The Northeast Residuals & Biosolids Conference

Lab-Scale Thermophilic Startup Influencing Full-Scale Startup

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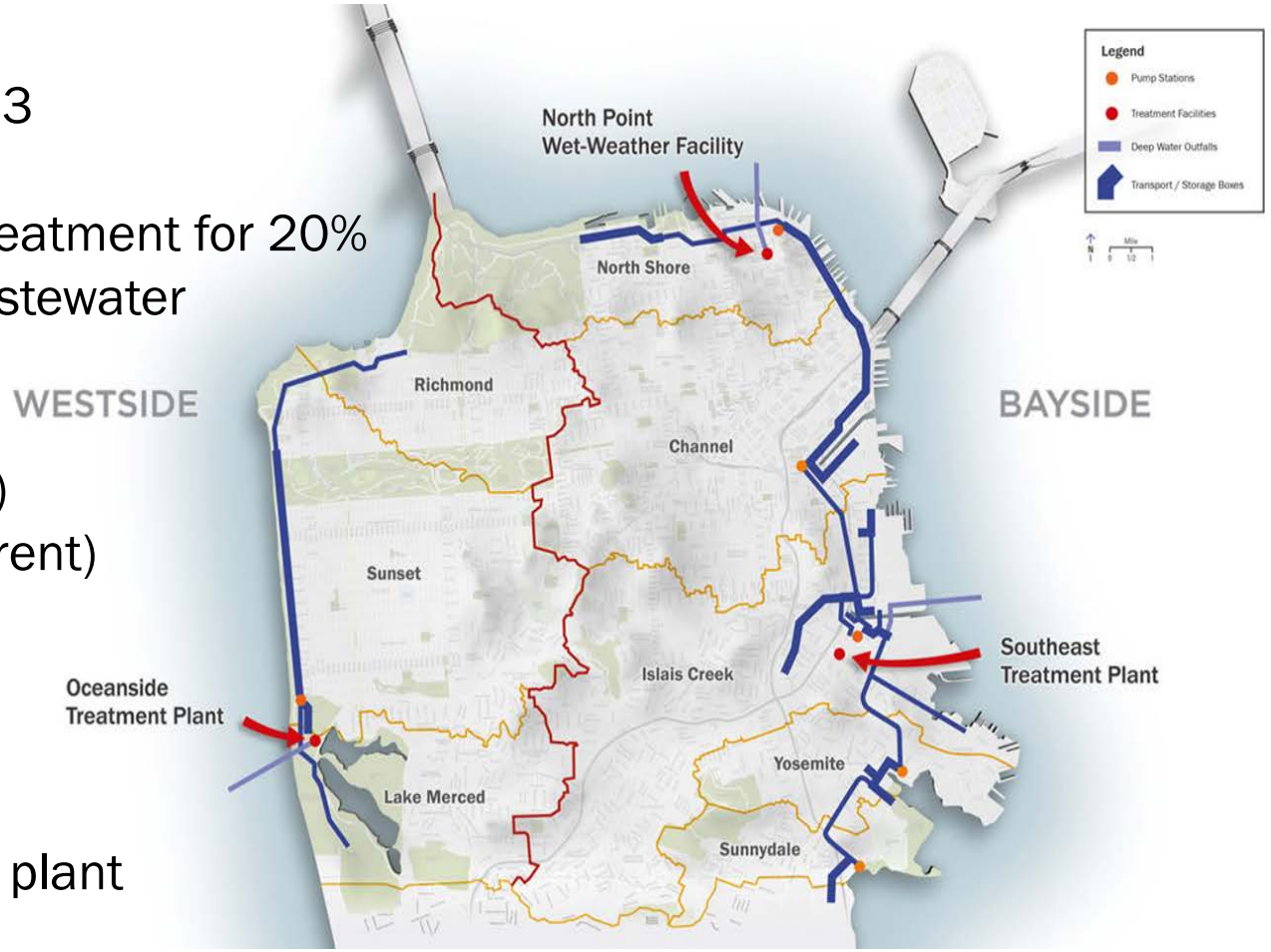
Presentation Outline

- Background
  - Oceanside Plant
  - Digester Upgrades
- Objectives and Results of Lab-Scale Studies
- Full-Scale Implementation
- Conclusions

Oceanside Plant Overview

- Commissioned in 1993
- Provides secondary treatment for 20% of San Francisco's wastewater
- Dry weather flow:
  - 21 MGD (design)
  - 12-14 MGD (current)
- Wet weather flow:
  - 65 MGD
- High rate pure oxygen plant



Oceanside Plant – Existing Operation

- Egg Shaped Digesters
  - 4 @ 750,000 gal each
- Flow Through Mode of Operation
- Achieve Class B Biosolids
  - 15 Days
    @ 95 Deg F (35 Degrees C)
- Current Biosolids End Uses
  - Wet Season – Landfill Beneficial Use (ADC)
  - Dry Season – Land Application in nearby Solano and Sonoma Counties

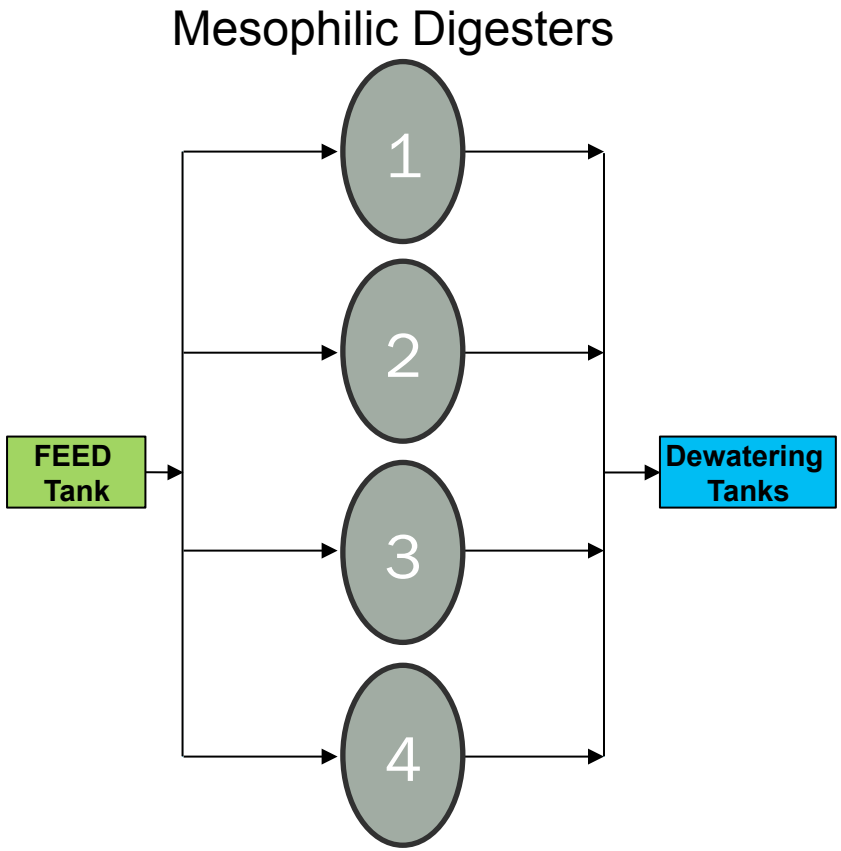
Temperature Phased Anaerobic Digestion

- Driver to Class A – County ordinance requirement in order to continue to land apply

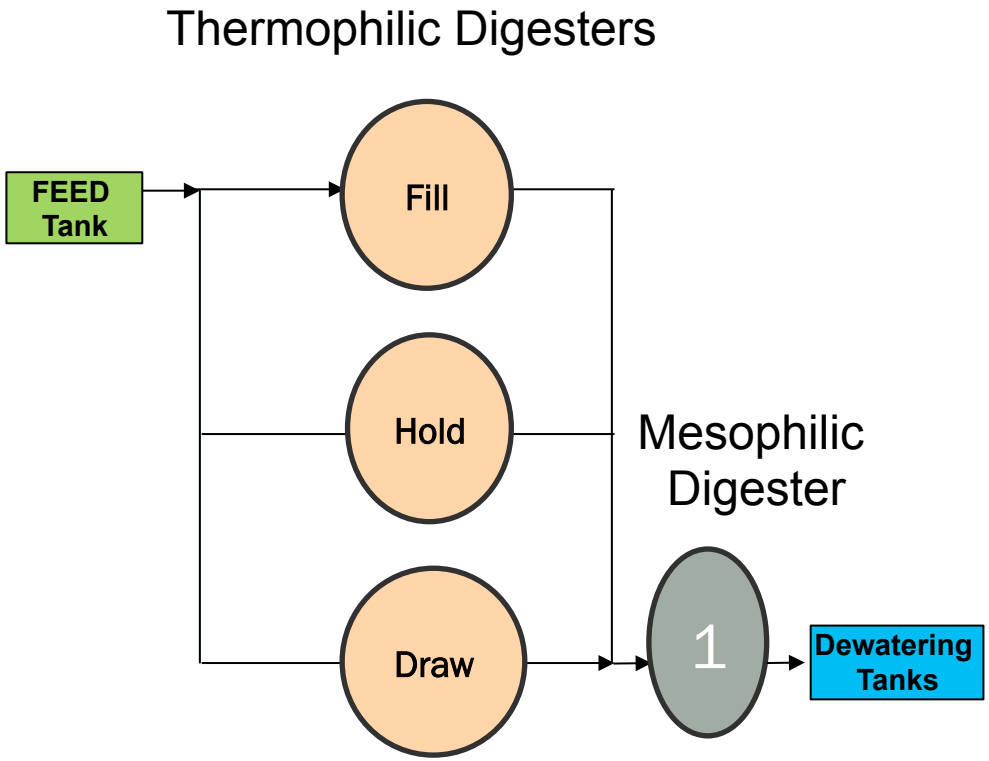
- Temperature Phased Anaerobic Digestion (TPAD) Process
  - Three thermophilic digesters operate in batch mode
  - One mesophilic digester receives all thermophilic sludge

- Achieve Class A through time and temp
  - 24 hours
    @ 131 Deg F (55 Deg C)

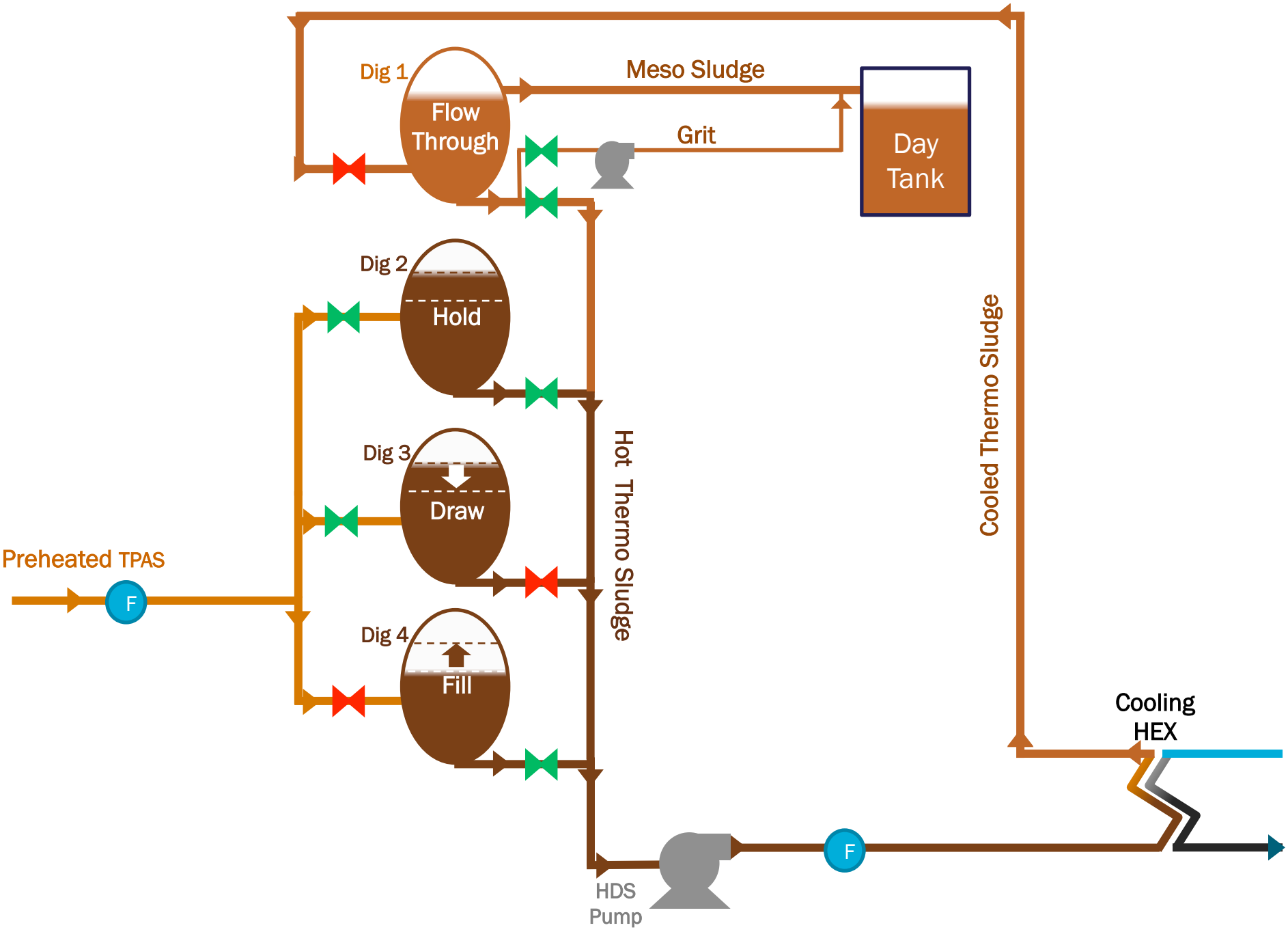
TPAD Conversion



- **Previous Operation**
  - 4 Mesophilic digesters operating in parallel
  - Daily feed evenly split to online digesters so each digester receives ~30,000 gal feed



- **Future Operation – TPAD**
  - 3 Thermophilic Digesters alternate in Fill-Hold-Draw Mode where Fill digester receives 130,000 gal feed
  - 1 Mesophilic Digester receives transferred thermophilic sludge


Dig 1
Flow Through
Meso Sludge
Grit
Day Tank
Dig 2
Hold
Dig 3
Draw
Dig 4
Fill
Preheated TPAS
F
Hot Thermo Sludge
Cooled Thermo Sludge
Cooling HEX
F
HDS Pump

Digester Upgrades

- Existing Digesters were Retrofitted

  - Corrosion repairs
  - Odor Control Improvements
  - Piping modifications
  - Insulation improvements
  - Heat exchanger upgrades
  - Heat recovery system
  - New boilers

Today’s Digesters

Lab-Scale Primary Objectives

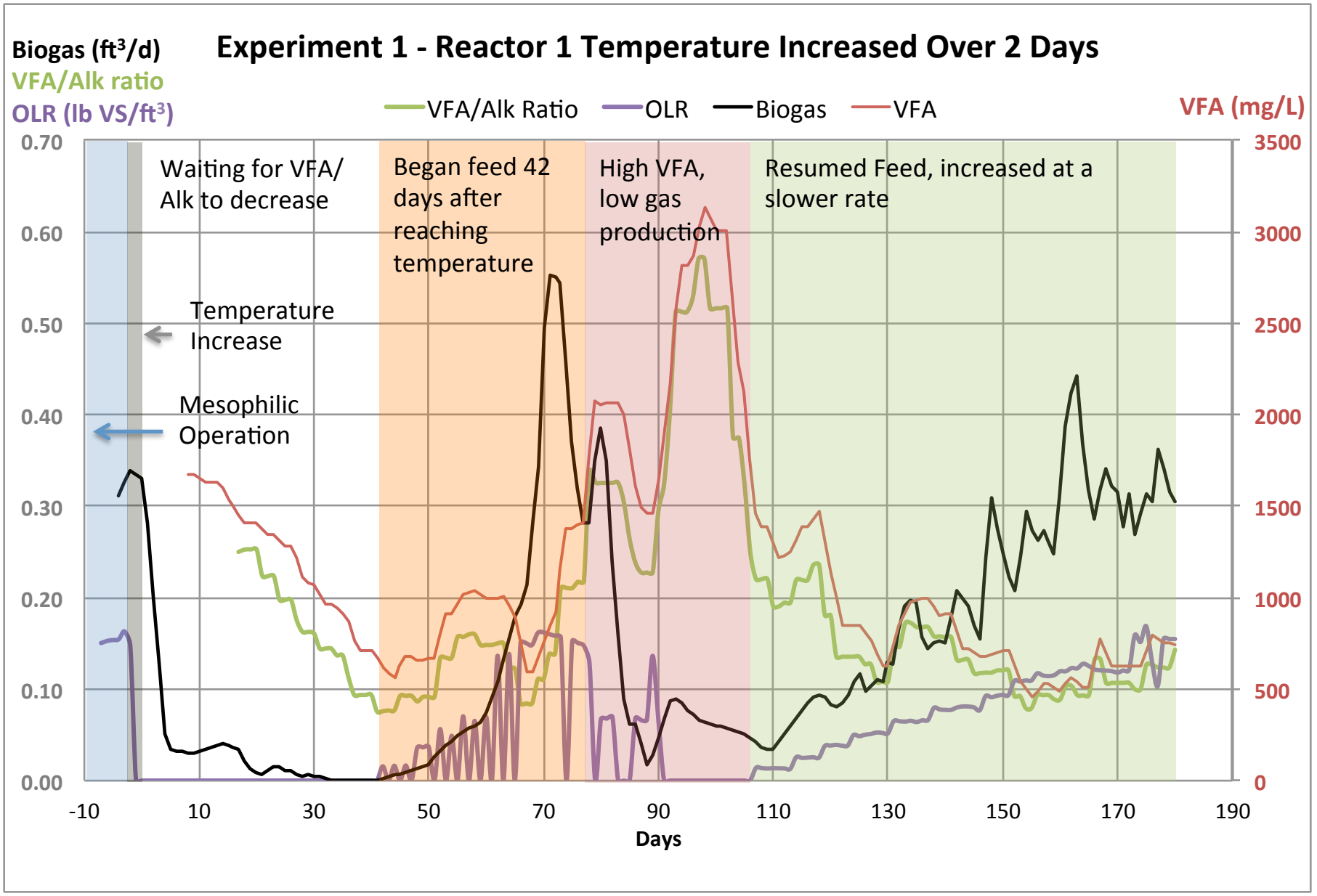
- Determine if existing mesophilic digesters could be converted thermophilic
- Develop full-scale startup procedure for thermophilic conversion
- Investigate impacts of batch mode operation

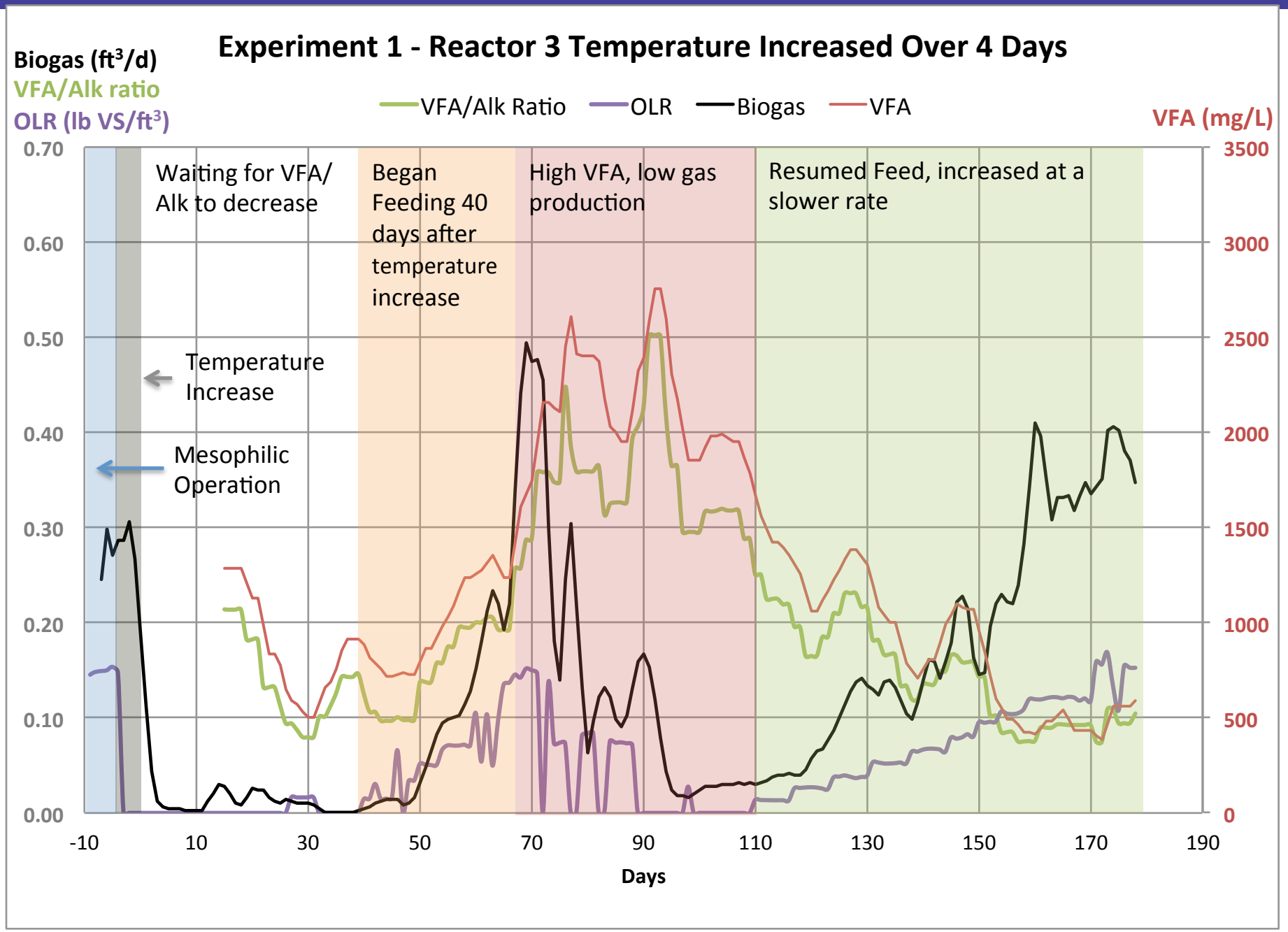
Lab-Scale Reactors

- Four – 14 L Stainless Steel Reactors
  - 11L working volume
- Continuous biogas flow measurement
- Key parameters measured
  - Volatile Acids
  - Alkalinity
  - pH
  - Ammonia
  - TS/VS

Experiment 1

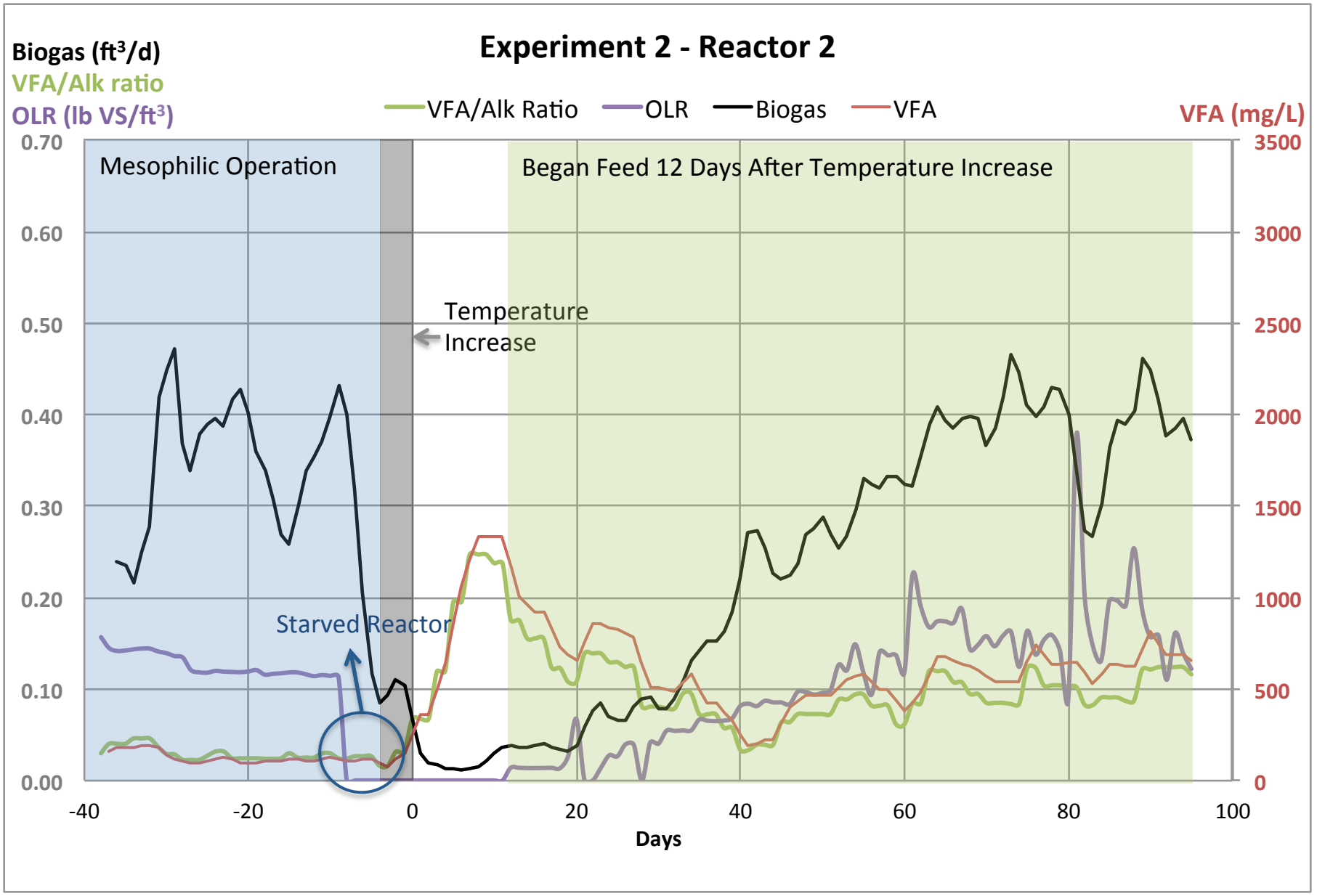
Objective	To determine the feasibility of converting mesophilic seed to thermophilic seed				
Main Configuration	Temp	2 day increase	2 day increase	4 day increase	Mesophilic Control
	Reactor	R1	R2	R3	R4
	Final OLR Goal (lb VS/ft^3-d)	0.17			

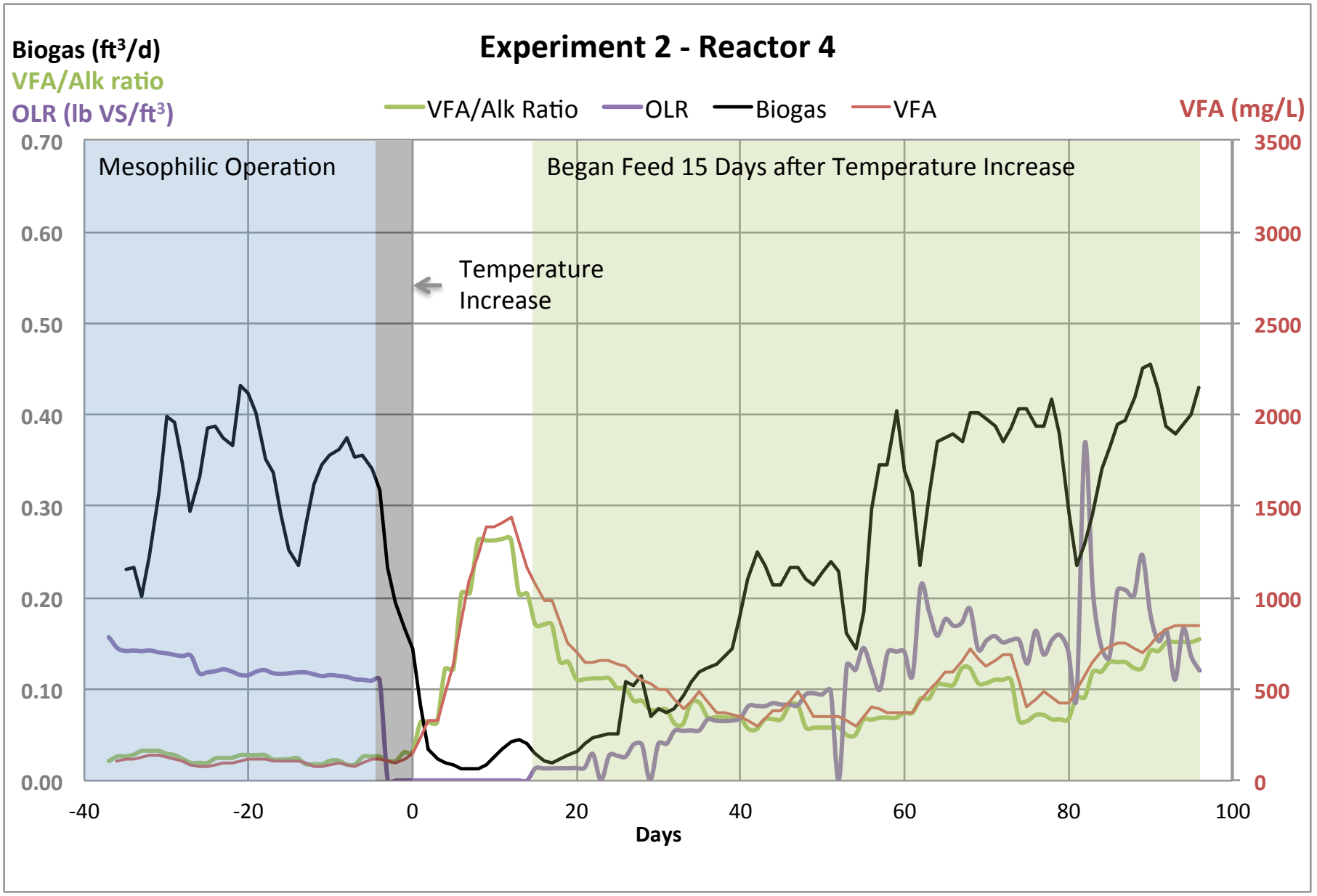

Experiment 1 - Reactor 1 Temperature Increased Over 2 Days
Biogas (ft³/d)
VFA/Alk ratio
OLR (lb VS/ft³)
VFA (mg/L)
VFA/Alk Ratio
OLR
Biogas
VFA
Waiting for VFA/ Alk to decrease
Began feed 42 days after reaching temperature
High VFA, low gas production
Resumed Feed, increased at a slower rate
Temperature Increase
Mesophilic Operation
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
3500
3000
2500
2000
1500
1000
500
0
-10
10
30
50
70
90
110
130
150
170
190
Days


Experiment 1 - Reactor 3 Temperature Increased Over 4 Days
Biogas (ft³/d)
VFA/Alk ratio
OLR (lb VS/ft³)
VFA/Alk Ratio
OLR
Biogas
VFA
VFA (mg/L)
Waiting for VFA/ Alk to decrease
Began Feeding 40 days after temperature increase
High VFA, low gas production
Resumed Feed, increased at a slower rate
Temperature Increase
Mesophilic Operation
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
3500
3000
2500
2000
1500
1000
500
0
-10
10
30
50
70
90
110
130
150
170
190
Days

Experiment 2

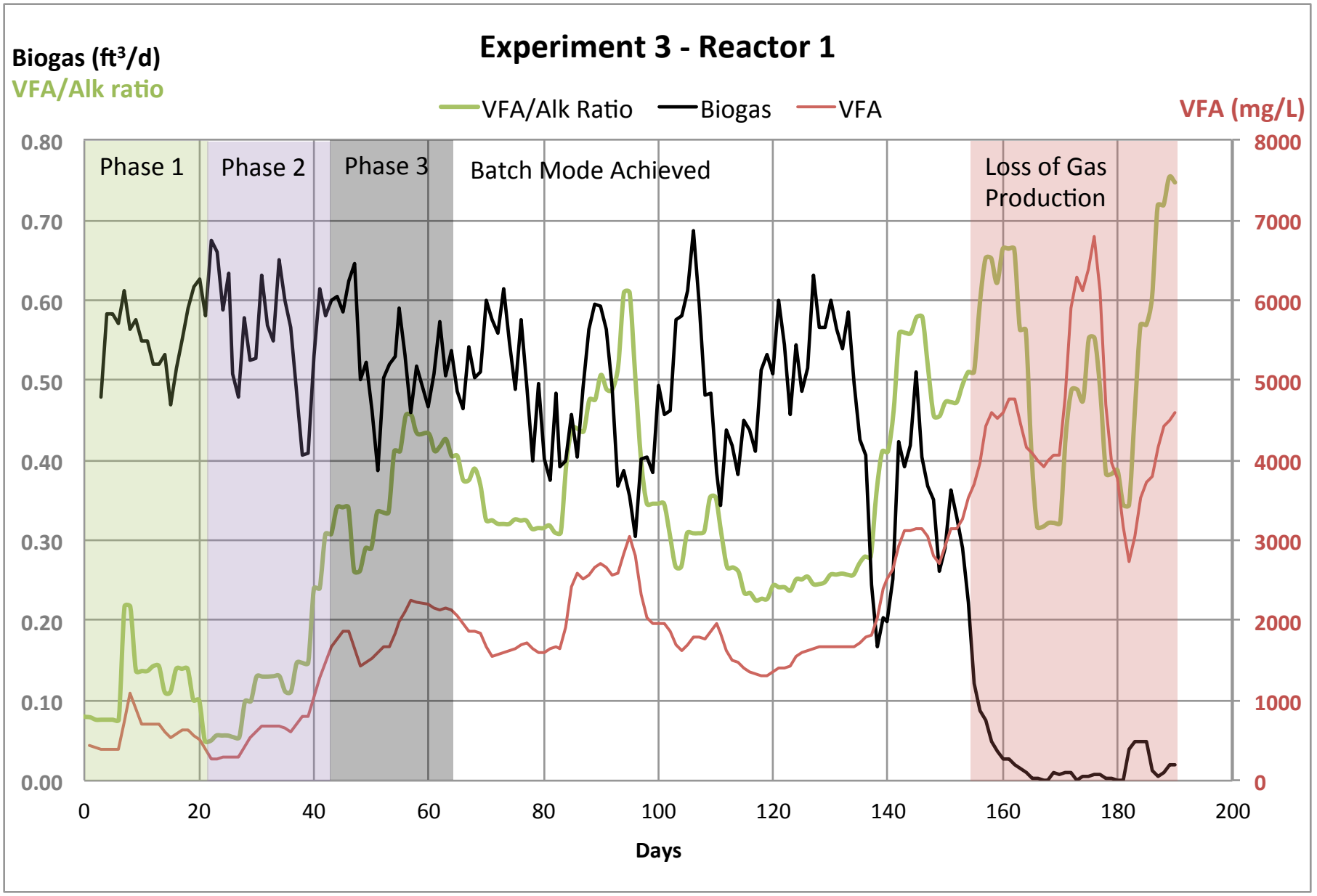
Objective	To repeat and confirm results from Experiment 1	
Main Configuration	Temp	4 day increase
	Reactor	R2&R4
	Final OLR Goal (lb VS/ft^3-d)	0.17

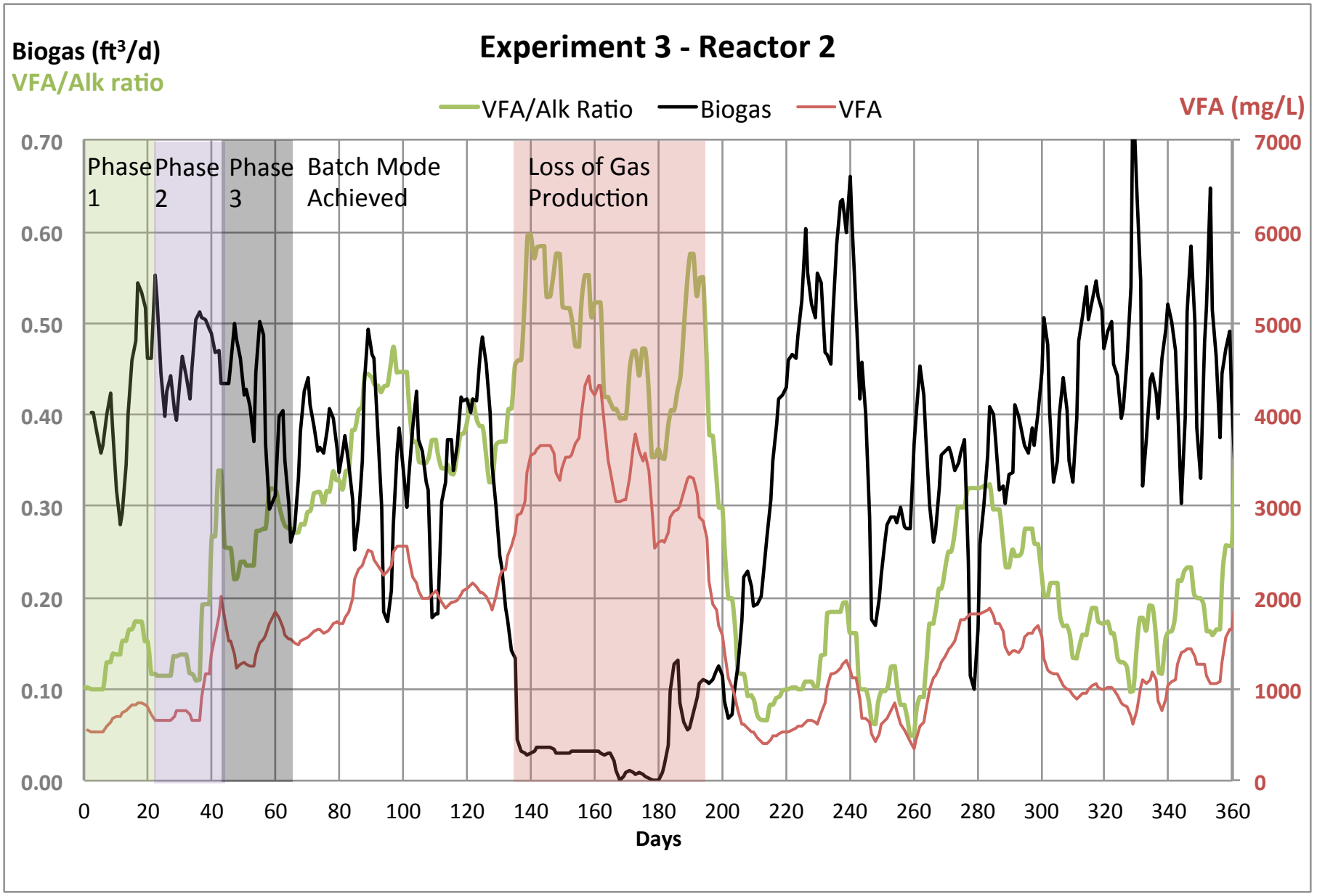

Experiment 2 - Reactor 2
Biogas (ft³/d)
VFA/Alk ratio
OLR (lb VS/ft³)
VFA/Alk Ratio
OLR
Biogas
VFA
VFA (mg/L)
Mesophilic Operation
Began Feed 12 Days After Temperature Increase
Temperature Increase
Starved Reactor
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
3500
3000
2500
2000
1500
1000
500
0
-40
-20
0
20
40
60
80
100
Days


Experiment 2 - Reactor 4
Biogas (ft³/d)
VFA/Alk ratio
OLR (lb VS/ft³)
VFA/Alk Ratio
OLR
Biogas
VFA
VFA (mg/L)
Mesophilic Operation
Began Feed 15 Days after Temperature Increase
Temperature Increase
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
3500
3000
2500
2000
1500
1000
500
0
-40
-20
0
20
40
60
80
100
Days

Experiment 3 - Transition to Batch Mode

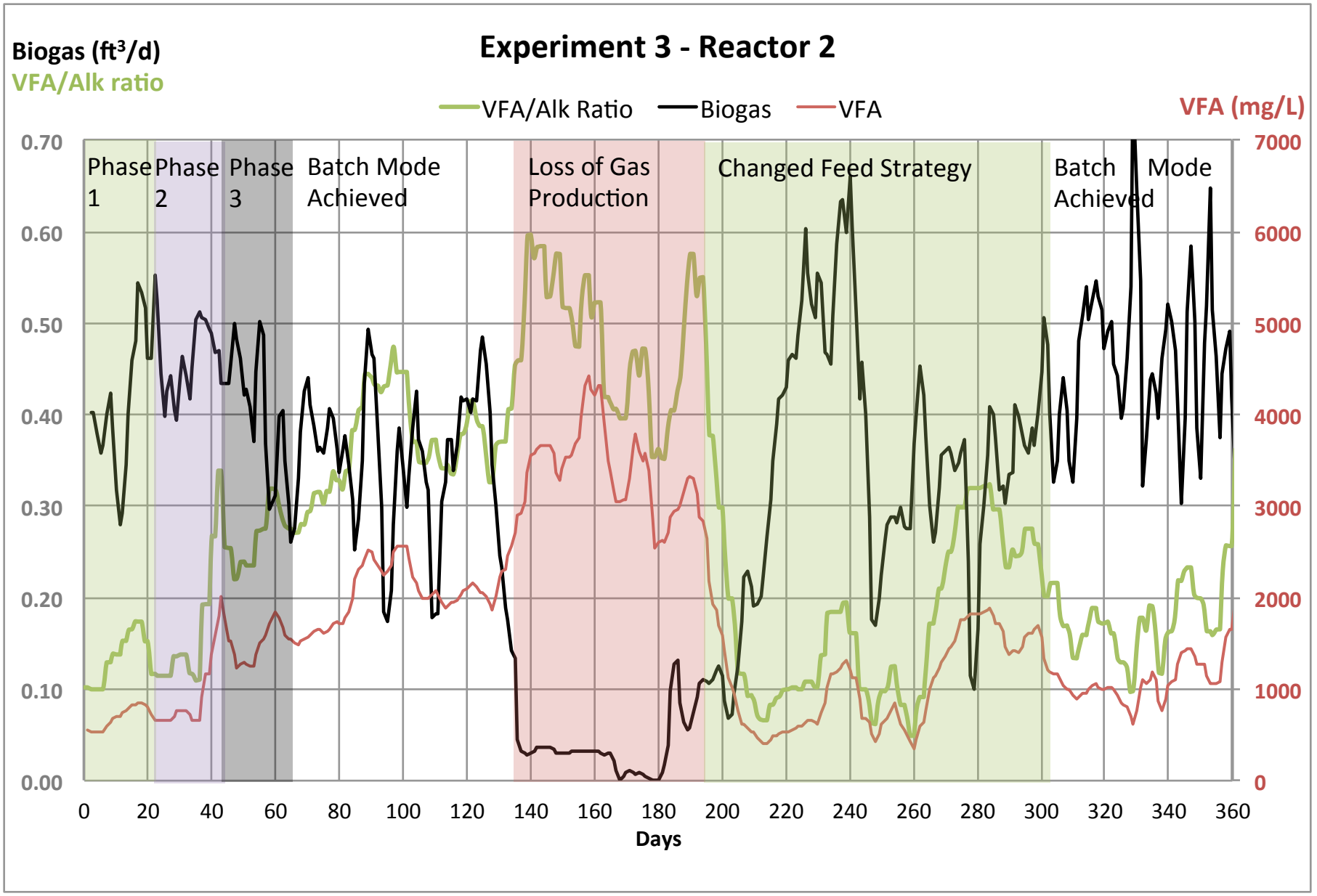
	Cycle = Fill-Hold-Draw	OLR (lb VS/ft^3-d)
Initial Conditions	Flow Through Operation	0.17
Phase 1	Cycle 1 - 7	0.25
		0.13
		0.13
Phase 2	Cycle 8 - 14	0.34
		0.08
		0.08
Phase 3	Cycle 15 - 21	0.42
		0.04
		0.04
Batch OLR Achieved	Cycle 22	0.51
		0.00
		0.00


Experiment 3 - Reactor 1
Biogas (ft³/d)
VFA/Alk ratio
VFA (mg/L)
VFA/Alk Ratio
Biogas
VFA
Phase 1
Phase 2
Phase 3
Batch Mode Achieved
Loss of Gas Production
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
8000
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
180
200
Days


Experiment 3 - Reactor 2
Biogas (ft³/d)
VFA/Alk ratio
VFA (mg/L)
VFA/Alk Ratio
Biogas
VFA
Phase 1
Phase 2
Phase 3
Batch Mode Achieved
Loss of Gas Production
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
Days

Modified Feed Strategy

	Modified OLR (lb VS/ft^3-d)
Flow Through Operation	0.17
Phase 1	0.25
	0.00
	0.00
Phase 2	0.34
	0.00
	0.00
Phase 3	0.42
	0.00
	0.00
Batch OLR Achieved	0.51
	0.00
	0.00


Experiment 3 - Reactor 2
Biogas (ft³/d)
VFA/Alk ratio
VFA (mg/L)
VFA/Alk Ratio
Biogas
VFA
Phase 1
Phase 2
Phase 3
Batch Mode Achieved
Loss of Gas Production
Changed Feed Strategy
Batch Mode Achieved
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
Days

Key Lab-Scale Findings and Impact on Full-Scale Startup

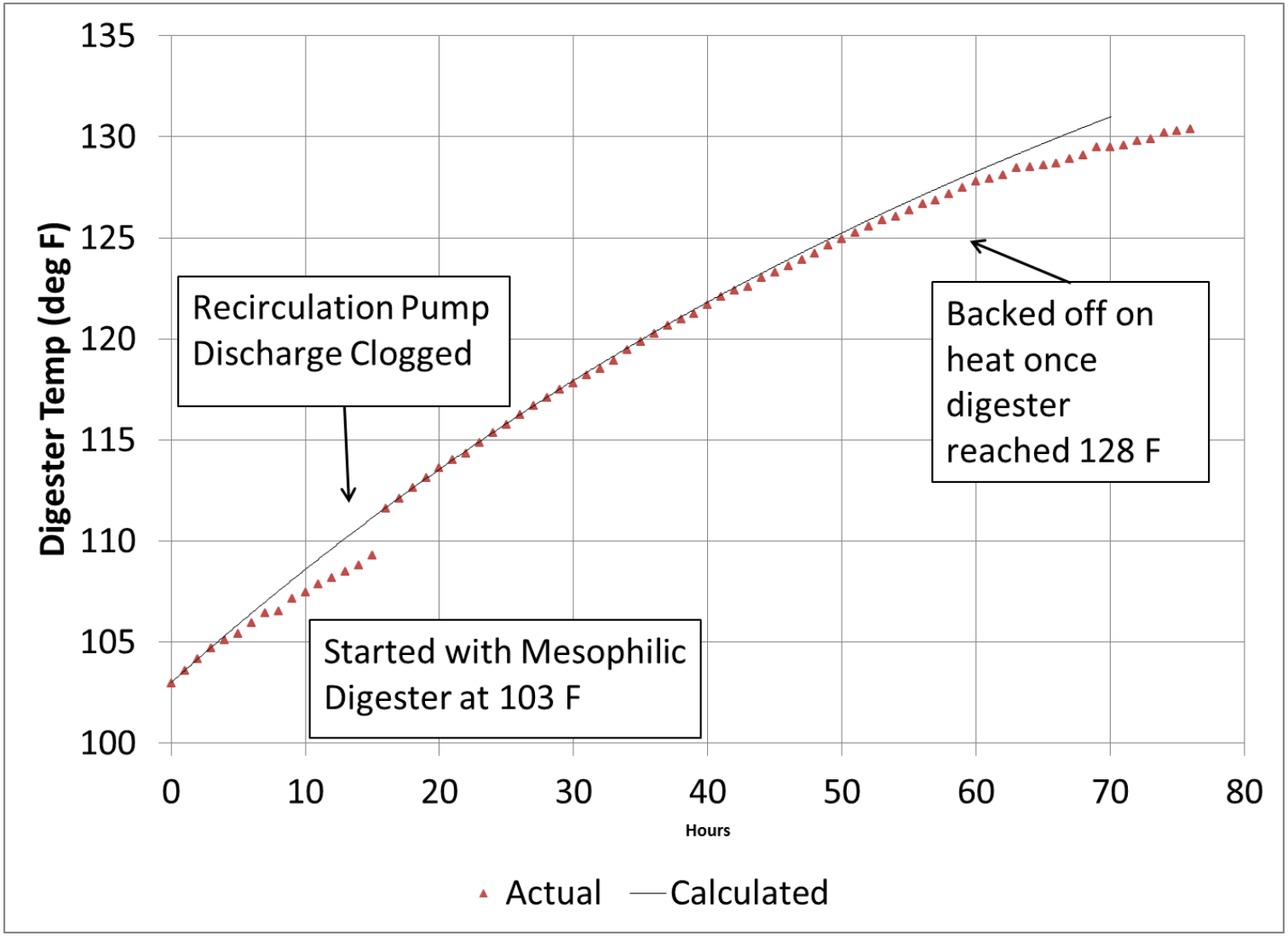
- Maintain Strict Temperature Control
  - Resulted in automating temperature control strategy in full-scale digesters
- Conservative Feed Strategy
  - Decision to “starve” digesters prior to temperature increase
  - Increase Feed to Digesters Weekly
- Transition from Flow Through to Batch Operation
  - Changed feed strategy to slowly ramp up overall OLR
  - One digester will be converted from flow through to batch mode while maintaining 3 mesophilic digesters

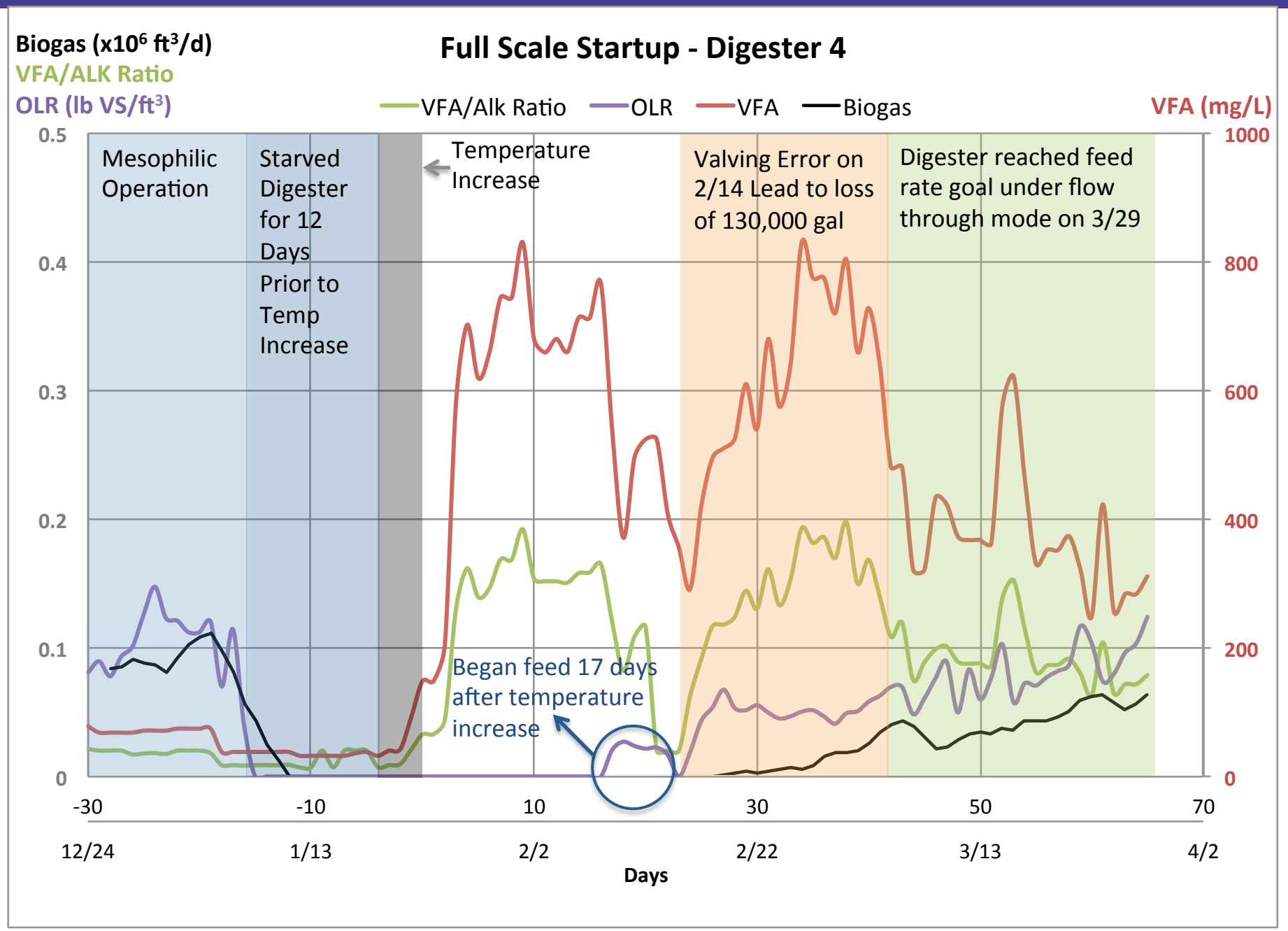

DIGESTER 1
END OF LARGE FEED PORT
END OF SMALL FEED PORT
2.5 DAY HEATING

Full-Scale Implementation

Step	Date	Description
1	January 7 – 19, 2016	“Starve” Digester 4
2	January 19 – 23, 2016	Increase Temperature from 95 to 131 Degrees F
3	February 9 – March 29, 2016	Increase Digester feed from 5,000 to 30,000 while operating in flow through mode
4	June 6 – 10, 2016	Temperature increase for Digester 3 after starvation

Temperature Increase




Biogas (x10⁶ ft³/d)
VFA/ALK Ratio
OLR (lb VS/ft³)
Full Scale Startup - Digester 4
VFA/Alk Ratio
OLR
VFA
Biogas
VFA (mg/L)
Mesophilic Operation
Starved Digester for 12 Days Prior to Temp Increase
Temperature Increase
Valving Error on 2/14 Lead to loss of 130,000 gal
Digester reached feed rate goal under flow through mode on 3/29
Began feed 17 days after temperature increase
0.5
0.4
0.3
0.2
0.1
0
1000
800
600
400
200
0
-30
-10
10
30
50
70
12/24
1/13
2/2
2/22
3/13
4/2
Days

Conclusions

Parameter	Lab-Scale vs. Full-Scale	Comments
Stringent Temperature Control	☑	Closely monitored during full-scale startup
Biogas Production Trends	☑	Expected gas production to stop during transition
Feed Strategy	☑	Conservative approach
Volatile Acids	☒	High peaks in lab-scale reactors likely from slug feeding
Flow Through to Batch Mode	☑	Full-Scale success anticipated

Acknowledgements

- Oceanside Plant Staff
  - Operations
  - Maintenance
  - Laboratory
  - Instrumentation & Controls
  - Distributed Control Systems

- Process Engineering Team (Co-Authors)
  - Alexandre Miot
  - Karla Guevarra
  - Bonnie Jones (retired)

- TPAD Design Team – CH2M

Questions?