

Northeast Residuals and Biosolids Conference 2014

Full-Scale Case Study of Rapid Volume Expansion of Digester Contents

October | 2014



Acknowledgements

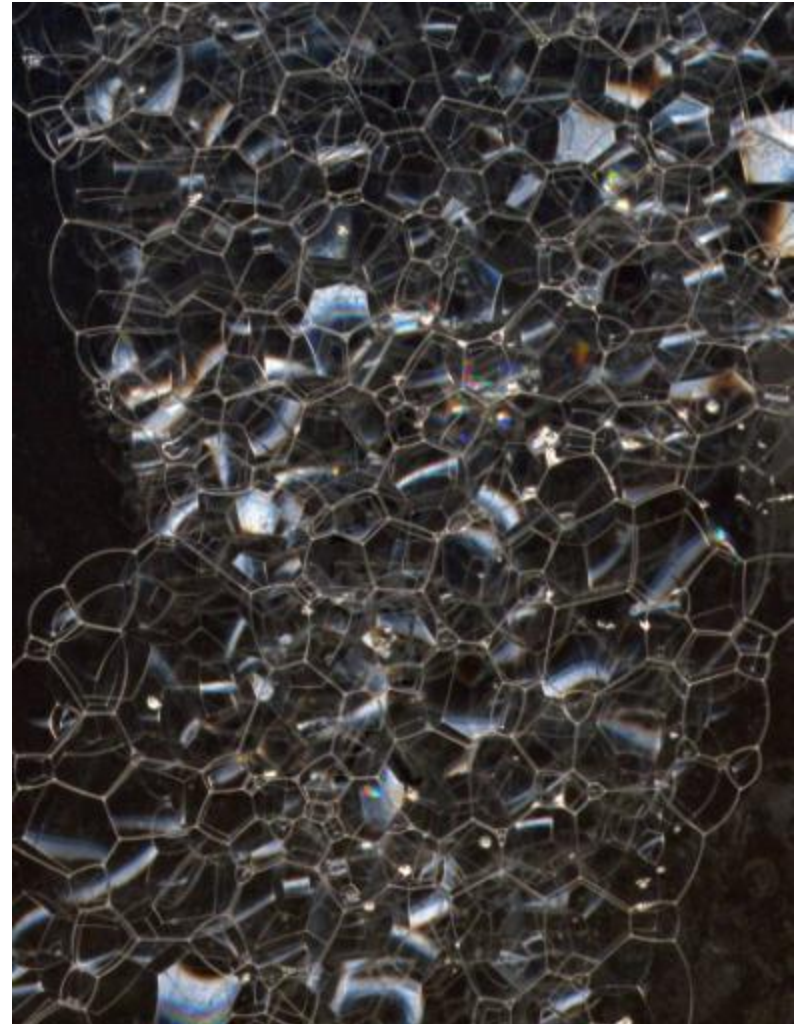
- Tom Chapman – Brown and Caldwell- Tucson, AZ
- Steve Krugel – Brown and Caldwell- Seattle, WA

Agenda

- What are we talking about when we say rapid volume expansion? Is it foaming or something else?
- What factors can influence events?
- Example events at the Brightwater WWTP in Woodinville, WA.
- Design modifications to manage events.
- Take homes

What is Foam?

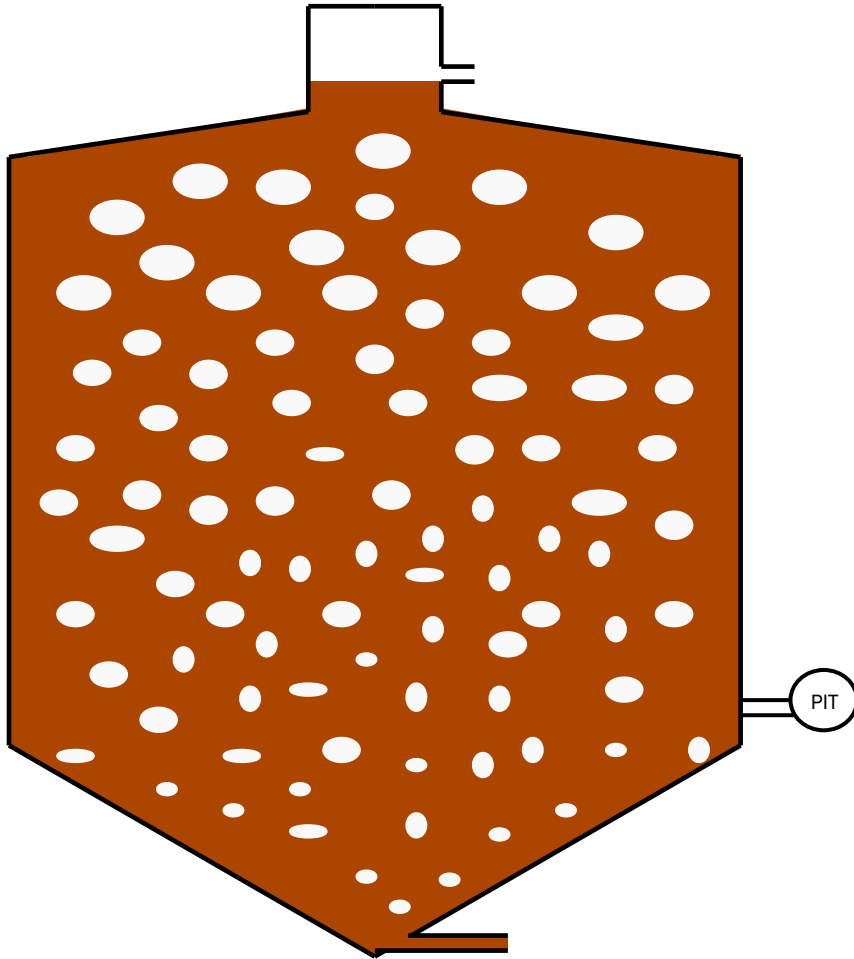
- Gas bubbles entrapped in the liquid matrix
- Surface tension and capillary forces stabilize foam bubbles
- Foaming increases when the surface tension of the liquid is reduced (increased bubble stability)
- Foaming agents (surfactants) increase foam formation
- Foam bubbles collapse when liquid drains by gravity



Foam in Digester Reduces Available Headspace

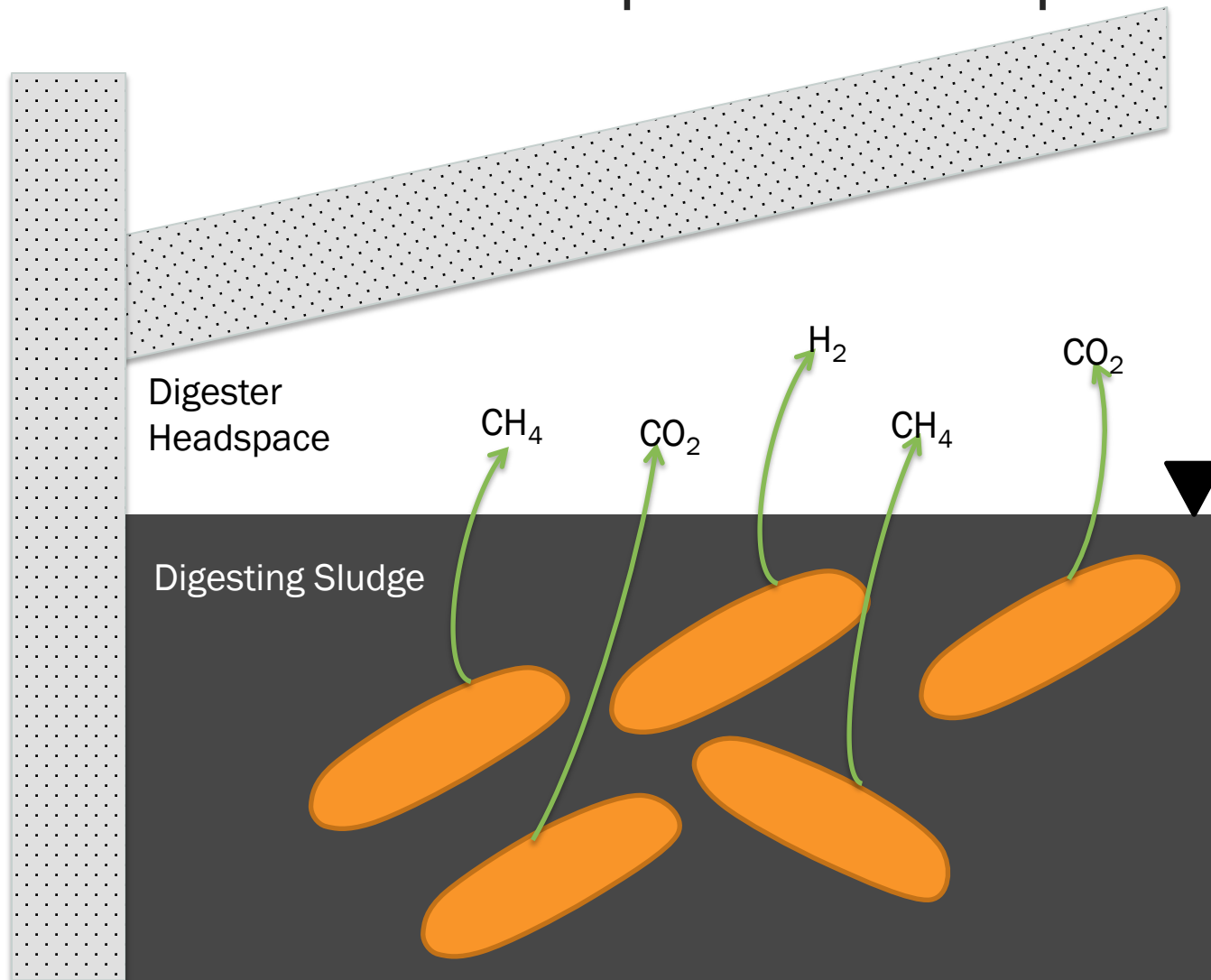


Why is digester volume expansion not foaming?

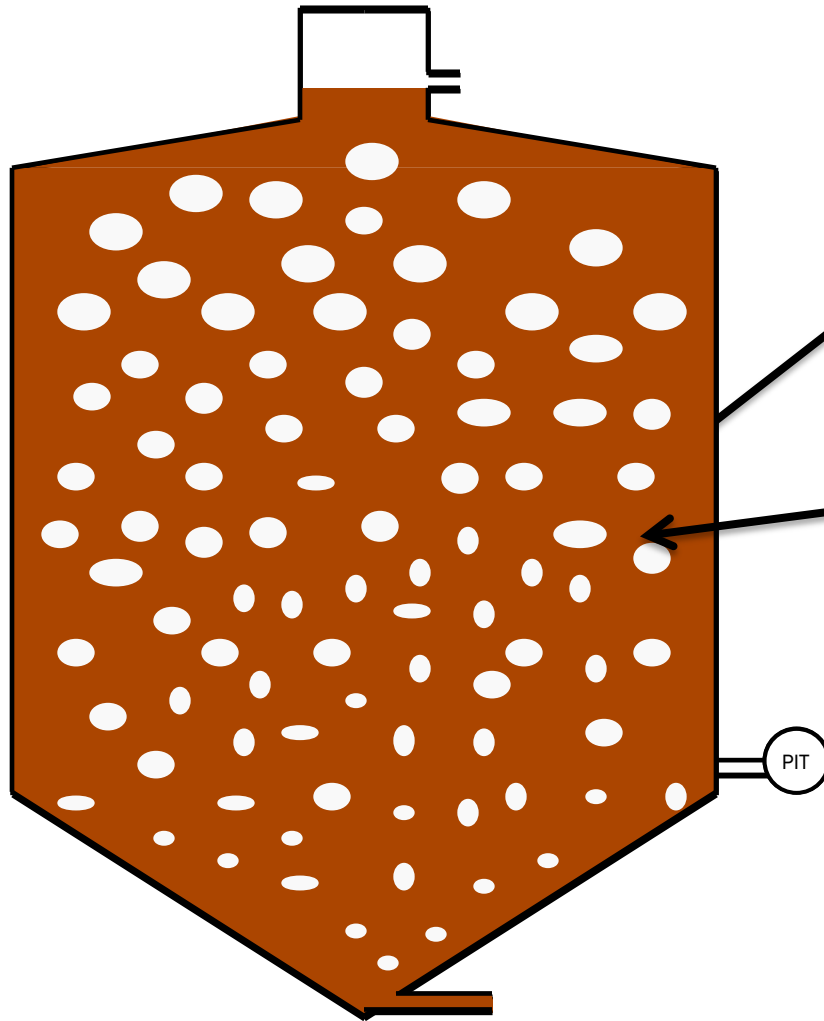


- Digester volume expansion is caused by changes in digester gas holdup
- In some cases, an apparent foaming event is actually caused by expansion of the digester contents
- Rapid volume expansion can present a significant risk to digester and operator safety

During normal digester operations gas generation and evolution to the headspace are at equilibrium



Principals of digester gas hold-up and volume expansion



Typical Digester Operation:
Gas production and
conveyance to headspace is
at steady state

When conveyance and
production are out of balance

Examples of gas hold up in liquids



Bubble Hydrodynamics – The Science of Gas Holdup

- Sludge Characteristics that impact/result in slow bubble rise rates
 - Size: Small bubbles rise slower than large ones
 - Viscosity: Digester sludge is viscous, behaves as a viscoplastic, reduced viscosity with increase shear stress (mixing)
 - Surface tension: Surfactants present in digesters reduce surface tension
 - Pressure: Tall digesters have higher pressures near the bottom
 - Particles: Grit and solids in the digester will impact bubble size

Improved digester design, increased process efficiency has made this an issue



Hyperion 1952

Hyperion 2010



WAS and Filaments

- Foam trapping allows accumulation of Nocardioforms
- Hydrophobic surface causes attachment to air bubbles

(Source: Parker et al, WER, Vol 86, No 6, 2014)

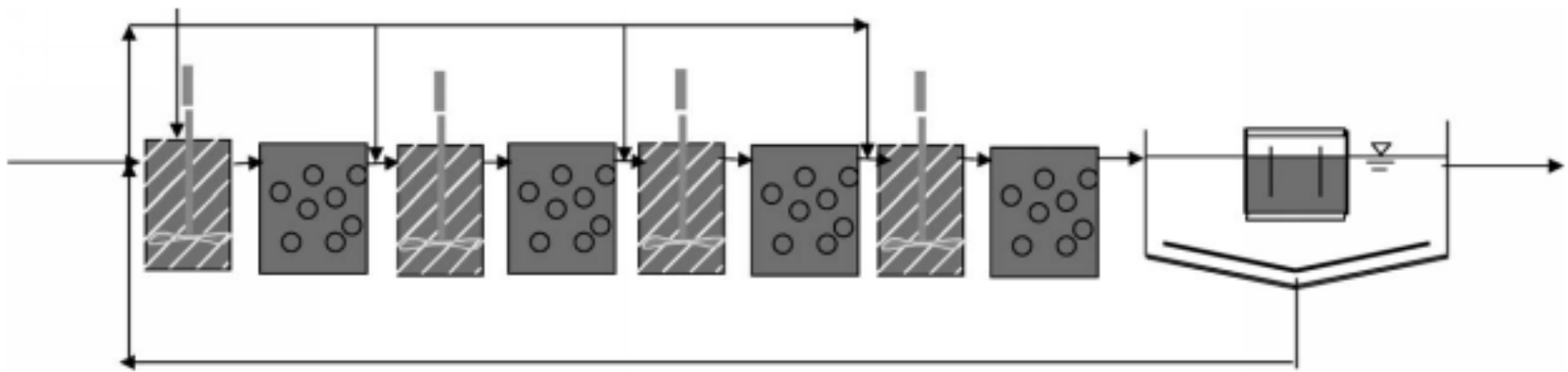
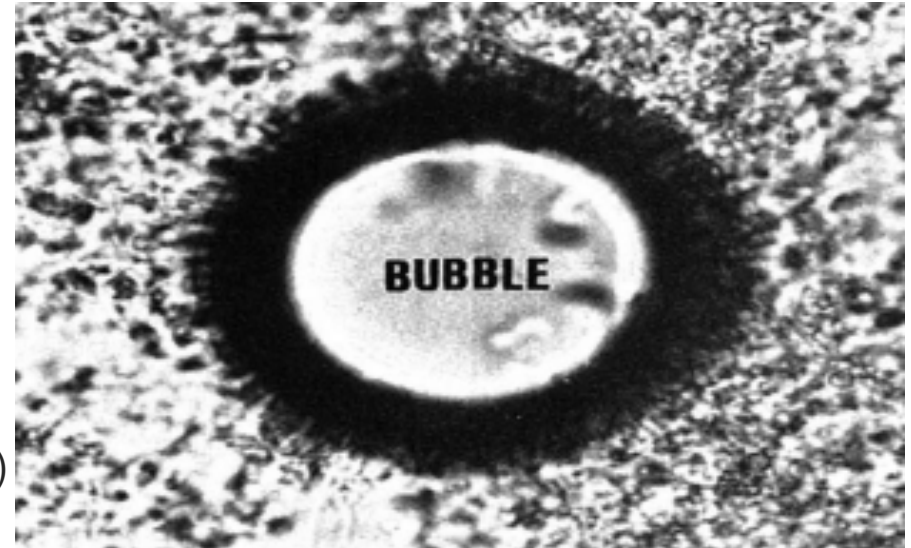


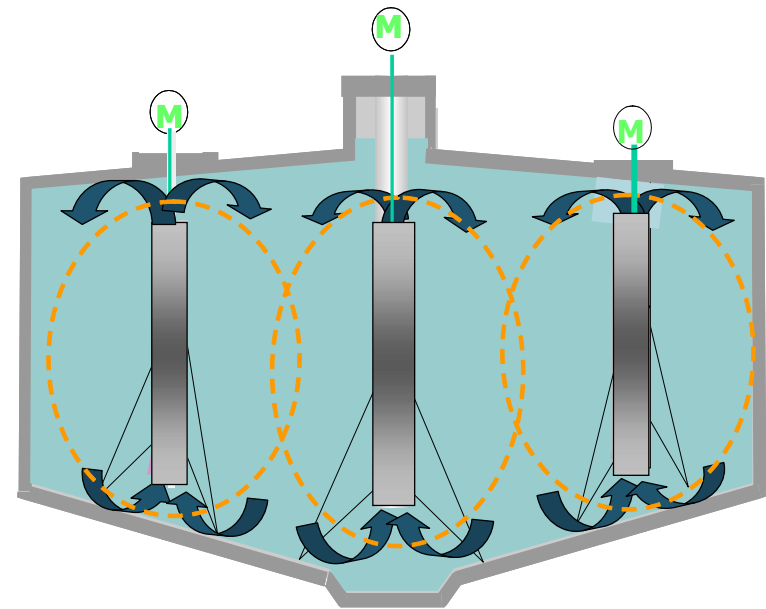
Figure 10—Step BNR flowsheet for nitrogen removal requires introduction of seven baffles in a four-pass tank.

Digester Operation Influences Gas Holdup

- Changes in gas holdup impact the volume of digester contents
- Common causes of volume expansion are related to digester operation:
 - Digester feed rates
 - Digester mixing intensity
 - Power outages
 - Scum addition
 - And more...
- It is unlikely we can eliminate or prevent all volume expansion events

Example - Sudden Changes in Mixing can Cause Volume Expansion

- Several documented cases of volume expansion following a sudden change in mixing
- Changes in mixing direction can cause a sudden shift in gas holdup resulting in a dramatic change in liquid level



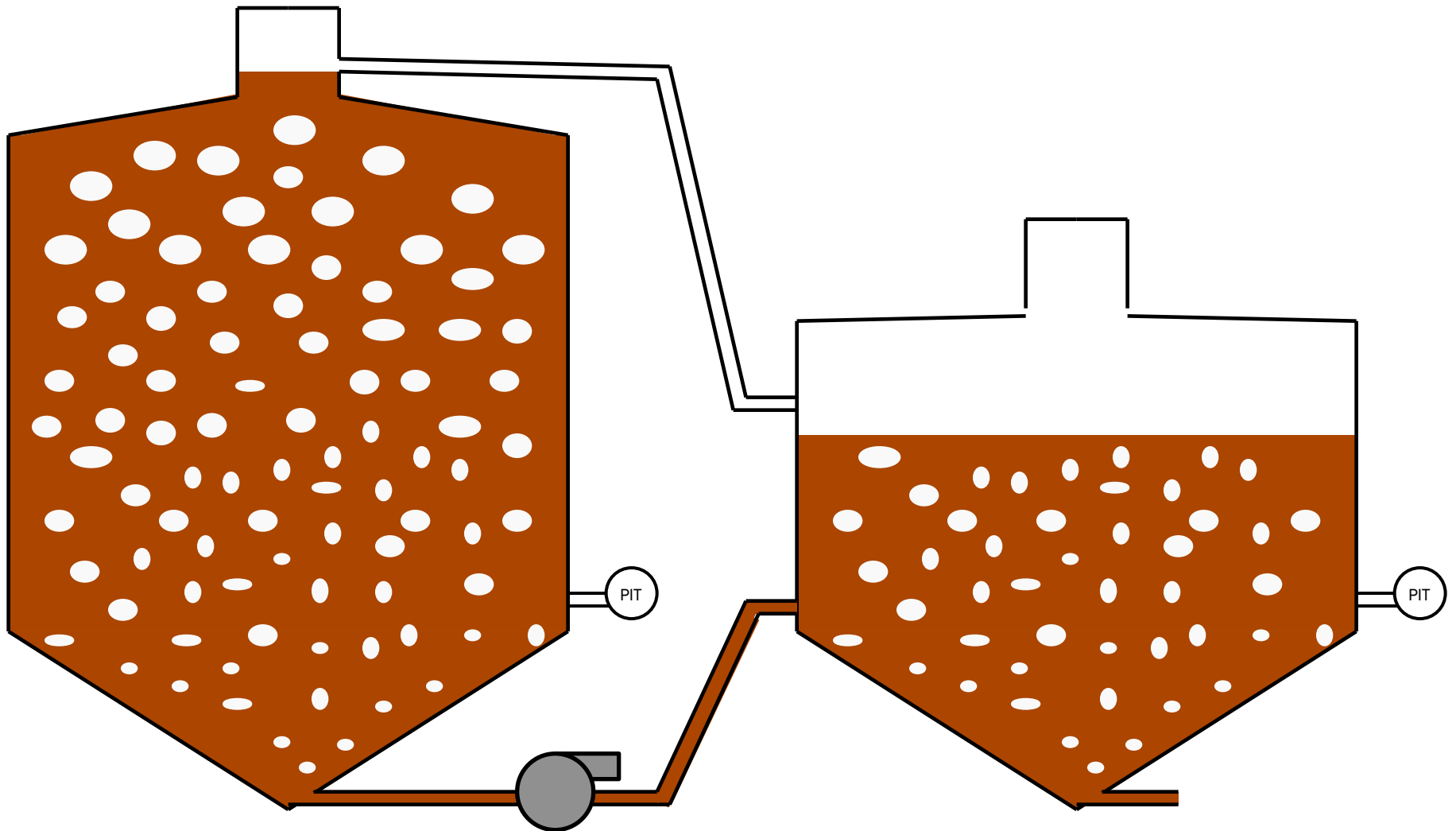
Brightwater Digesters Info

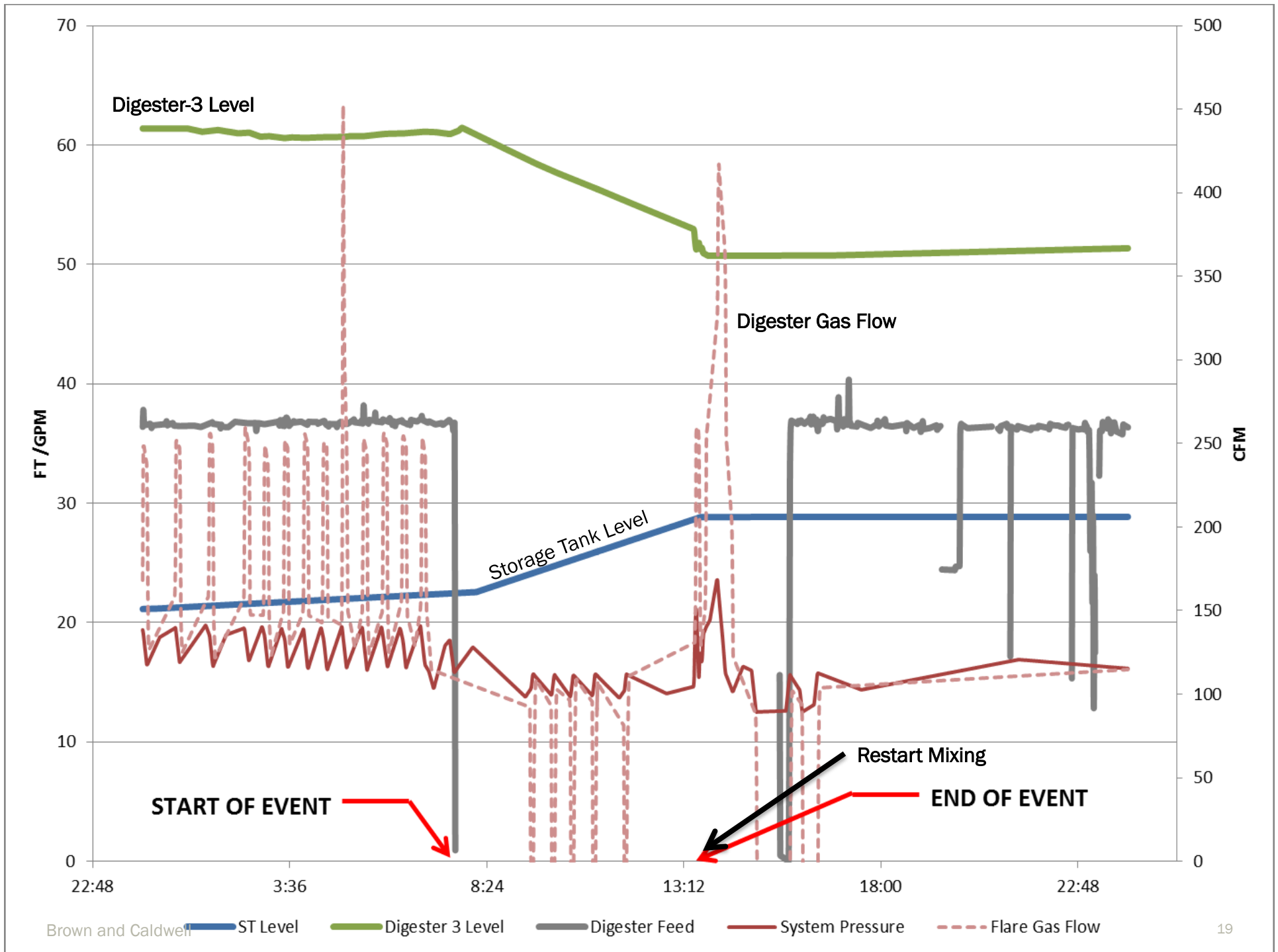
- Modern digester design
- Similar to an egg shaped digester but lower construction cost (Modified Silo)
 - 3 digesters, 1.25 Mgal each
 - 1 storage tank, 790kgal
 - Diameter 59 ft
 - Digester SWD 65 ft



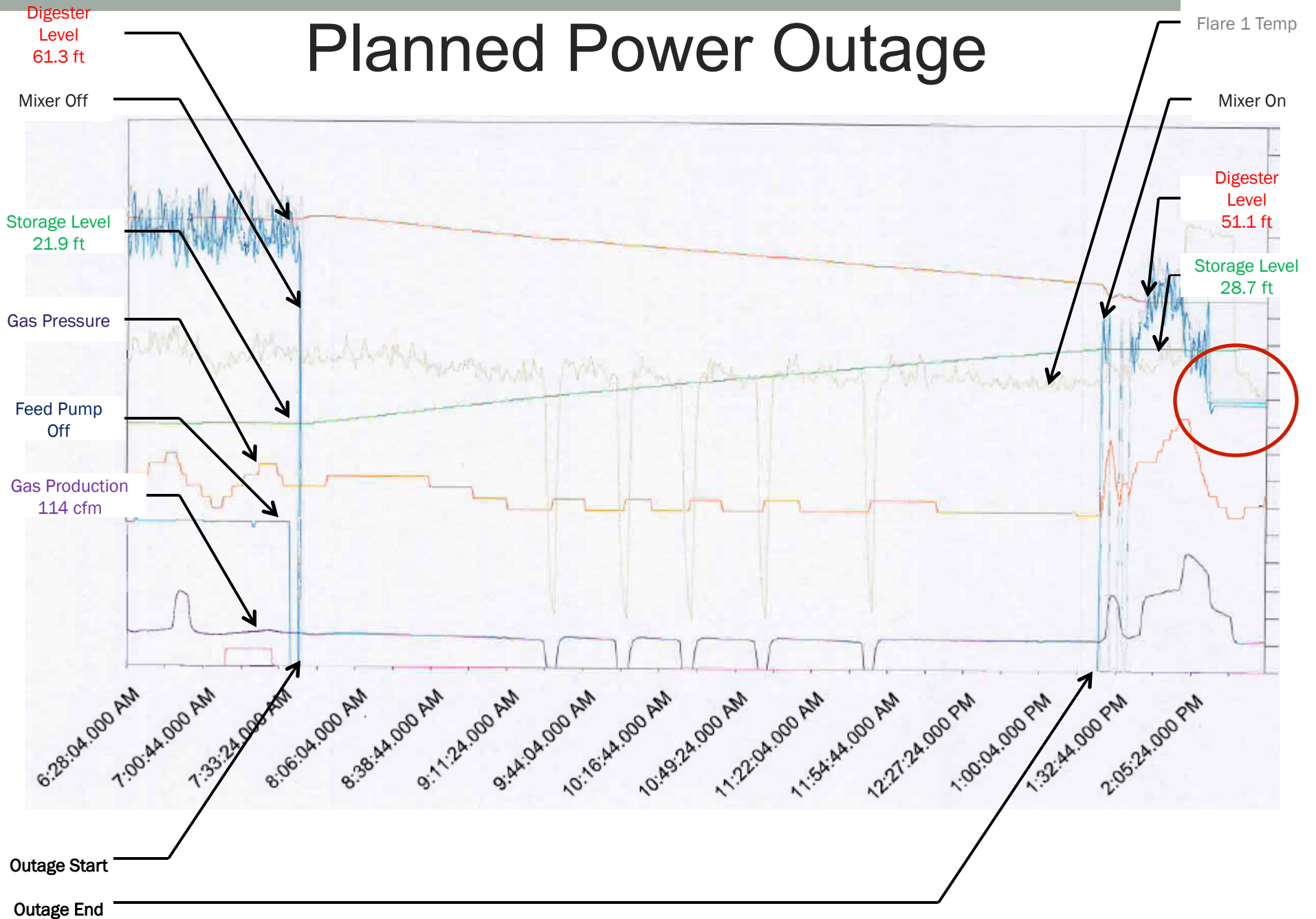


Brightwater WWTP digestion process





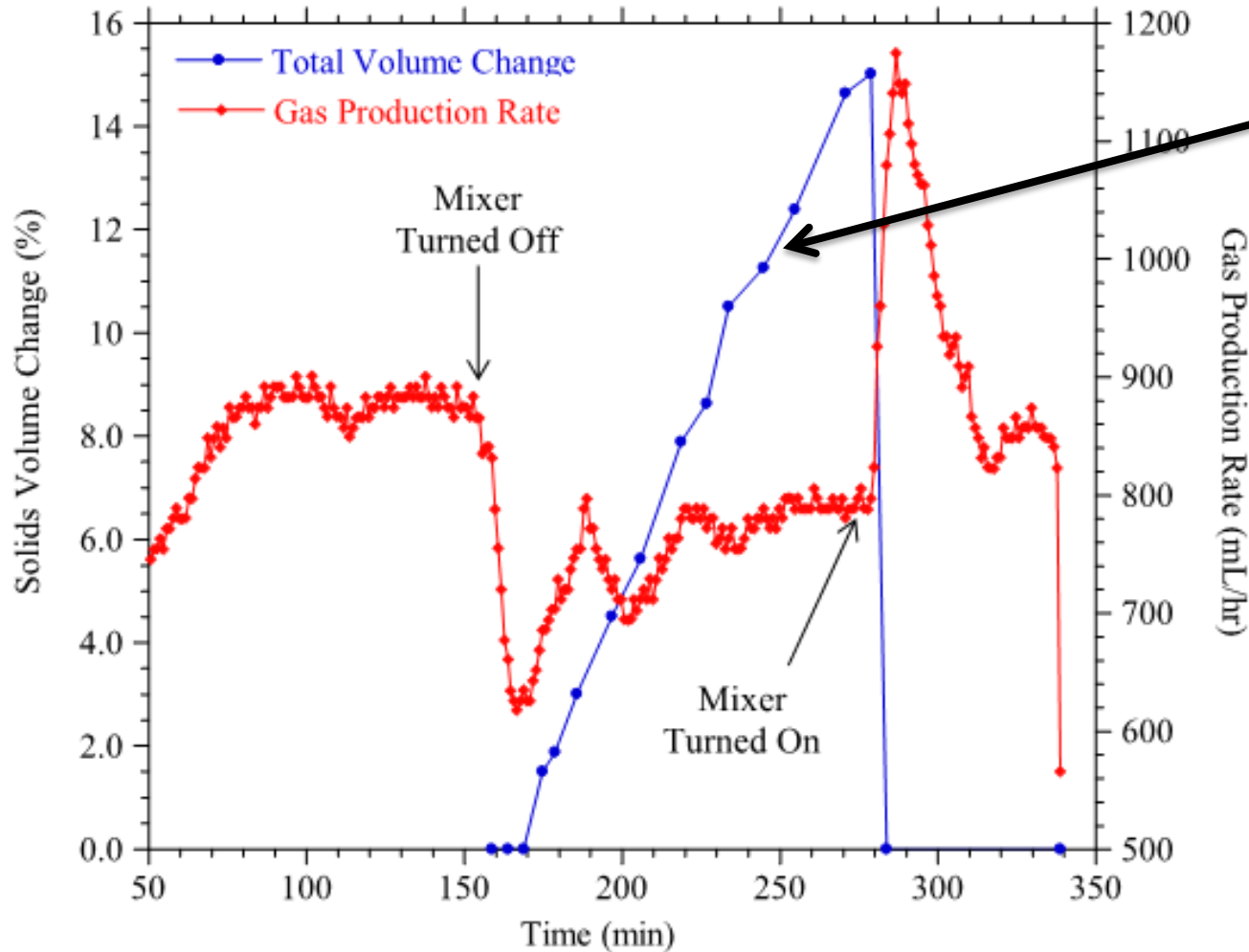
Planned Power Outage



6-Hour Power Outage Statistics

- Density change due to gas holdup
 - Start density near water: SG = 0.92
 - End density lower than water: SG = 0.77
- Volume transferred:
 - 140,000 gal, 11% of digester active volume transferred to Blending Storage tank
 - 400-500 gpm transfer rate

New Research: Laboratory scale supports the full scale observations



Measured liquid surface level in clear Plexiglas reactor

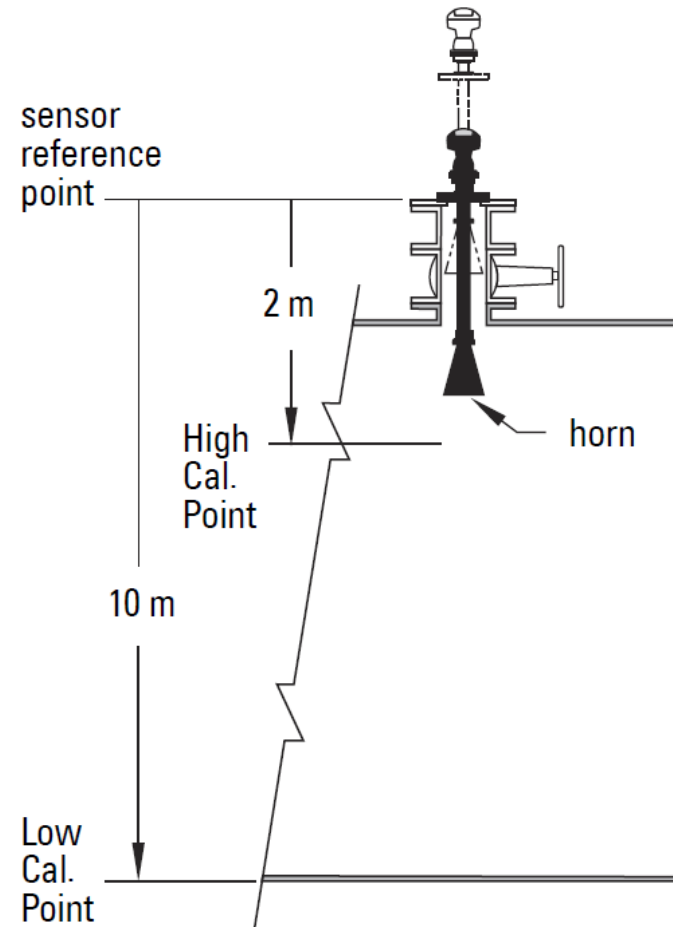
Source: Higgins et al (2014) Proceedings of the WEF Residual and Biosolids Conference

Digester Modifications During Commissioning

- Verified existing overflow capacity was sufficient – Yes, it was!
- VFD operation of digester mixers - slow changes in mixer speed and direction
- Radar level monitoring – accurate surface/liquid level monitoring



Surface Level measurement

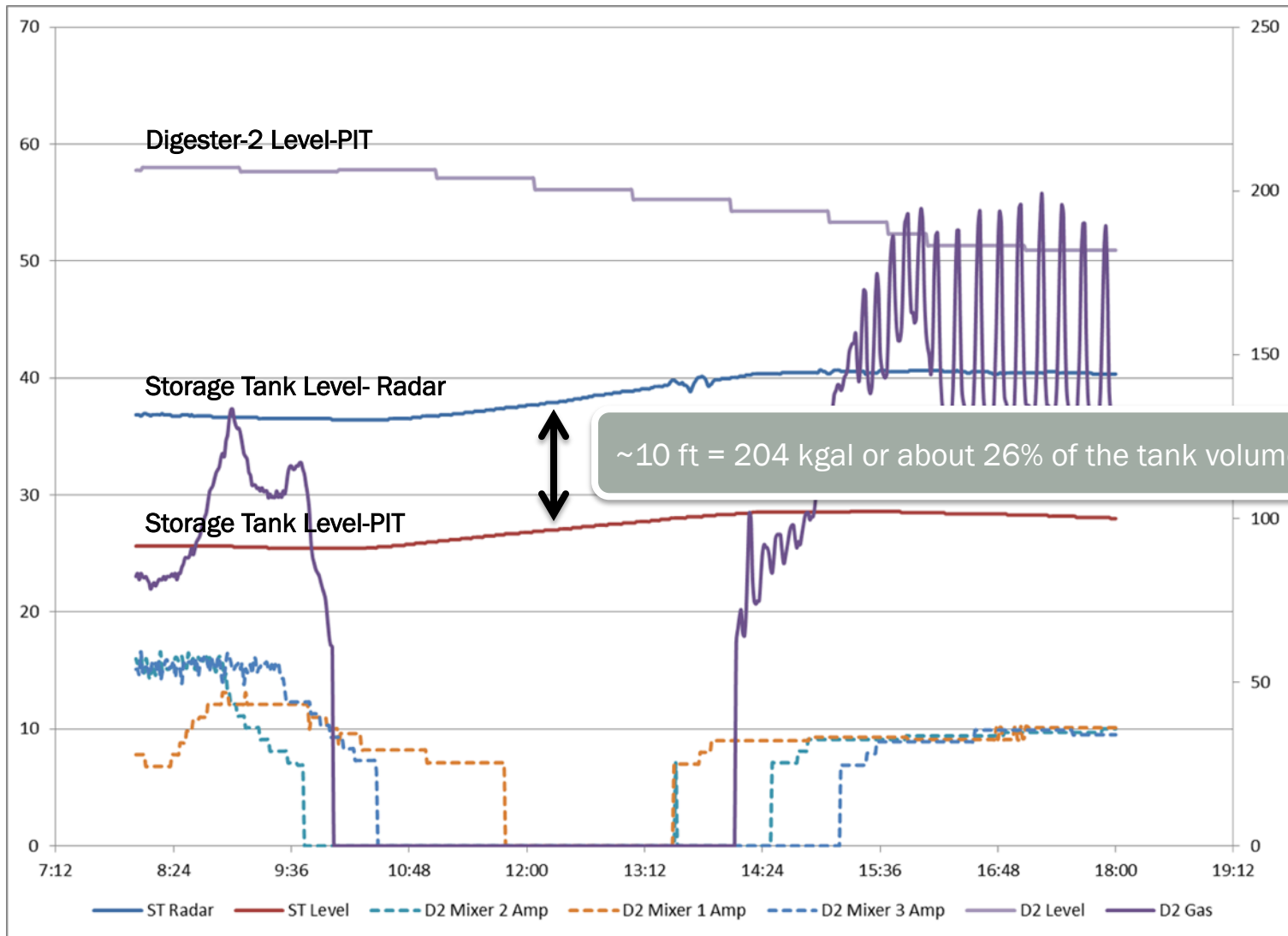


Verifying Radar Accuracy

- Verified with tank level measured in the sample hatches
- Accuracy measured within 1%



Radar shows the true digester level



Take Home Message

- DESIGNERS:
 - Consider rapid volume expansion in future digester designs
- OPERATORS:
 - Be aware of rapid volume expansion during operations and maintenance activities
- I would be interested in hearing about experiences from your plants





Thank You

Christopher Muller, PhD, P.E. (WA)
Brown and Caldwell, Andover, MA
cmuller@brwncald.com
978-983-2059