

Advanced, Low-Cost, System for Algae Dewatering

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Can membrane filtration produce algae paste?

Common skeptical reactions:

- Really? Producing algae paste? At steady state?
- Wouldn't it get clogged stopping filtration?
- How high concentration can it really produce?
- Wouldn't it get fouled?
- It probably won't last very long and be very expensive.

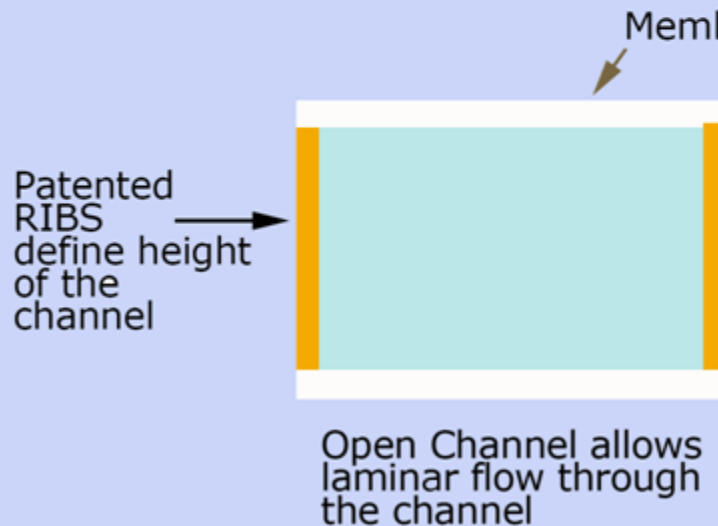
These reactions are based on common membrane formats:
Spiral modules, cassettes, and hollow fiber bundles

Issues with conventional membrane modules:

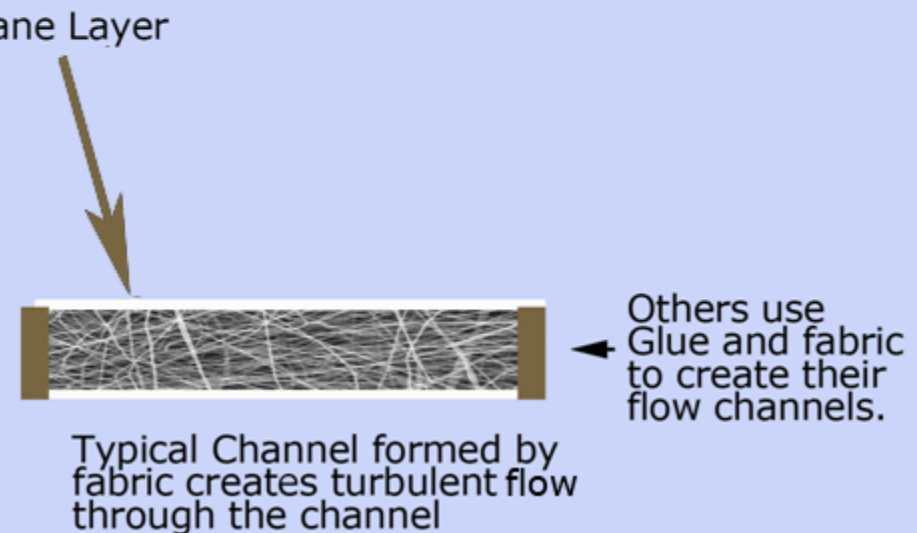
- Spiral wound modules and cassette modules use porous spacer between membranes that can clog
- Hollow fiber bundle modules and others formats have inherently non-uniform flow distribution with different fluid flow path lengths from inlet to outlet
- Non uniformities cause flow channeling and dead spots where solids start to accumulate, cause high pressure drop and eventually clog
- High solids content algae compounds non-uniform flow

SmartFlow Technologies' Patented "Open Channel" Membrane Module Technology

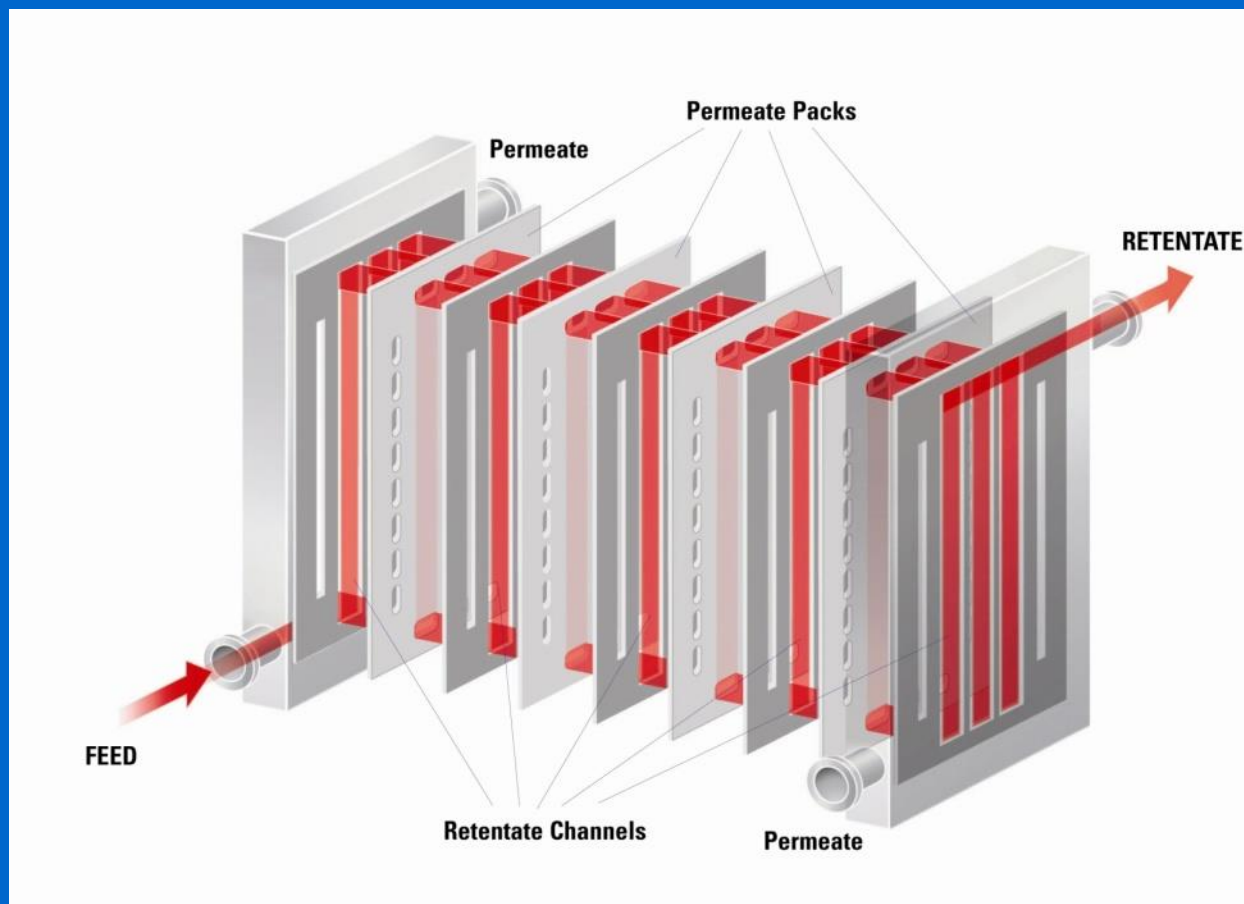
SmartFlow Design



Traditional Design- Cassettes and Spirals



Flow pattern in SmartFlow membrane modules



<https://youtu.be/xO9gdckMOck>

Advantages of SmartFlow Membrane Modules

- Uniform flow velocity over all of the membrane surfaces
 - Utilizes 100% of membrane surface area
 - Provides equal filtration performance in all membrane areas
- Equal fluid path length in all flow channels - Equal flow resistance for each fluid element passing through the module
 - Avoids channeling and dead spots
- Increasing channel height with increasing solids concentration
 - Easily handles fluids with high solids content, high viscosity
 - Allows producing high solids content algae concentrates
- Three interacting controllable factors determine TFF efficiency and permeate flux rate - Channel Height, Shear (velocity), and Feed Pressure

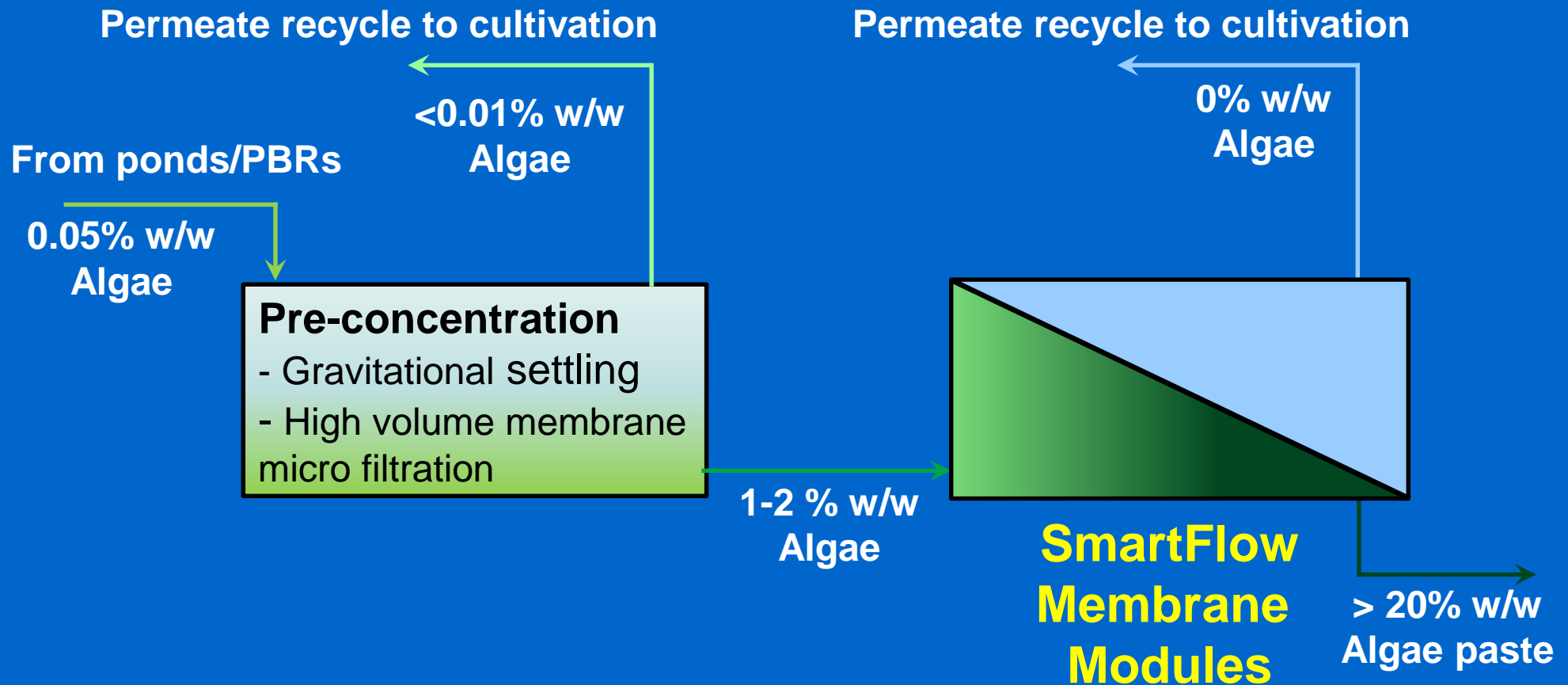
SmartFlow Technologies Membrane Modules



ConSep 11000 Module – 11 Feed side channels

- Commercial technology with large scale systems built
- Systems with $> 1,000 \text{ m}^2$ membrane area in different applications
- Large selection of membrane materials (MF, UF, NF, RO; RC, PES, PVDF)

Techverse 2-Step Algae Dewatering Process





U.S. DOE SBIR Phase II Project

Techverse, Inc.
Advancing Energy Technologies



Year 1

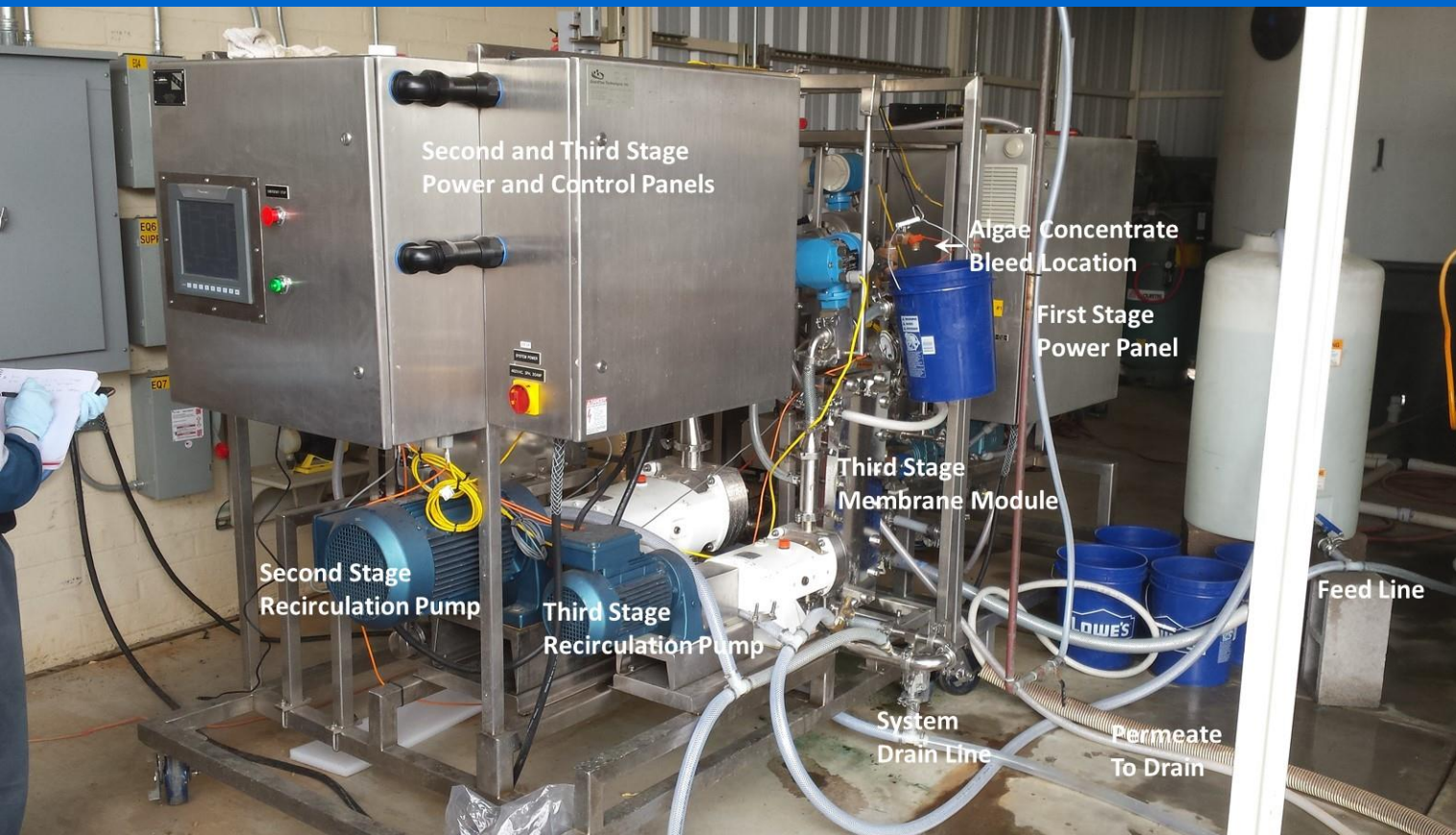


Year 2

DOE Financial Support Acknowledgement

Financial support from the U. S. Department of Energy, Office of Science, for the SBIR Phase II project (Award # DE-SC0013737) for the work presented here is gratefully acknowledged.

Membrane 3-stage algae dewatering system



- Feed rate - 100 L/h
- Feed ~ 0.5-2% w/w
- Product - >20% w/w
- No. of stages – 3
- Total membrane area - 3.8 m²
- Testing at AzCATI

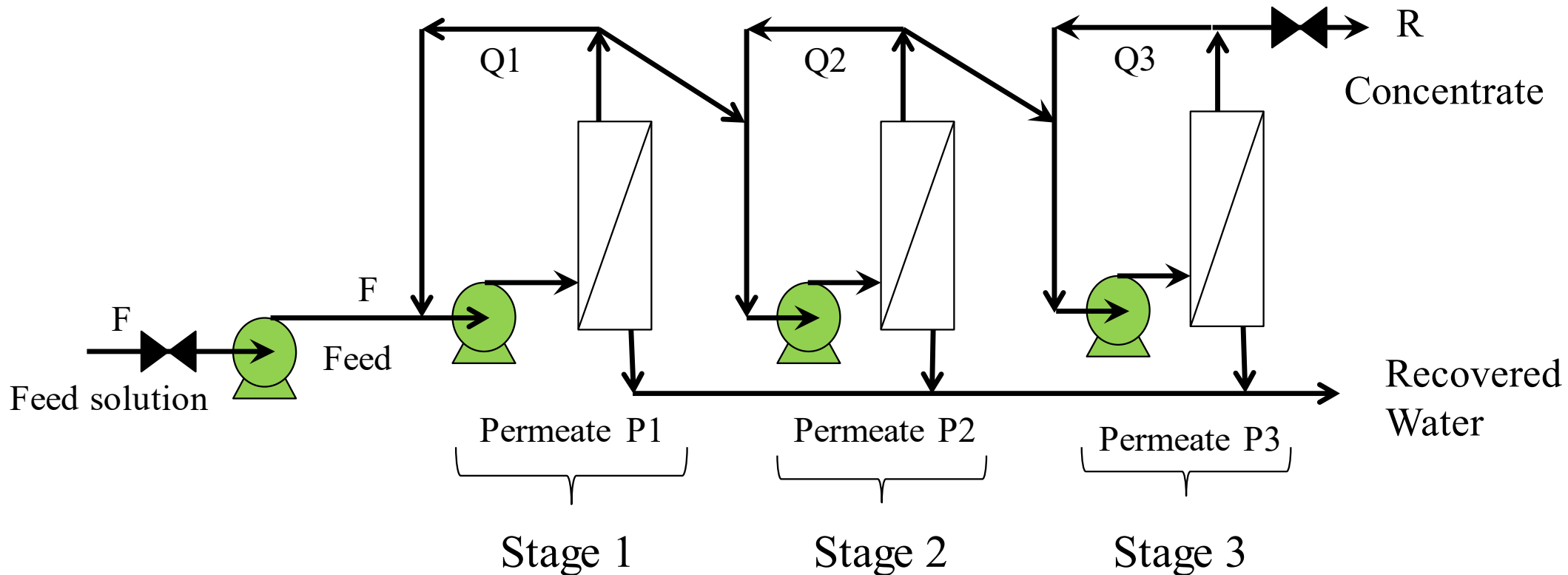
Front View

Membrane 3-stage algae dewatering system – cont.

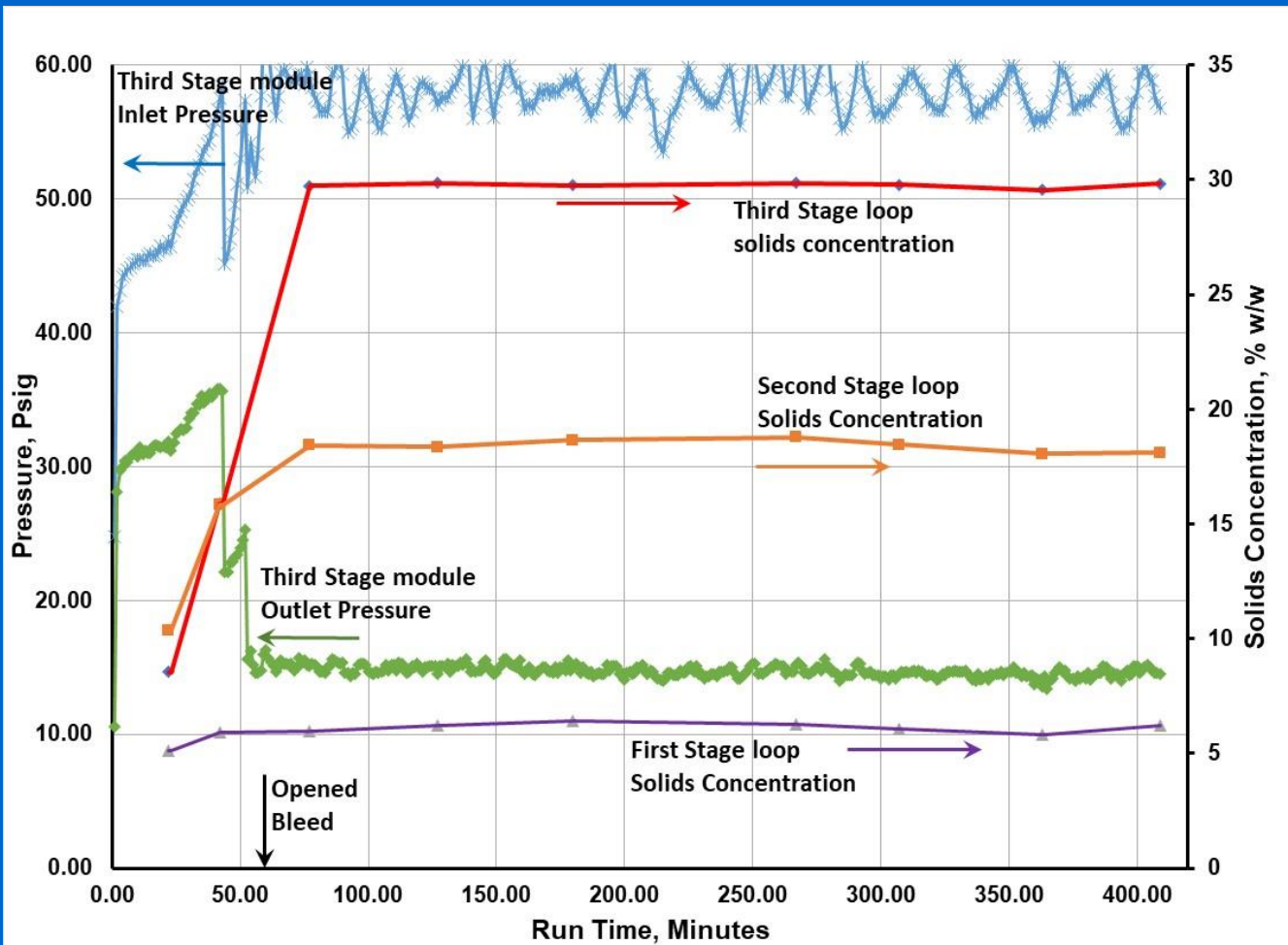


Back View

Membrane 3-stage system schematic



Typical dewatering process



Feed rate - 100 L/hr

Feed conc. – 2.2% w/w

**Steady state output
Paste conc. – 30% w/w**

Summary of Year 1 Algae Dewatering Tests

- Eight different algae species of commercial interest
- Algae production and Pre-concentration by AzCATI
- Total of 17 runs – feed concentrations 0.3 – 2.2% w/w
- Paste concentration – 21% w/w to 36% w/w depending on algae species, growth conditions, feed rate, feed concentration, stage pressures, bleed rate
- Permeate – clear, algae-free in all runs
- Cleaning protocol restored membrane performance

Year 2 Plans

- Demonstrate pilot-scale, continuous, long term (>24 hours), algae dewatering in commercial facilities
 - Proprietary algae strains and growth processes
 - Pre-concentration by gravitational settling or high volume microfiltration
- Detailed techno-economic and energy analysis
- Discussions are ongoing for commercial on-site trials for different applications

Videos of Algae Paste Collection



<https://youtu.be/Niu-wRooOgM>



https://youtu.be/c7rBYl_9Yso

More information? Questions?

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