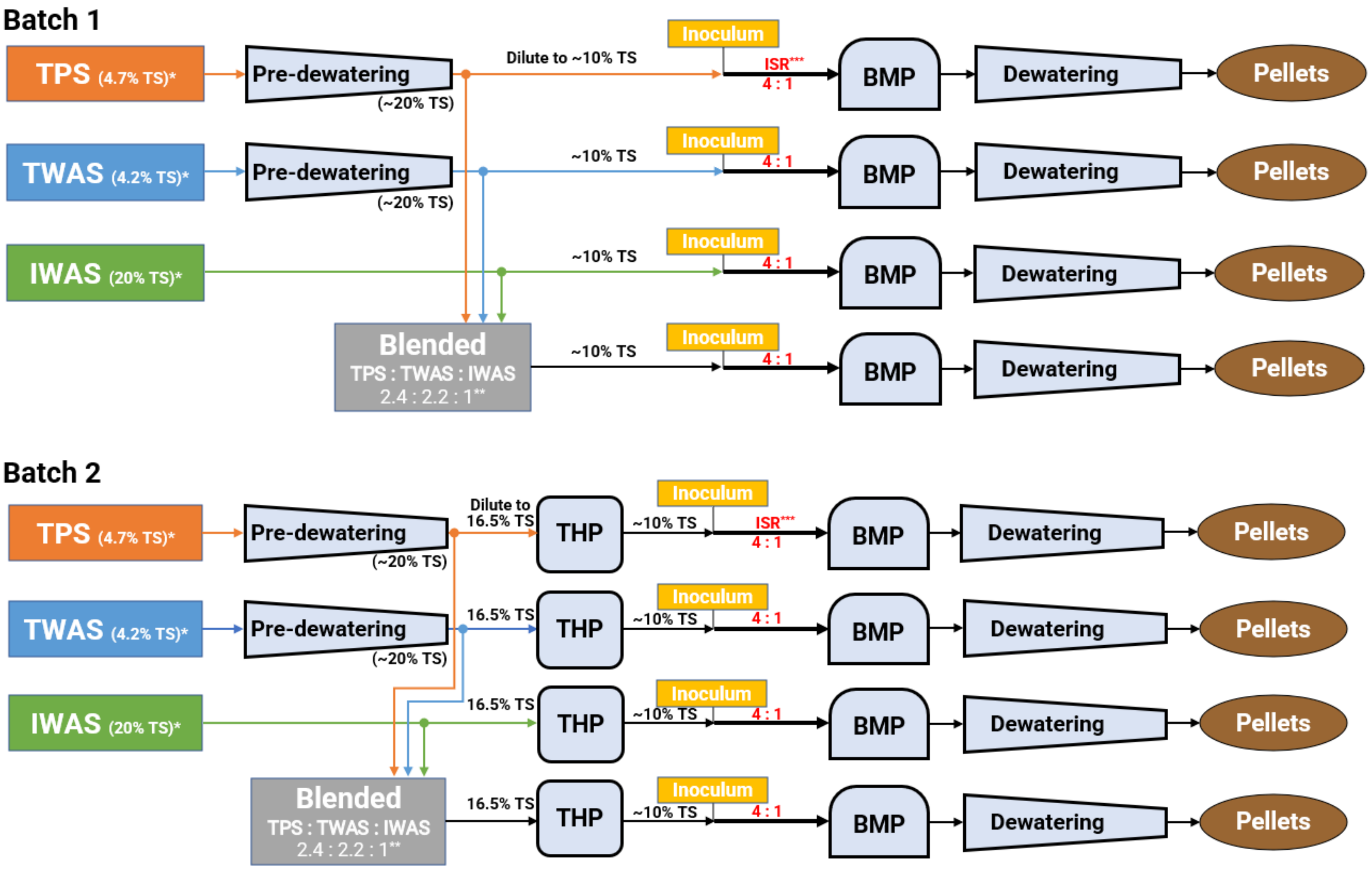
- THP (thermal hydrolysis pretreatment) will have the following effects:
  - Improve digestibility
  - Improve dewaterability
  - Increase friability of thermally dried biosolids pellets
- Friability influenced by:
  - Dryer heat input (product dryness)
  - Sludge type (TPS, TWAS, IWS)

Methodology

Experimental Design

Control- No THP

Experimental – THP Implemented



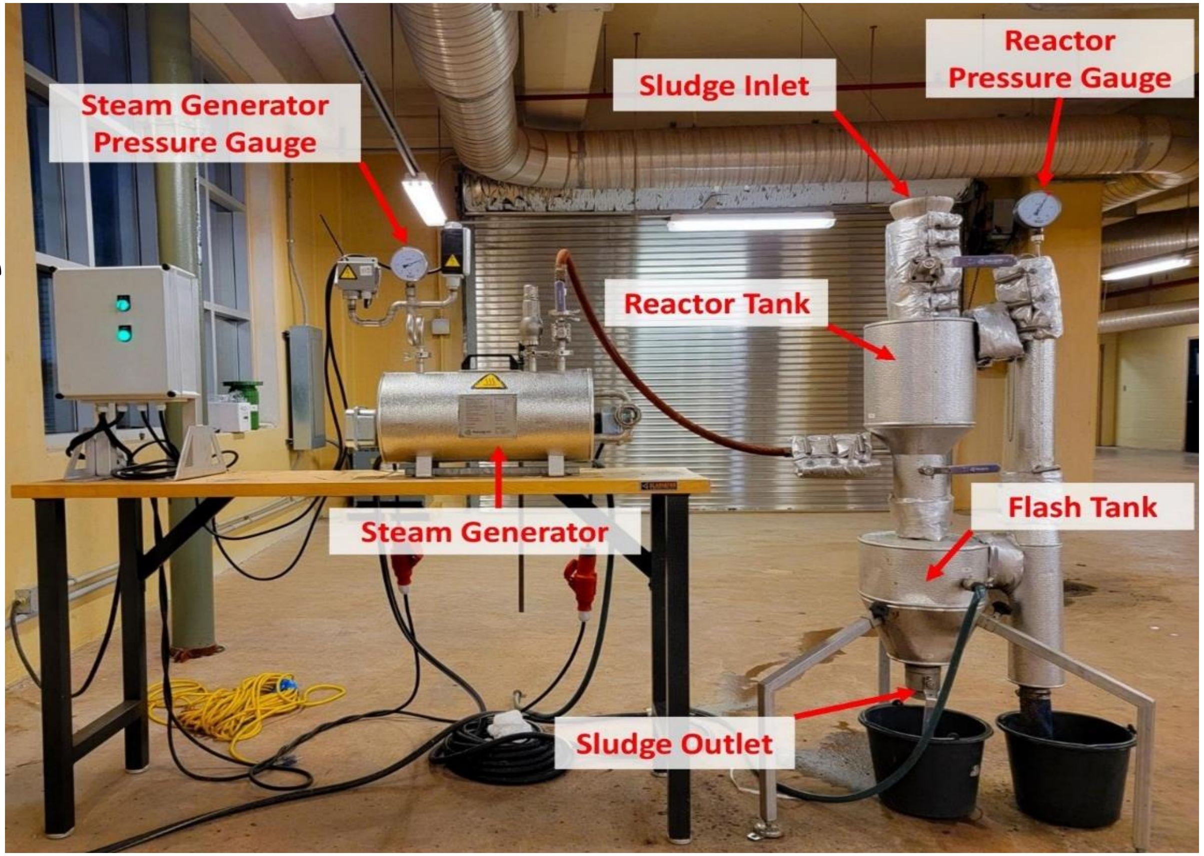
Sample Collection and Transport


- TPS and TWAS samples were collected from MFWQTC and IWAS cake samples were collected from DRGWQTC—all were in sealed 5-gallon buckets provided by Louisville MSD

Pilot Dewatering and THP Units

PWTech Pilot Screw Press Dewatering Unit

- Pre-dewatered using pilot screw press dewatering unit (ES-051, PWTech).
- Achieved 25% TS and 15% TS for TPS and TWAS
- Neat polymer diluted to 0.33% active polymer solution



CAMBI™ Pilot THP Unit

- Blended group: TPS, TWAS, and IWAS cake in a 2.4 : 2.2 : 1 ratio
- In Batch 2→ 16.5% TS
- Pretreated in pilot THP unit→ **6 bar** steam pressure for **30 mins**
- Pretreated sludge injected into flash tank from reactor tank

Biological Methane Production(BMP) Testing

BMP test using an incubator and respirometer

- Methane production:
  - measured with AER-800 system
  - Monitoring until methane production plateaued
- THP-processed sludge diluted to ~10%, standard BMP protocol
- Inoculum:
  - DC Water's THP-AD effluent
  - 4:1 ratio
- AD Conditions:
  - Temp→36.5°C
  - Volume→500-mL bottles

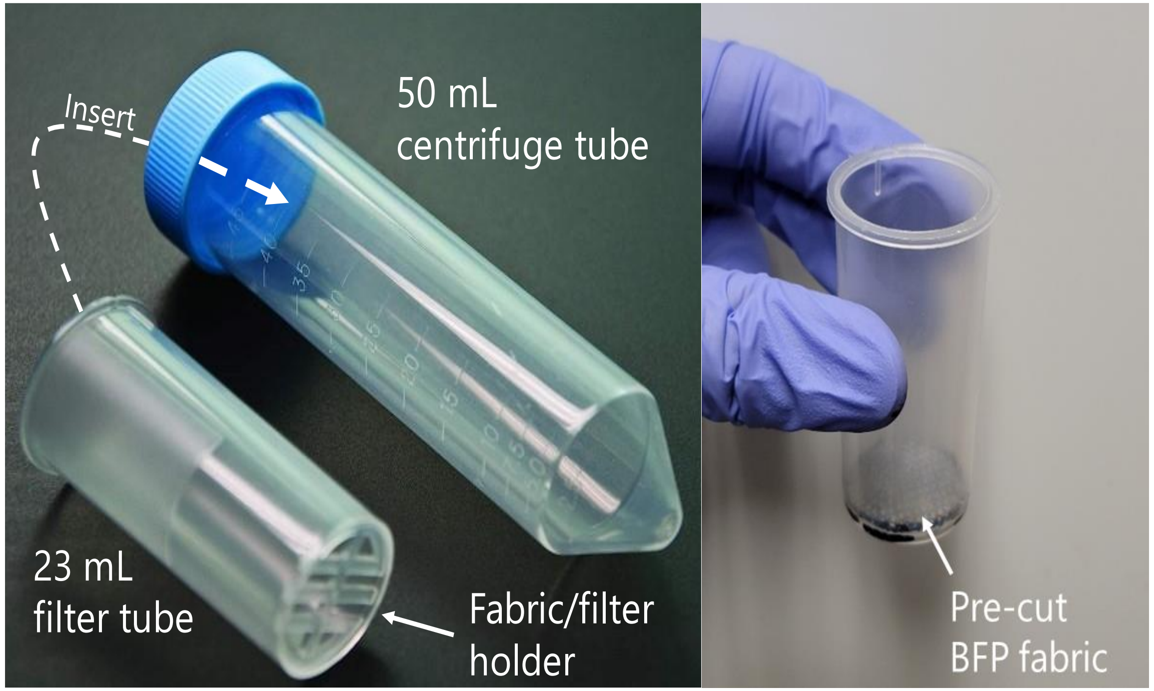
Dewaterability and Polymer Dosing

- OFI Testing Equipment device
- CST tests based on Standard Method 2710 G5.
- Device components include stainless-steel column, electrodes, plastic plates, chromatography paper, and timer
- 5 mL sludge (without polymer) added to column → CST measures filtrate travel time between circles.

- Digested sludge mixed with optimal polymer dose
- ONiLAB Scientific mixer used 2,200 RPM, 60 N*cm torque.
- Controlled shear intensity at $Gt=1.110*10^5$
- Shear intensity quantified using G*t, with comparisons to other equipment shear intensities

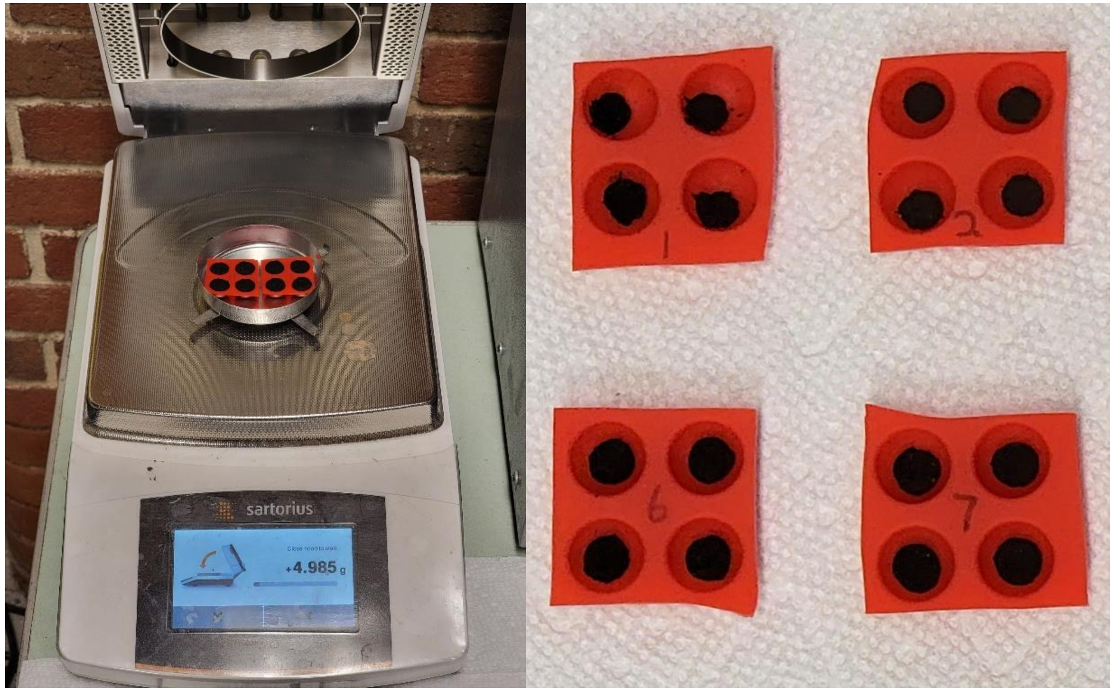
Pellet Formation

Demonstration of the fabric/filter-integrated centrifuge tube used for centrifugal dewatering



- Gravity-drained solids placed in 23 mL filter tube within 50 mL centrifuge tube.
- Pre-cut belt filter press fabric placed at filter tube bottom
- Loaded filter tube centrifuged for 20 minutes at 4000 x gravitational constant
- Dewatered cake on fabric and filtrate collected for analysis

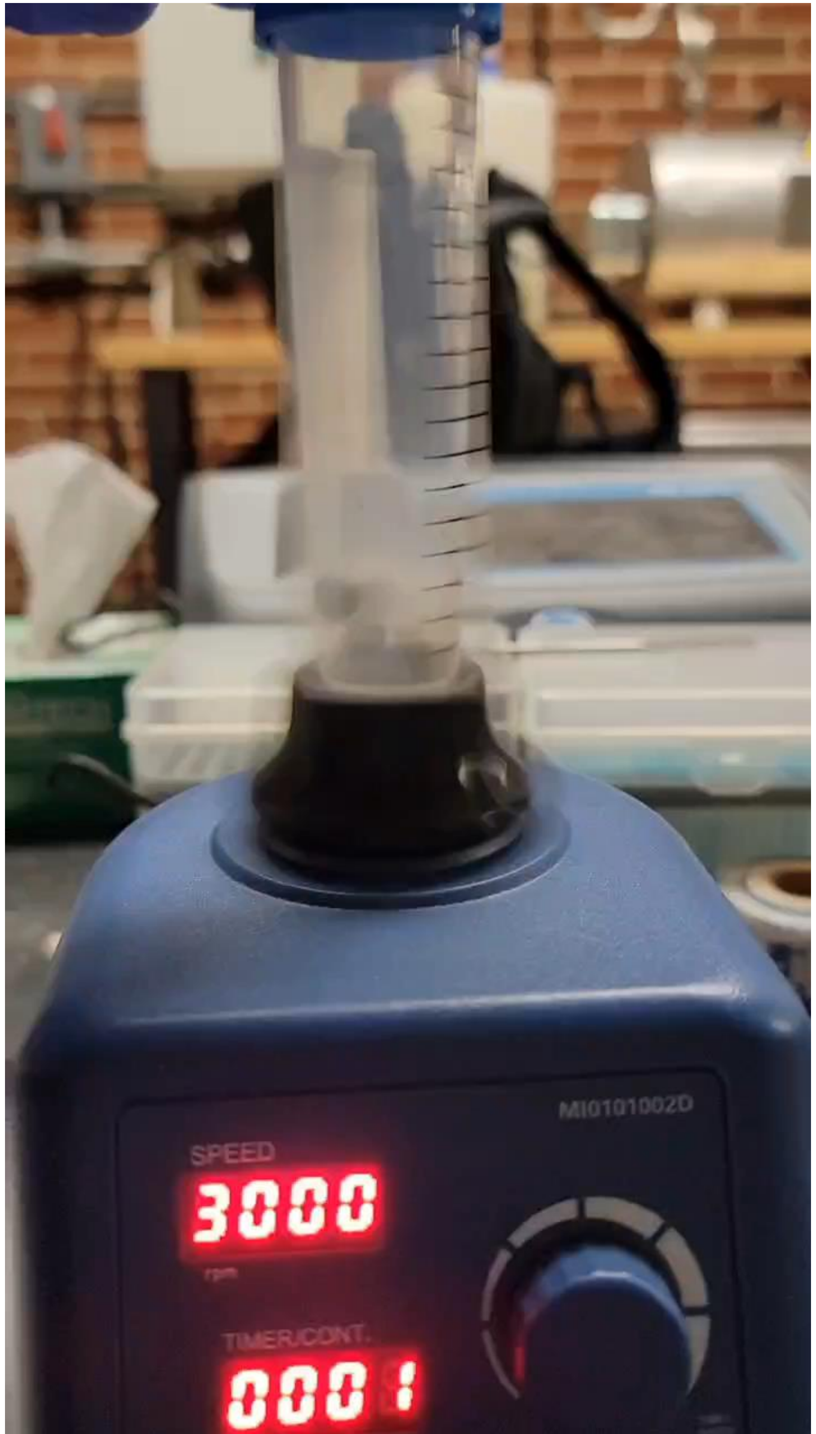
Wet cake pellets were dried with molds in a moisture analyzer (left) and pellets after drying (right)



- Dewatered cake samples reshaped with 1-cm diameter silicone mold
- Wet pellets dried with molds in batches using a moisture analyzer (MA37, Sartorius Corporation) at 105 °C to 90%, 95%, and 100% dryness

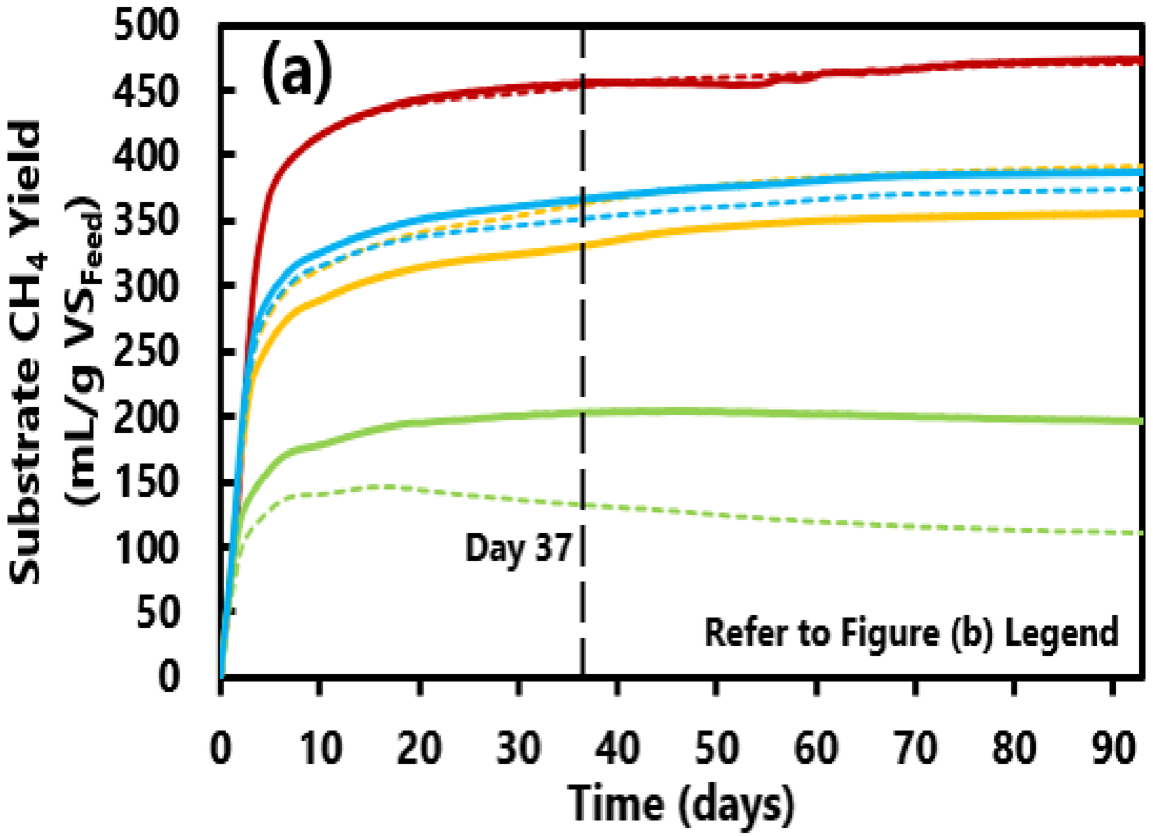
Vortex Mixer

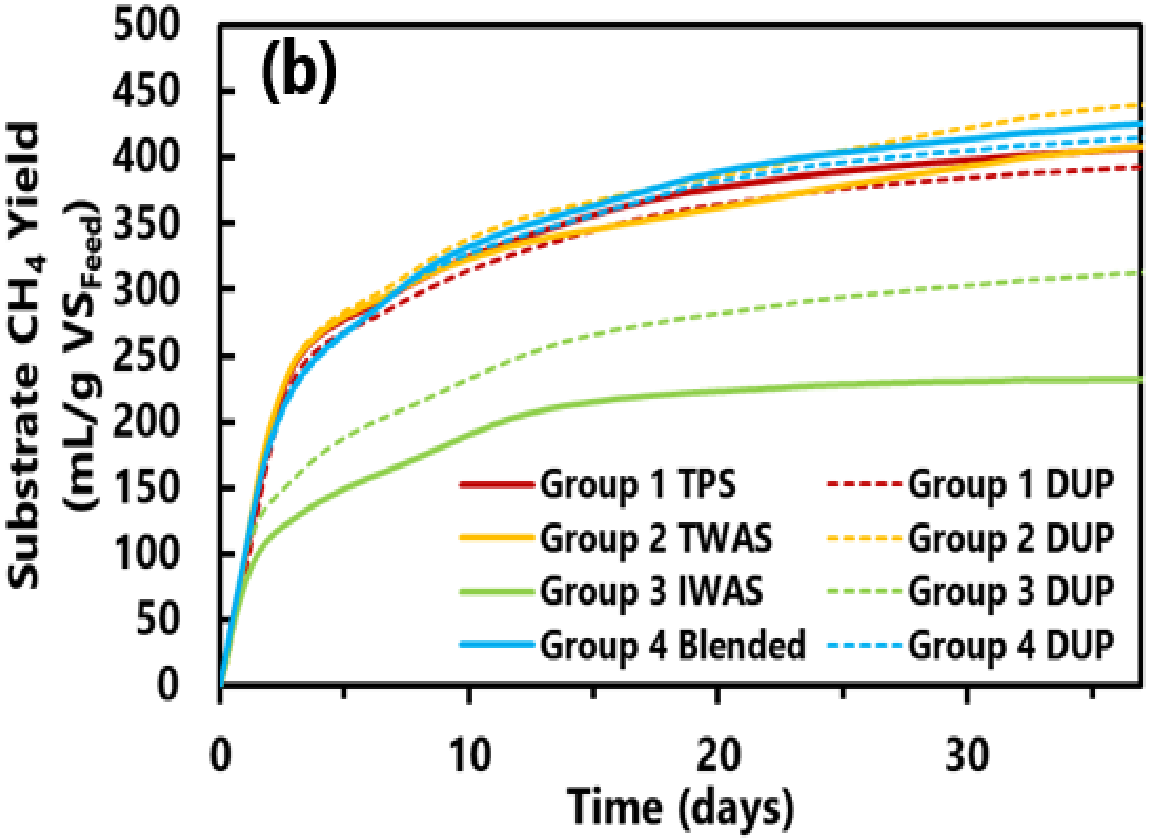
- Developed lab-scale vortex mixer-based friability test method
- Four dried biosolids pellets were used and placed in the centrifuge tube
- Agitated by digital vortex mixer (3000 RPM) for 10 minutes Pellets screened with 1 mm stainless steel mesh sieve
- Weight loss of particles >1 mm quantified as friability
- Particles <1 mm collected for dust particle size analysis



Results and Discussion

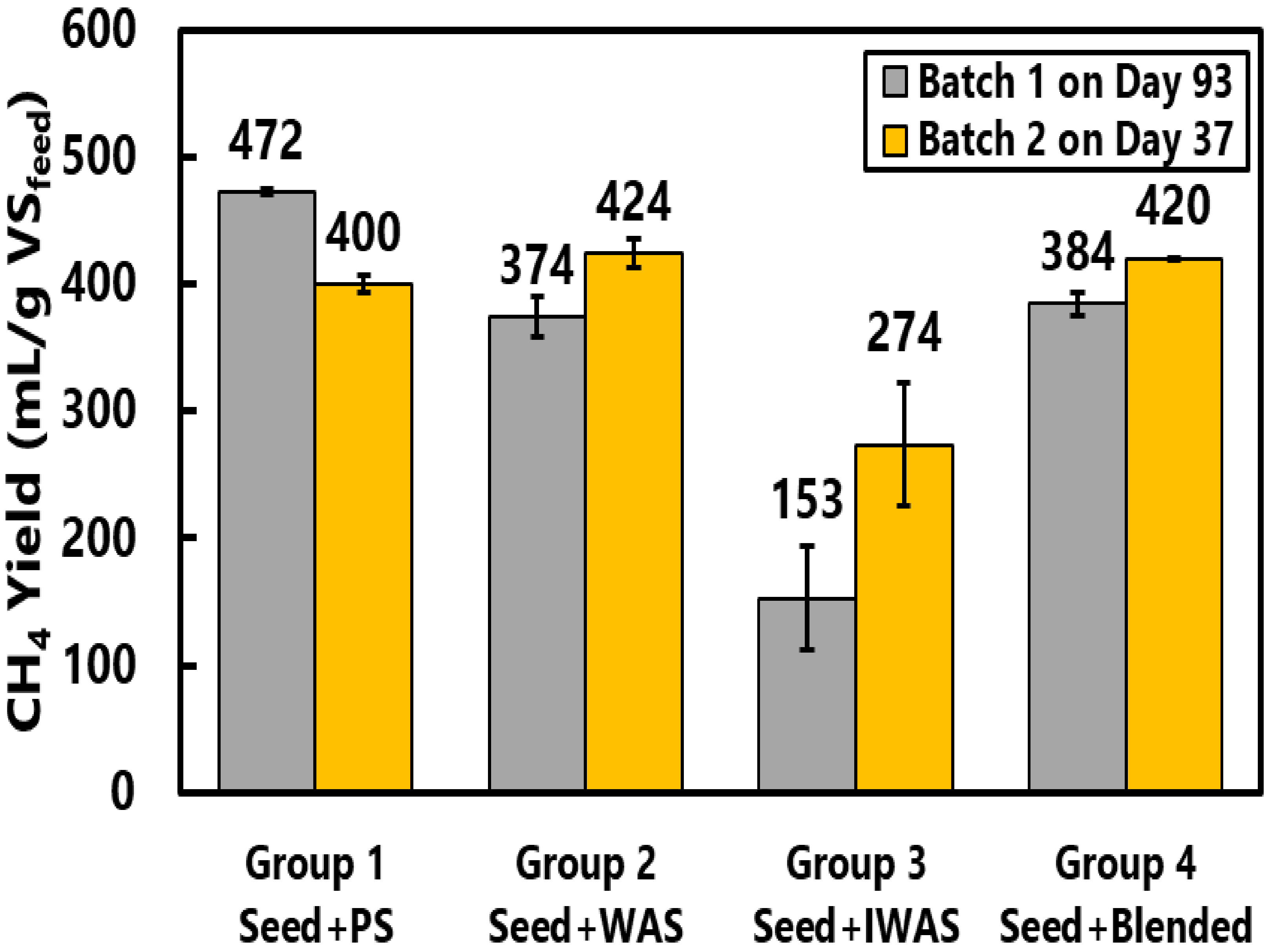
Methane Production





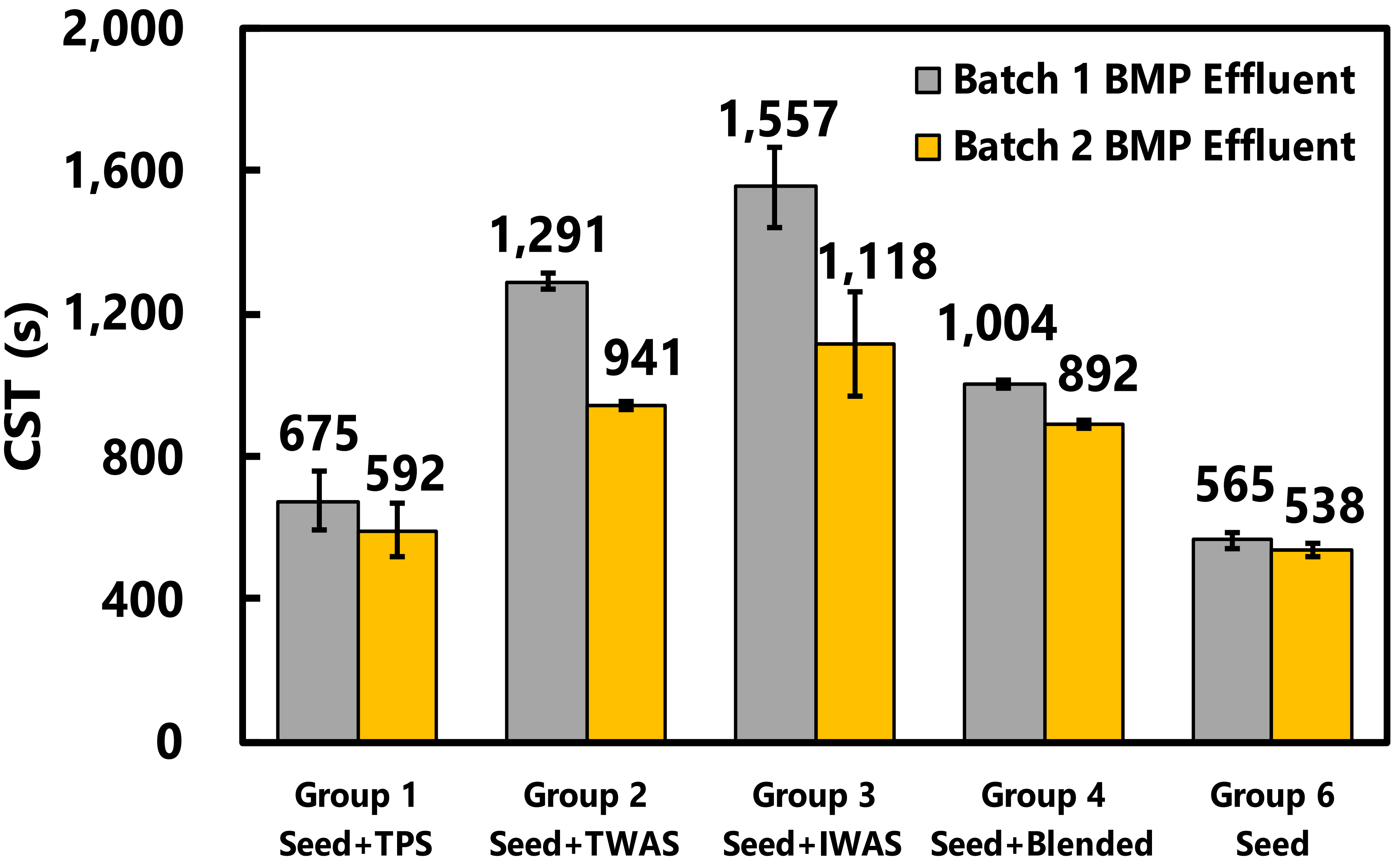
Methane Yield

- TPS and TWAS exhibit good digestibility without THP
- Limited enhancement in digestibility →TPS and TWAS with THP
- IWAS's poor digestibility improves significantly with THP
- THP is most effective on secondary sludge, especially with longer sludge age
- Bench study mitigates risk of abnormal sludge and inhibition



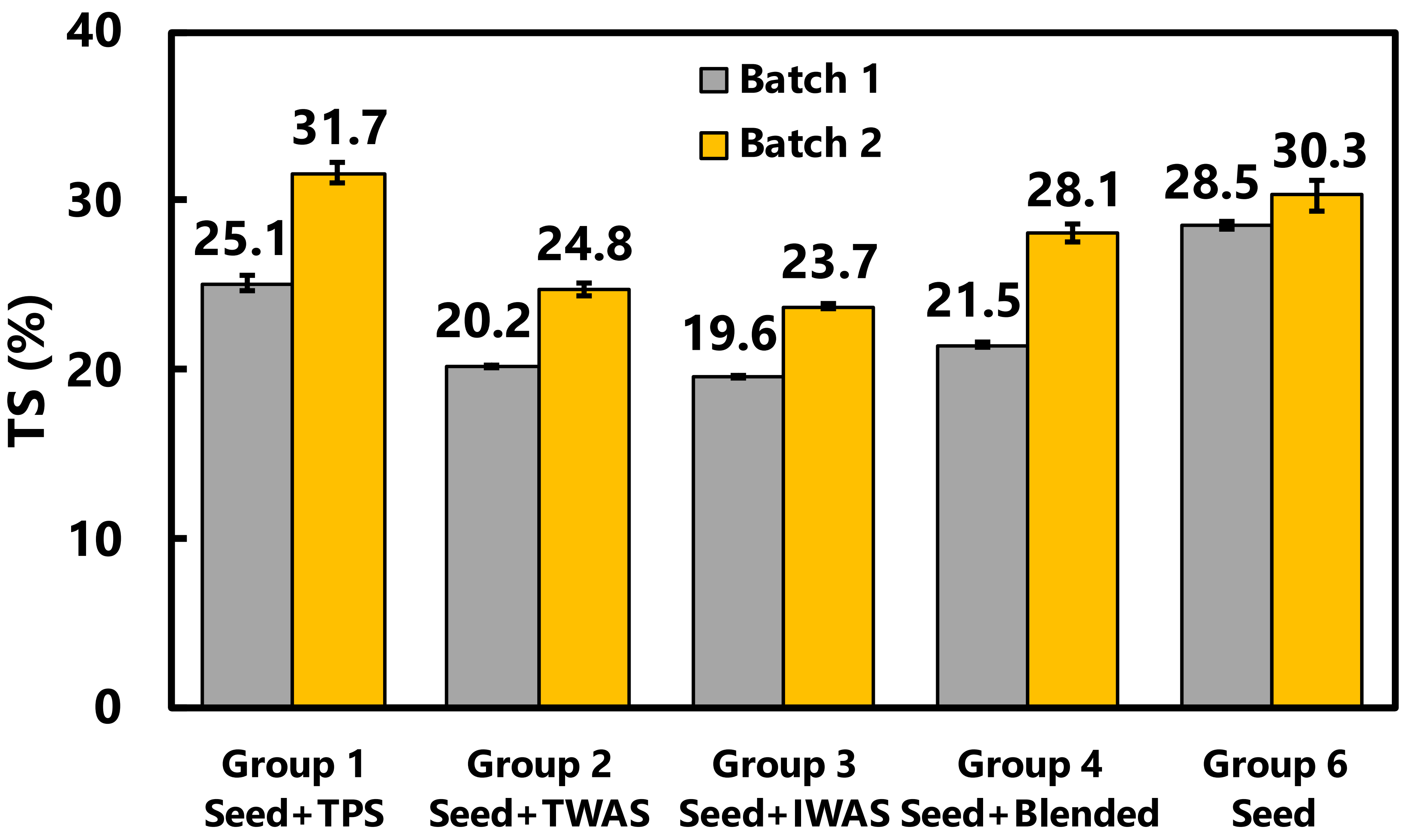
Capillary Suction Time (CST)

- Dewaterability:
  - Primary sludge > Secondary sludge
- THP Improves Dewaterability: → especially secondary sludge
- THP Benefits for Full Scale:
- THP-treated digested sludge can achieve over 30% cake total solids (TS), offering capacity and energy savings for dryers
- Leveraging THP Benefit: MSD could optimize dryer feeding by using high TS% cake while managing dust concerns with a smaller final TS% target



Cake Dryness

- Trends in cake dryness align with CST measurements
- Seed-only group consistency was observed in both batches

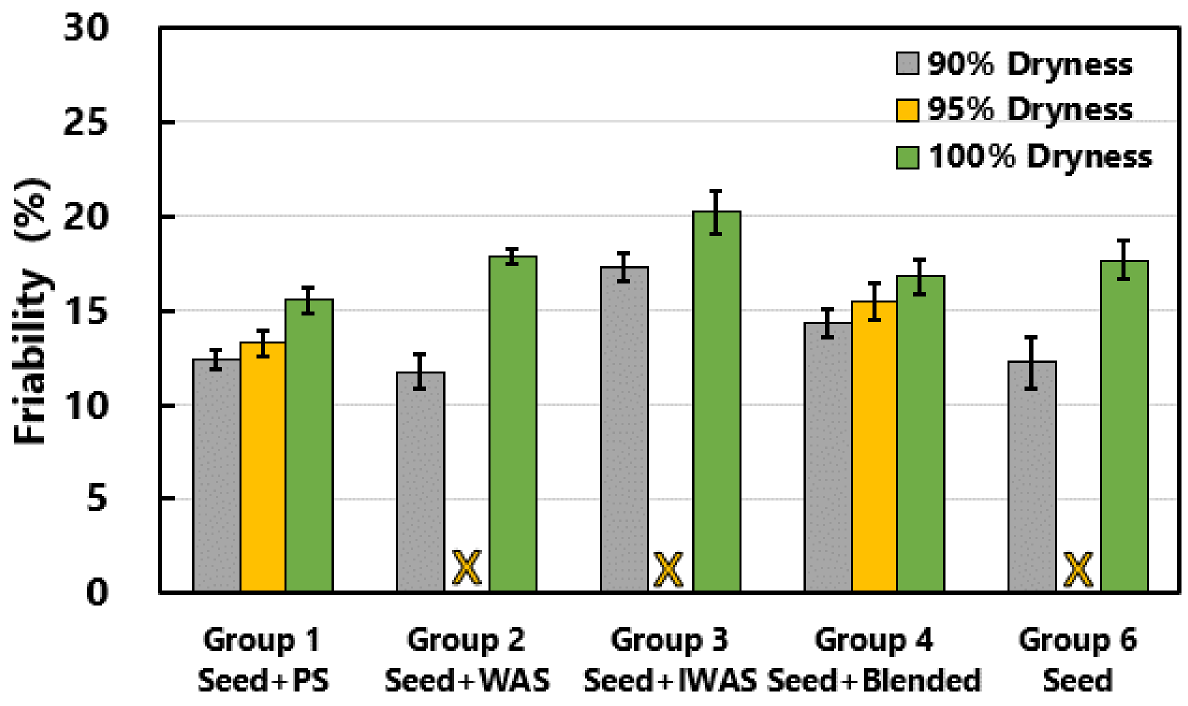


Cake Dryness

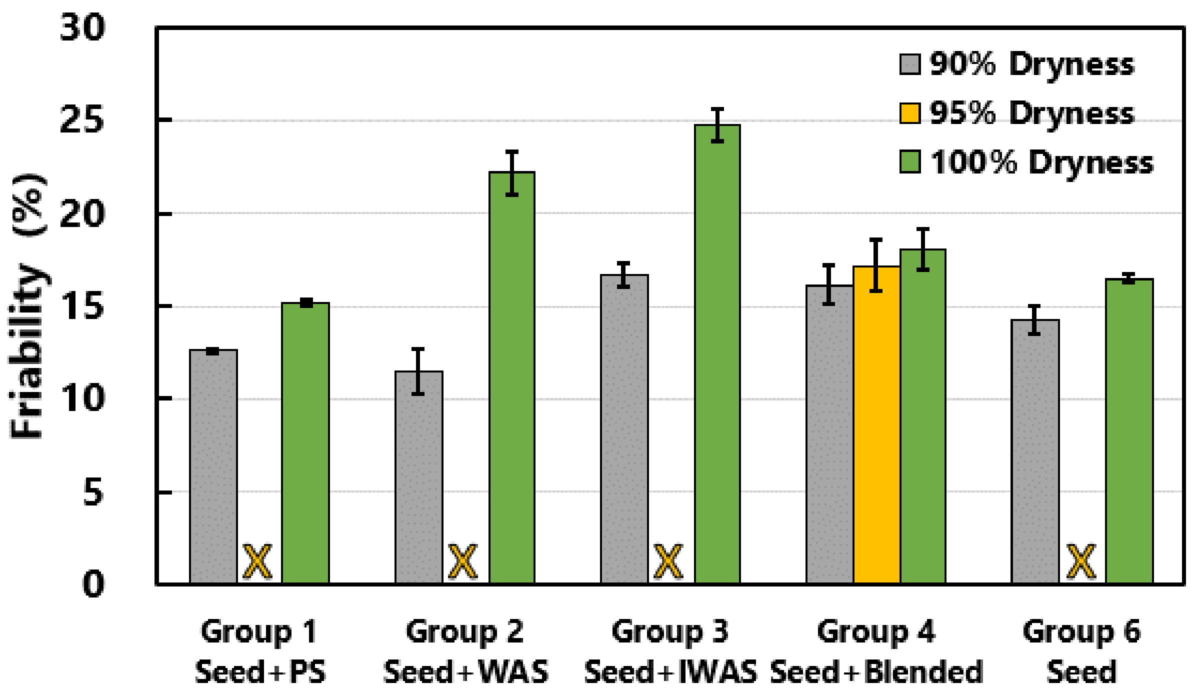
- THP significantly enhanced sludge dewaterability
- Full-scale reports confirm THP's ability to achieve cake TS% over 30%.
- THP's positive impact on dewaterability is supported by the data

Drying Property/Friability

- Dryness and friability of dried biosolid pellets show a positive correlation
- TWAS and IWAS exhibit significant friability increases from 90% to 100% dryness
- IWAS pellets have the highest friability, followed by TWAS, blended sludge, and TPS



Control- No THP



Experimental –
THP Implemented

Drying Property/Friability

- THP Impact on Friability:
  - No effect on friability of digested primary sludge
  - Increased friability of digested secondary sludge after THP treatment
  - Suggests increasing primary sludge ratio improves pellet structure integrity
- Pellet Dryness and Friability:
  - Pellet dryness or heat input affects product friability
  - Friability increases with higher pellet dryness target
  - Reduction from 95% to 90% dryness compensates THP-induced friability in blended sludge

Hypothesis/Goals Check

- THP (thermal hydrolysis pretreatment) will have the following effects:
  - Improve digestibility
  - Improve dewaterability
  - Increase friability of thermally dried biosolids pellets
- **Hypothesis mostly supported – TPS had better BMP for control group**

Stantec

msd
Safe, clean waterways

VIRGINIA TECH

Questions?