

West Point Digestion System Current Conditions and Assessment

Technology Assessment Program
King County Department of Natural Resources and Parks
Wastewater Treatment Division



Presentation Outline

- **Digestion System Configuration**
- **Digester Operating Conditions**
- **Digester Upset Conditions**
- **Digester Assessment**
- **Recommendations**

References

- **West Point Treatment Plant Operating Data**
- **West Point Treatment Plant Digestion System Manual**
- **University of Washington Fellowship Program Thesis**
- **Thermophilic Anaerobic Digestion Demonstration Project Report**
- **Black and Veatch Digestion Survey**

West Point Treatment Plant

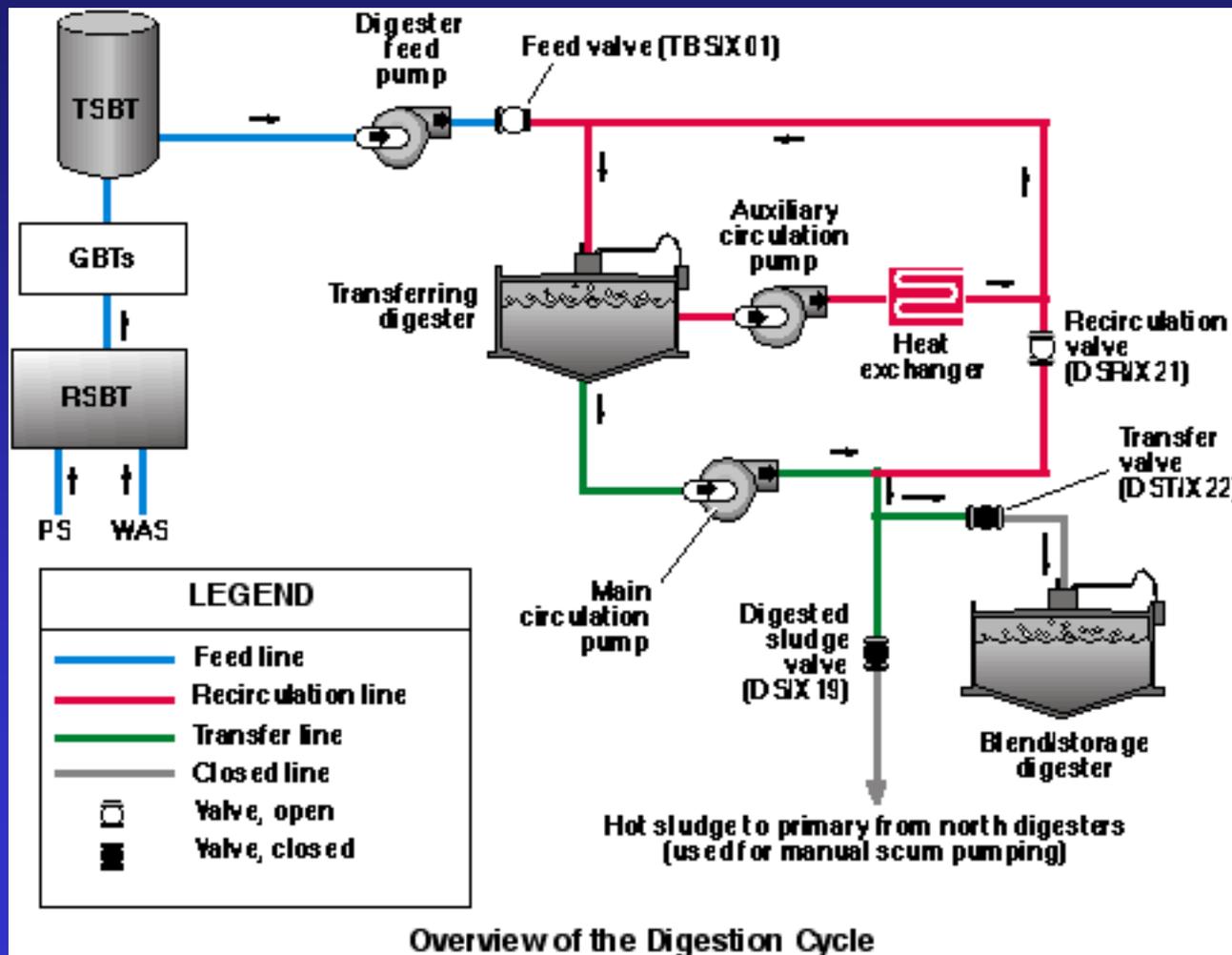


Digester Physical Attributes

- **5 Primary - 1 Secondary Digester**
- **2.4 MG digester volume**
- **100ft diameter x 37.5ft side-wall**
- **Floating cover on primary digesters**
- **Mesophilic operating temperature**
- **Gas (diffuser and draft tube) and Pumped Mixing**

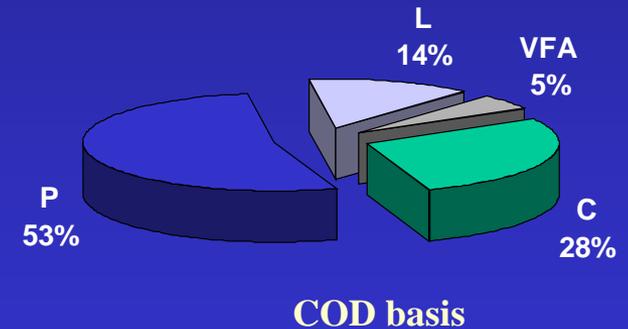


Digester Configuration

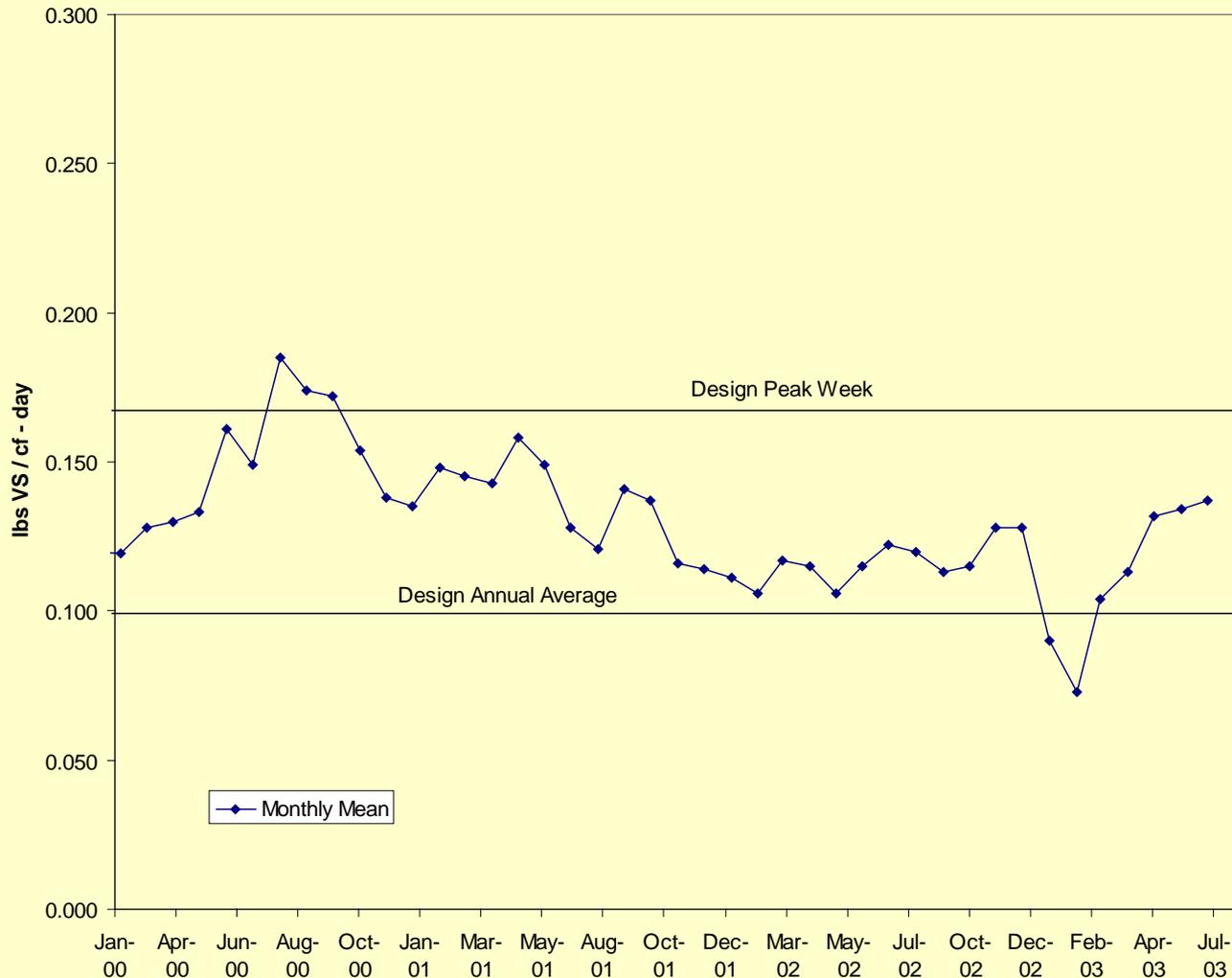


Digester Feed Characteristics

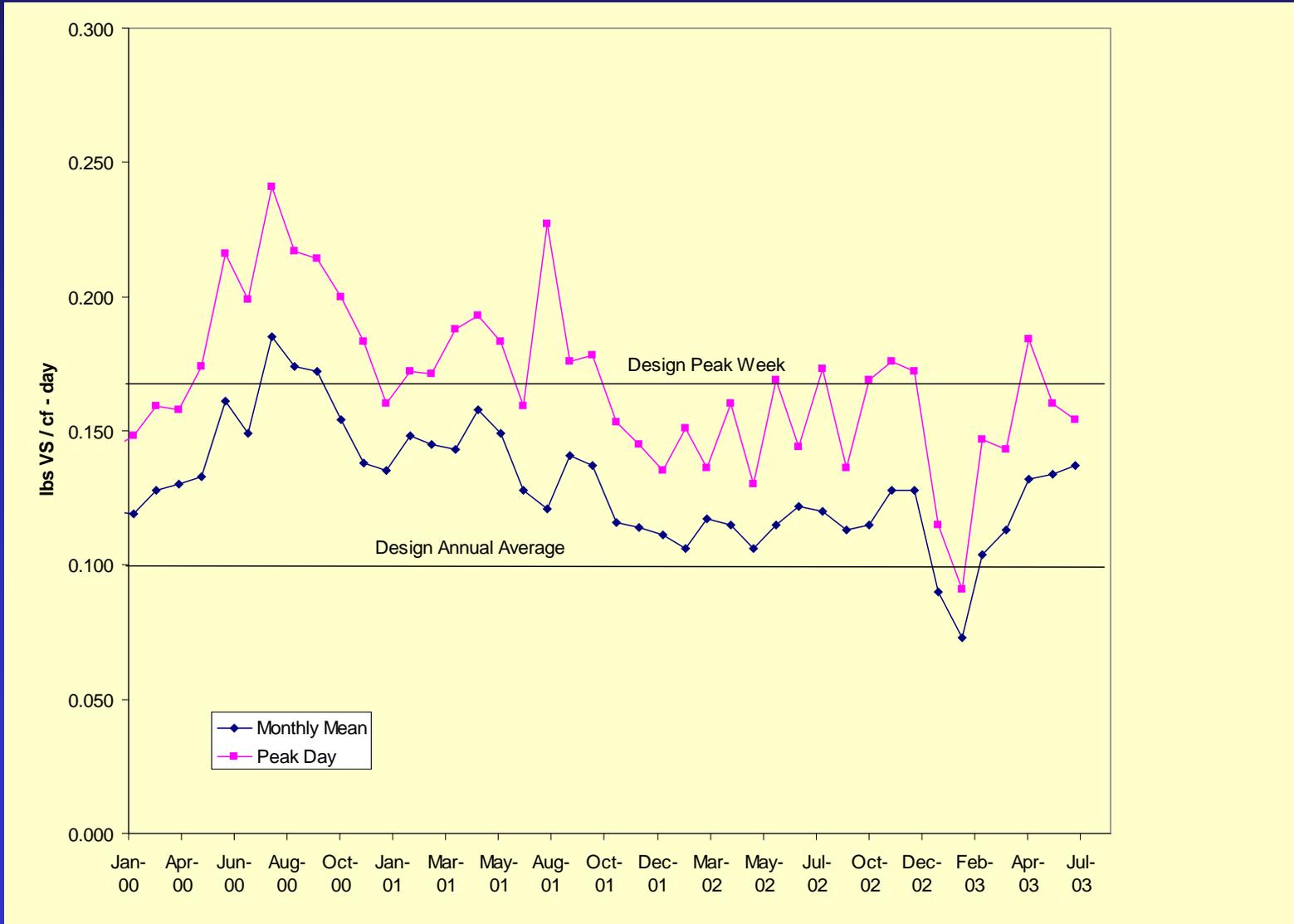
- 50% Primary : 50% Secondary (w:w)
- protein, carbohydrate, lipid, VFA fractions
- scum sequentially fed to digesters 1 through 3
- gravity thickened to 6%TS (80%VS)
- grit content in primary fraction



Digester Organic Loading Rate



Digester Organic Loading Rate



Digester Process Monitoring

- **Analytical - TS, VS, alkalinity, pH, VFA, CO₂, H₂S**
- **SCADA (control) - cover height, feed volume, withdrawal volume**
- **SCADA (instrumentation) - gas production, temperature, cover height, feed volume, withdrawal volume**
- **Visual - foam, mixing system gas flow**

Primary Digester Operating Conditions

	VS Loading (lb VS/cf-day)	TS (%)	VFA (mg HAc/L)	ALK (mg CaCO₃/L)	CO₂ (%)
2000	0.147	2.82	94	6,600	38
2001	0.136	2.85	77	6,800	38
2002	0.116	2.86	81	6,800	38
2003	0.112	2.82	70	6,600	38

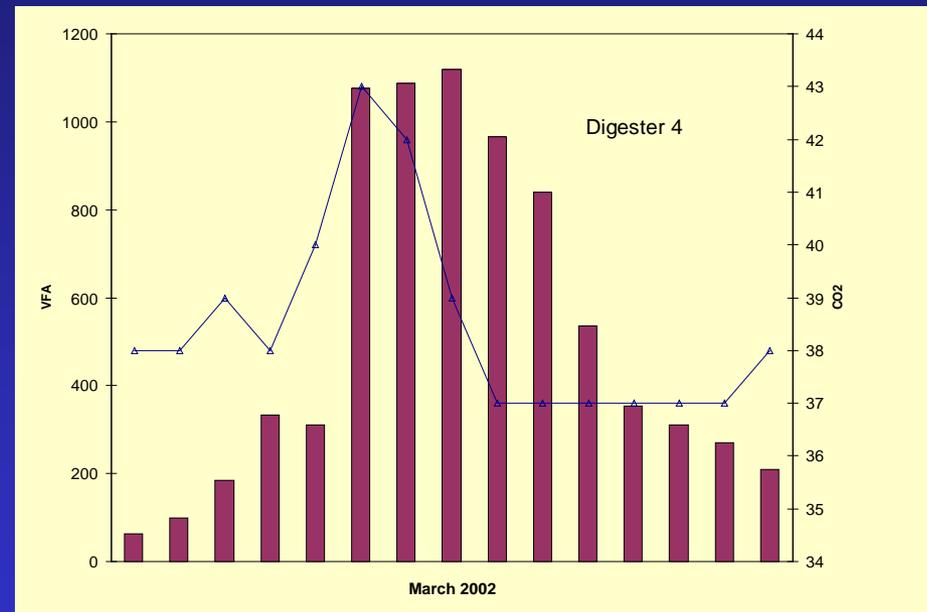
Primary Digester Performance

	VSR (%)	SRT (days)	Gas Production (cf/lb VSR)
2000	66	25	21.5
2001	63	28	20.5
2002	66	32	20.8
2003	67	34	21.8

Anaerobic Digestion typically 12 - 16 cf/lb VSR. High values attributed to digester gas flow meter.

Digester # 4 in March 2002

- Increase in VFA concentration
- Increase in %CO₂ in gas
- Decrease in gas production
- Decrease in alkalinity

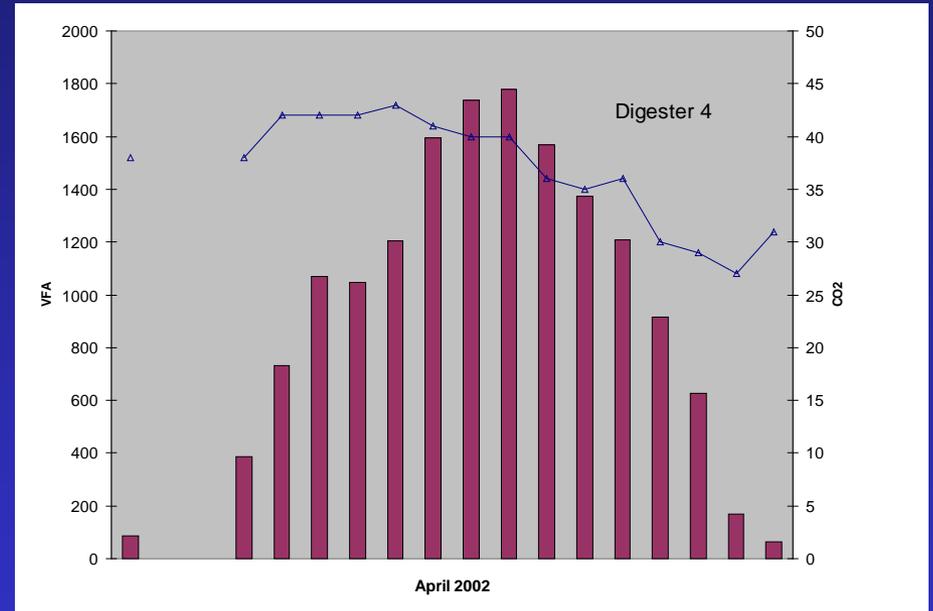


Response to Digester 4 “Upset” Condition

- **Decreased organic loading rate**
- **Increased monitoring of operating conditions**
- **Inspection of digester operating system**
 - check of digester feed valve
 - feed and withdrawal sequence control
 - gas mixing
- **With recovery, slowly increased organic feed rate**

Digester # 4 in April 2002

- Increase in VFA concentration
- Increase in %CO₂ in gas
- Decrease in gas production
- Decrease in alkalinity



Potential Causes of Digester 4 Upset

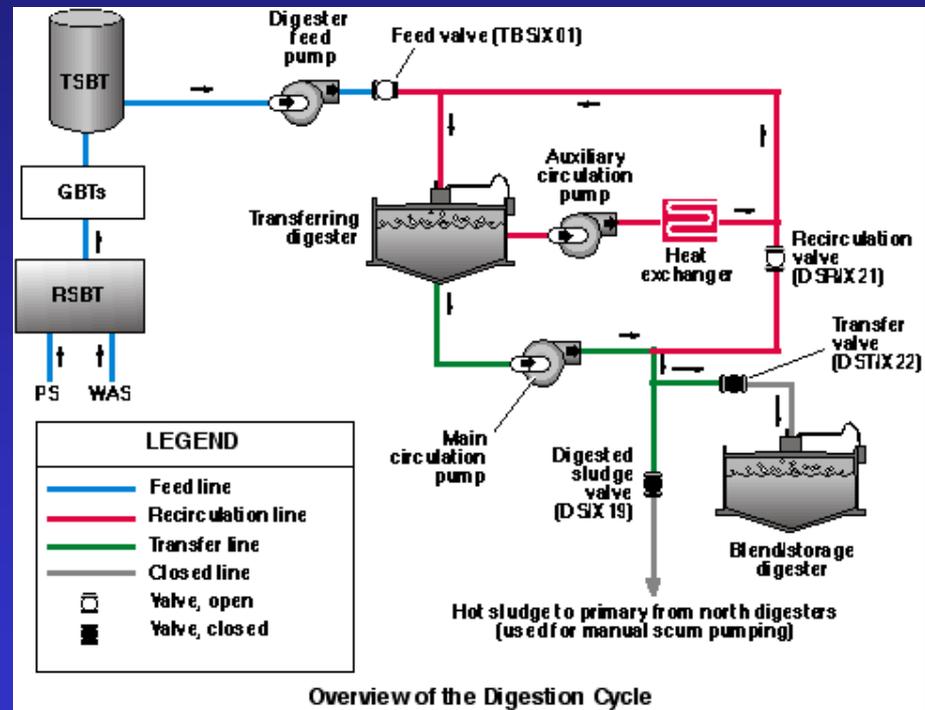
- **Organic Shock Loading**
 - feed & transfer control system failure
 - thickening process control
- **Inadequate Mixing Energy**
 - failure of mixing compressor
 - clogging of draft tube gas lances
- **Toxicity**
 - inhibitory compound introduced into system
 - accumulation of inhibitory compound in digester

Digester Assessment Process

- **System Review (West Point Process Staff)**
- **Digester Health Monitoring (TAP Staff)**
- **Digestion Survey (TAP Staff)**
- **Modeling (TAP Staff)**

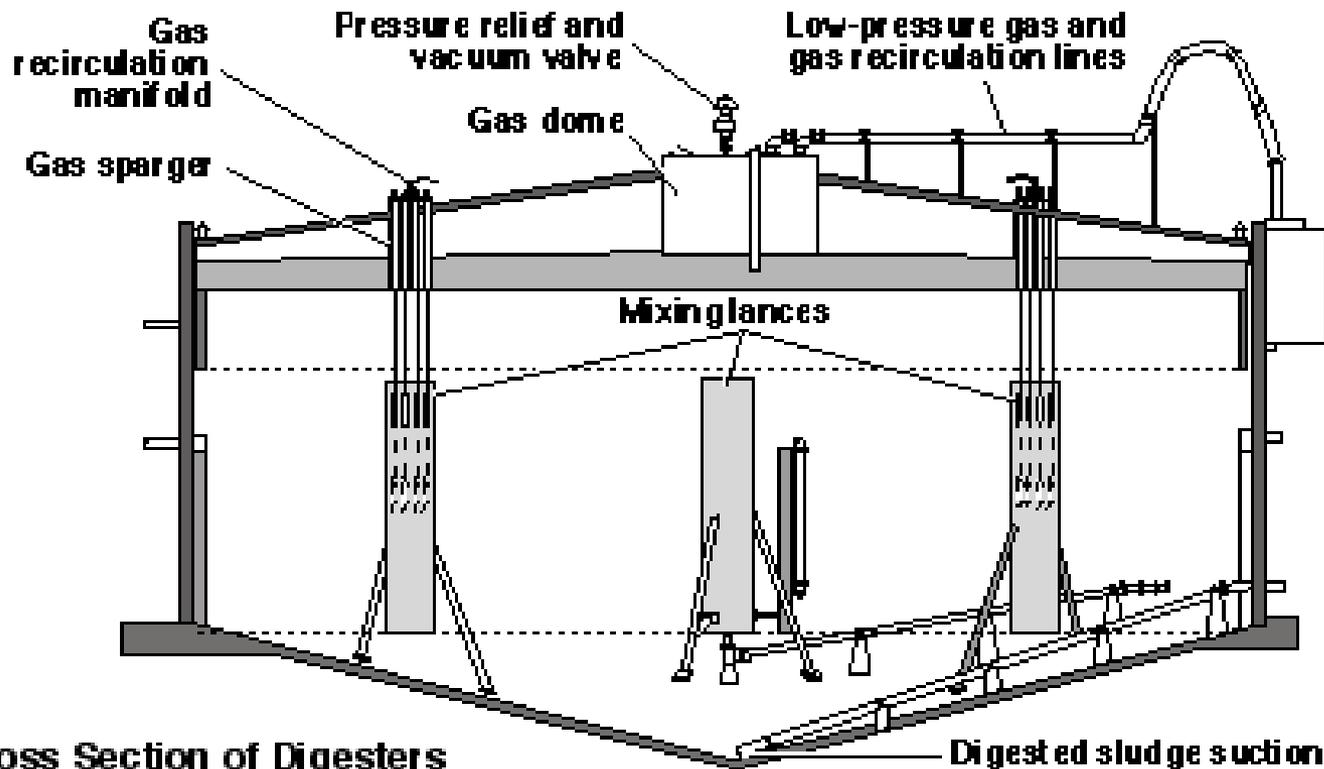
Digester System Review Feeding and Withdrawal Cycle

- Feeding Frequency
- Feed Valving
- Feed Flowmeter



Digester 4-5 Mixing System

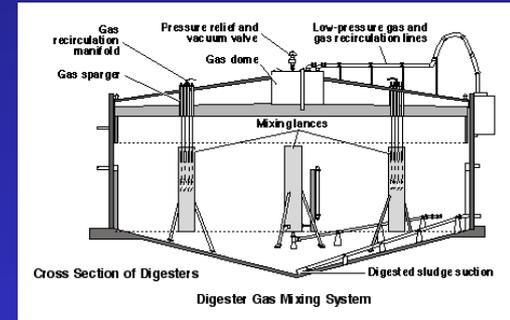
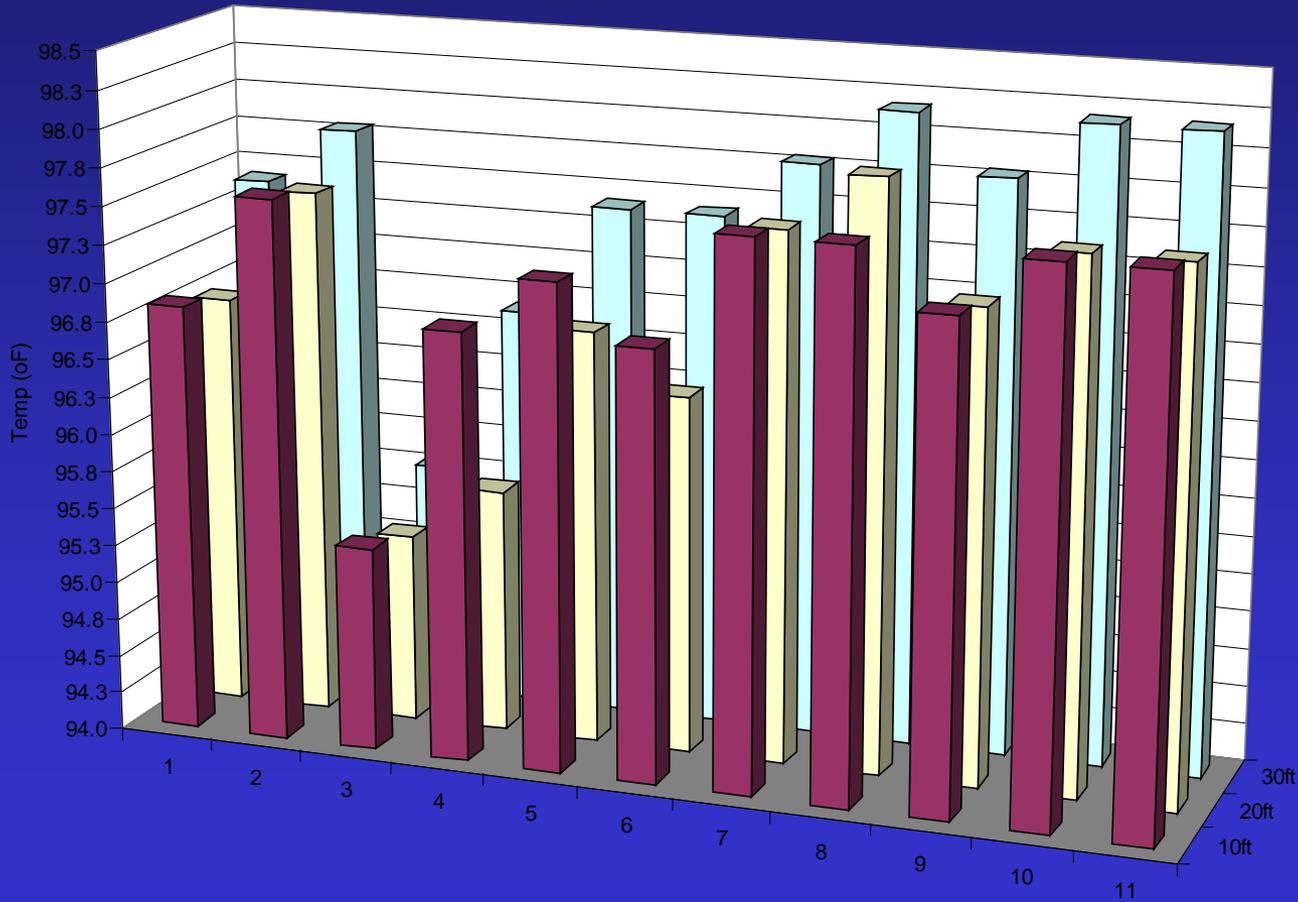
- Main Pump
 - 700 gpm
- Auxiliary Pump
 - 350 gpm
- Gas draft tube



Digester Gas Mixing System

Digester 4 Temperature Profile

Peak Temperature of each Sampling Port



Digestion Process Monitoring

- **Current process parameters associated with stability**
 - operating temperature
 - pH
 - volatile fatty acids
 - alkalinity
 - volatile solids loading
 - volatile solids reduction
 - gas production and composition

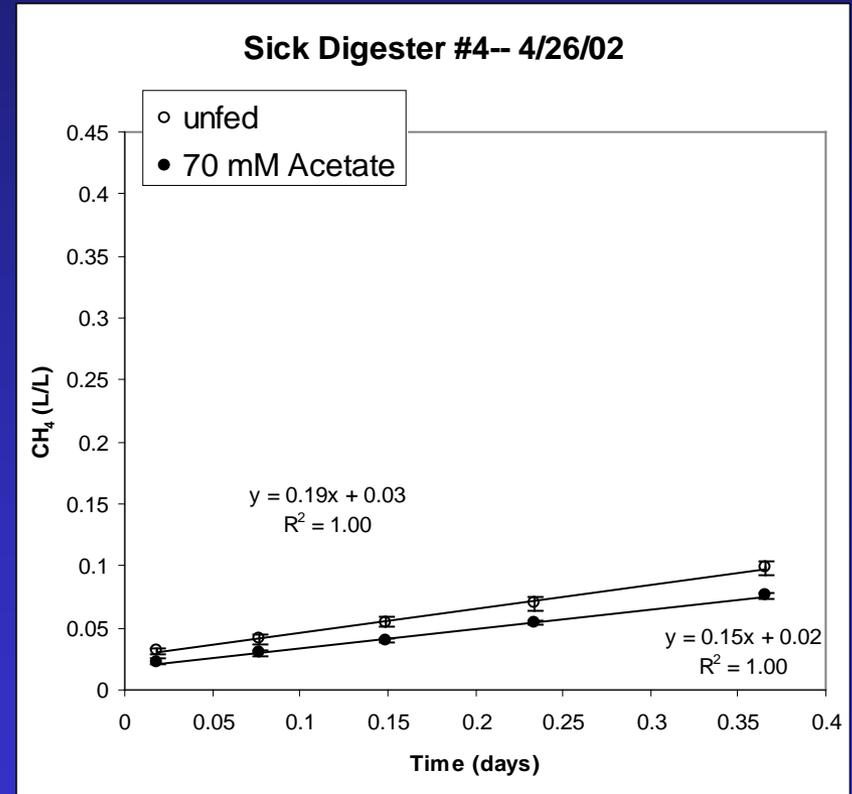
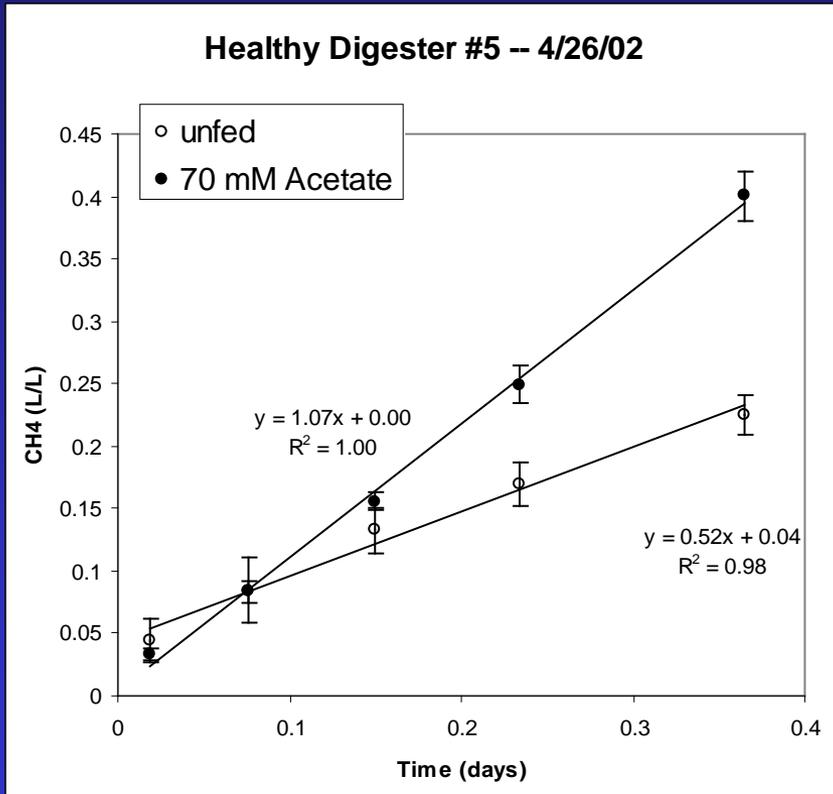
Digestion Process Monitoring

- **Current process parameters associated with stability**
 - operating temperature
 - pH
 - volatile fatty acids
 - alkalinity
 - volatile solids loading
 - volatile solids reduction
 - gas production and composition
- **Development of additional monitoring tools**
 - acetate utilization rate (University of Washington)

Acetate Utilization Rate Test Development (University of Washington)

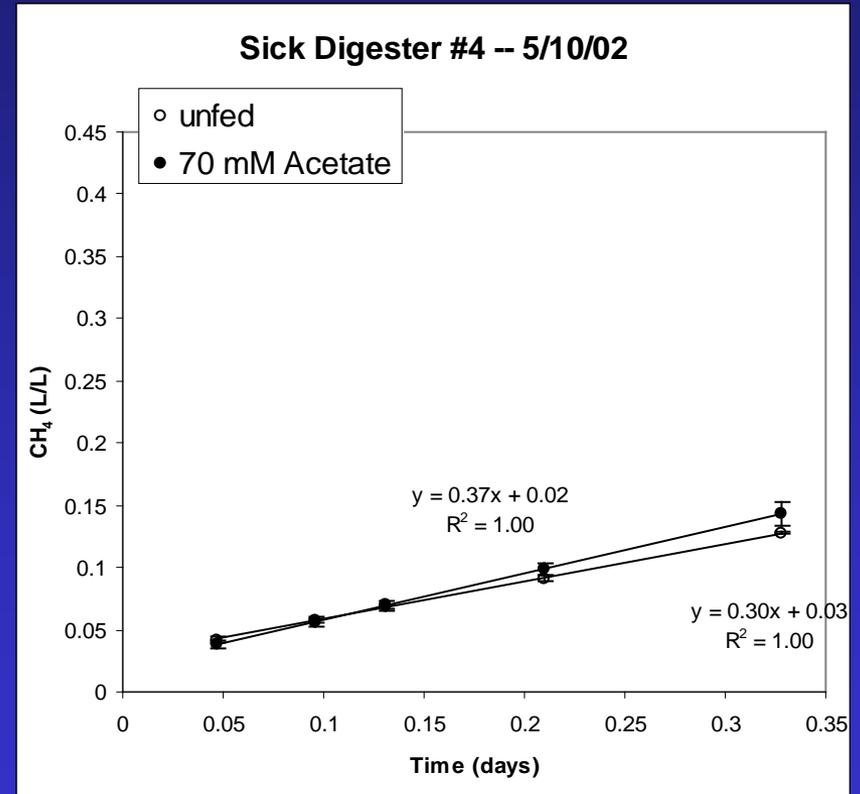
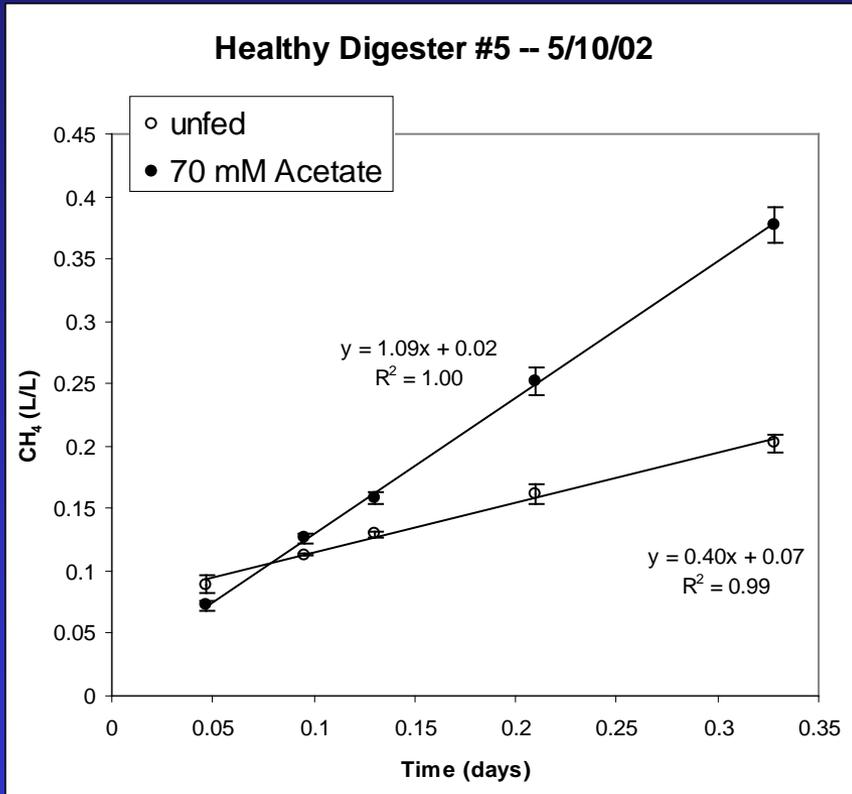
- **Test method used by King County Fellowship Program Graduate students in on-going anaerobic digestion research**
 - **digester sample collected and transported to university with analysis within 24-hours**
 - **55mL serum bottles filled with digested sludge (triplicates)**
 - **bottles spiked with acetate with corresponding unspiked bottles**
 - **methane production monitored for 8-10 hours using GC-TCD**
 - **data plotted as CH₄ (L/L sludge) over time**

Acetate Utilization Rate Test Development (University of Washington)



- Comparison of slope between fed and unfed samples
- Process Lab VFA analysis: dig #5 = 47 mg/L, dig #4 = 1,207 mg/L

Acetate Utilization Rate Test Development (University of Washington)



- Comparison of slope between fed and unfed samples
- Process Lab VFA analysis: dig #5 = 68 mg/L, dig #4 = 93 mg/L

Digestion Survey Development

- **Full-scale Digester Comparison**

- configuration
- stability
- performance

- **Posted on King County website**

<http://dnr.metrokc.gov/wtd/survey-1>

Parameter	Average	Peak or Range	STP's Average	STP's Peak &/or Range	WP's Average	WP's Peak &/or Range
Digester Feed:						
Dig. Feed Solids (%TS)			6.0	5.0 – 7.0	6.0	5.1 – 7.5
Dig. Feed VS/TS (%)			81	76 – 83	82	68 – 86
Primary Sludge VS/TS (%)			83	70 – 83	78	60 – 85
Waste Activated Sludge VS/TS (%)			81	78 – 82	82	78 – 85
Primary Sludge/Pri. Sludge + WAS Ratio (lbTS/lbTS)			1.0	0.4 – 0.65	0.55	0.48 – 0.62
SRT of Secondary Process (days)			3.0	2.5 – 5	2.8	2.2 – 3.8
Are chemical coagulants added in liquid processing (enhanced primary, P-removal, etc.)			No		No	
Where do dewatering & thickening recycle streams go?			Dewatering recycle goes to sludge thickener & thickener recycle to secondary process		Dewatering centrate & Thickening filtrate go to secondary process	
Digester Design:						
Number of Digesters (each)			4	5	5	5
Vol. of Digesters (MG)			2.75	2.6 – 3.0	2.1	2.0 – 2.2
Shape & Dimensions (e.g., cylinder, egg-shaped)			Cylindrical: 100 ft dia		Cylindrical: 100 ft dia	
Mixing Methods (gas diffusers, draft tube, recirc. Pumping, mechanical)			Gas diffusers & pumped recirculation		Gas diffusers & Pump circ Draft tubes & Pump circ	
Feeding Frequency (continuous, intermittent)			Continuous		Intermittent	
Feeding Sequence (parallel, series, ?)			3 (or 4) primary digesters are fed in parallel and they discharge to a fifth digester		Cycle feeding from 1 to 5	
Digester Operation:						
Temperature (° F)			96	95 – 98	98	97.8 – 98.3
Solids Retention Time (days)			26	18 – 33	30.9	27 - 34
Organic Loading Rate (lbs VS/cf-day)			0.15	0.12 – 0.19	0.138	0.114 – 0.158
Digester Performance						
Volatile Solids Reduction (%)			58	55 – 63	63	50 - 67
Dig. Sludge VS/TS (%)			62.5	60 – 65	62.2	59 – 64
Gas Production (cf CH ₄ /lb VS removed)			11		15.0	13.0 – 16.0
CO ₂ in digester gas (%)			34	32 – 28	38	36 – 41
H ₂ S in digester gas (ppm)			80	30 – 200	60	40 – 220
Alkalinity (mg CaCO ₃ /L)			7000	5500 – 7800	6840	5900 – 7900
pH			7.5		7.3	7.2 – 7.6
Volatile Acids (mg/L)			60	30 – 200	64	35 – 180
NH ₄ -N (mg/L)			2500	1800 – 3500	2300	1700 – 3200

Existing Digestion Survey Data

	VS Loading (lb VS/cf-day)	SRT (days)	VSR (%)	Mixing Energy (Hp/kcf)
West Point Digester 4 (2003)	0.101	34	67	0.33
Facility Survey	0.102	24	59	0.28

Survey Source: Black and Veatch (50 facilities)

Assessment Recommendations - Present

- **Monitor feeding and withdrawal system**
- **Perform periodic acetate utilization rate testing of digesters**
- **Investigate potential application of on-line instrumentation**
- **Conduct lithium tracer testing of digesters**
- **Continue collecting data from Digestion Survey**

Assessment Recommendations - Future

- Upgrade existing primary digesters to enhance monitoring capabilities
- Investigate digester mixing system modifications
- Investigate modification of Digester 6 to operate as primary digester as a contingency plan
- Evaluate potential for digestion system modeling

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Questions

Digestion Survey

<http://dnr.metrokc.gov/wtd/survey-1>

