Annual IAWEA Biosolids Conference
March 15, 2023

Iowa City Biosolids and Biogas Planning

Tim Wilkey, P.E., Superintendent, City of Iowa City
Randy Wirtz, P.E., Strand Associates, Inc.®

History of WWTP/Digestion Components

- 1988-89 - South WWTP Construction:
  - 2 Meso Digesters + Storage
  - Land application of Class II (B) biosolids
- 2000-2002 Upgrades:
  - 4 new digesters
  - 2 Thermo + 4 Meso
  - Three stage TPAD operation
  - Land application of Class 1 (A) biosolids
- 2012-14 Upgrades:
  - Covered biosolids storage

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Scope of Facility Plan

- Anaerobic digestion complex
- Struvite mitigation
- Digester gas reuse

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Project Drivers – Age and Sustainability

To be successful, this project must:

- Establish a plan and CIP to renew assets related to digestion
- Iowa City Sustainability Goals
  - Digester gas
  - Nutrient recovery
  - Class A biosolids
  - Planning to meet future needs

Digester Complex Rehabilitation





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Digester Loadings – Current Conditions

Year	Average Digester Sludge Feed Flow (gpd)	Maximum Month Digester Sludge Feed Flow (gpd)	Total System Average HRT (days)	Total System Maximum Month HRT (days)	Thermophilic Average HRT (days)	Thermophilic Max Month HRT (days)
2017	61,200	80,800	39	30	17	13
2018	57,000	78,900	42	30	18	13
2019	53,800	68,900	45	35	19	15
2020	46,300	65,500	52	37	22	16
2021	49,400	71,200	49	34	21	15
Average	**53,700**	**73,100**	**45**	**33**	**19**	**14**

Note: gpd=gallons per day

Table 2.03-2 Digester Feed Flow

Fairly Long HRTs

Digester Loadings – Current Conditions

Year	Total System Average VLR (lb VS/1,000 ft^3/day)	Total System Max Month VLR (lb VS/1,000 ft^3/day)	Thermophilic Average VLR (lb VS/1,000 ft^3/day)	Thermophilic Max Month VLR (lb VS/1,000 ft^3/day)
2017	60	84	137	194
2018	57	75	131	173
2019	55	73	128	169
2020	49	65	112	150
2021	60	111	138	256
Average	**56**	**82**	**129**	**188**

Notes: VLR=volumetric loading rate; Max=maximum

Source: Table 2.03-2 and Table 2.03-3

Table 2.03-4 Digester Loading Rates

Fairly Low Loadings

Digester Gas Production – Current Conditions

Year	Digester Sludge Feed (lb VS/day)	% VS of Raw Sludge	% VS of Digested Sludge	%VS Destroyed	VS Destroyed (lb VS/day)	Gas Produced (ft^3/day)	Gas Produced (ft^3/lb VS destroyed)
2017	19,100	77	62	51	9,797	190,400	19
2018	18,200	77	62	53	9,573	179,000	19
2019	17,800	78	62	54	9,701	206,100	21
2020	15,600	80	63	58	9,062	197,700	22
2021	19,200	81	63	59	11,393	239,800	21
Average	**17,900**	**79**	**62**	**55**	**9,856**	**200,500**	**20**

Notes: ft^3/lb VS=cubic feet per pound volatile solids; ft^3/day=cubic feet per day

Table 2.03-5 Biosolids Loading and Gas Production Summary

Population Projections

	2014[1]	Current	2025[2]	2035[2]	2045[2]
Iowa City	73,415	77,971	80,700	88,200	95,700
University Heights	1,125	1,172	1,200	1,300	1,400
Total	74,540	79,143	81,900	89,500	97,100

Notes:
[1]Source: US Census Bureau
[2]Source: 2017-2045 MPOJC Long Range Transportation Plan

~30% increase

Table 3.02-1 Population Projections

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Digester Loading and Gas Production Projections

Year	Digester Sludge Feed (gpd)	Digester Sludge TS Load (lb TS/day)	Digester Sludge VS Load (lb VS/day)	Overall Digestion HRT (days)	Overall VLR (lb VS/1,000 ft^3/day)
Current[1]	53,700	22,800	17,900	45	56
2025	55,600	23,600	18,500	43	58
2035	60,700	25,800	20,200	40	63
2045	65,900	28,000	22,000	36	69

[1]Source: Table 2.03-2 and Table 2.03-3

Plenty of Capacity for the Future

Table 3.02-3 Projected Overall Digester Loadings

Anaerobic Digester Complex - Capacity

- Existing TPAD process has capacity for year 2045 design conditions
- Project Focus = Rehabilitation and Asset Renewal
- Evaluate digester mixing technologies

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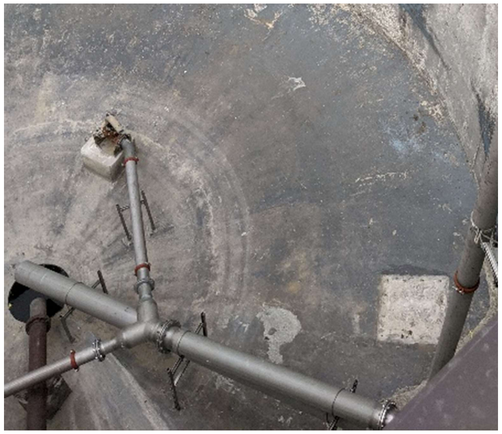
Evaluation of Mixing Alternatives

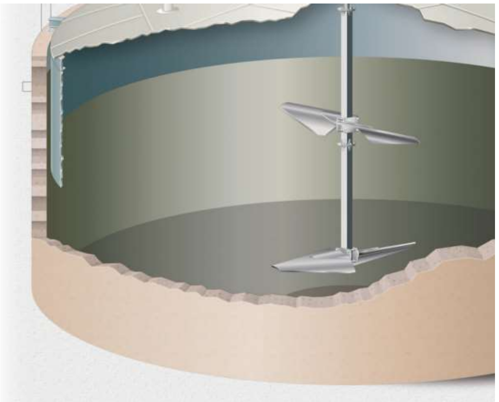
- Existing Mixers
  - EQ Tank (draft tube)
  - Thermos (draft tube)
  - Mesos Stage 1 (draft tube)
  - Mesos Stage 2 (pumped recirc)
  - Storage (pumped recirc)

- Problems with existing
  - Age and condition
  - Struvite adhesion and deposition

Evaluation of Mixing Alternatives

- Alternatives
  - M1: draft tubes for all
  - M2: pumped recirculation for all
  - M3: linear motion (LM) mixers for all
  - M4: vertical shaft mixers for all
  - M5: replacement in-kind





Evaluation of Mixing Alternatives – Pumped Recirculation

- M2: Pumped Recirculation
  - Replace meso pumped recirc mixing in-kind
  - Install pumps and nozzle systems on thermos and newer mesos.
  - Glass-lined ductile iron to reduce struvite
  - Include standby pumps for redundancy

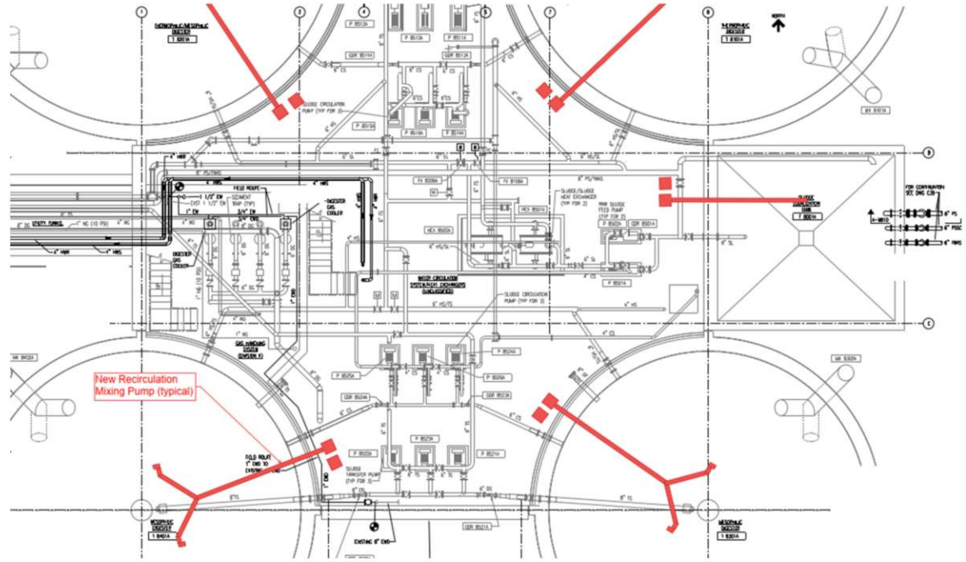


Figure 4.02-2 Preliminary Layout of Pumped Recirculation Mixing

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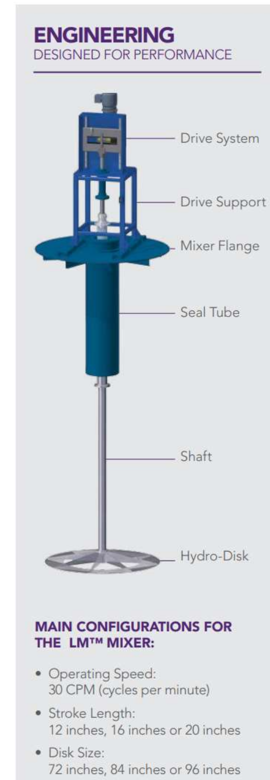
Evaluation of Mixing Alternatives – LM Mixers

- M3: LM Mixers
  - Mounted to top of gas dome
  - Low HP
  - Not as uniform mixing, but no reduction in VS destruction



Source: Ovivo

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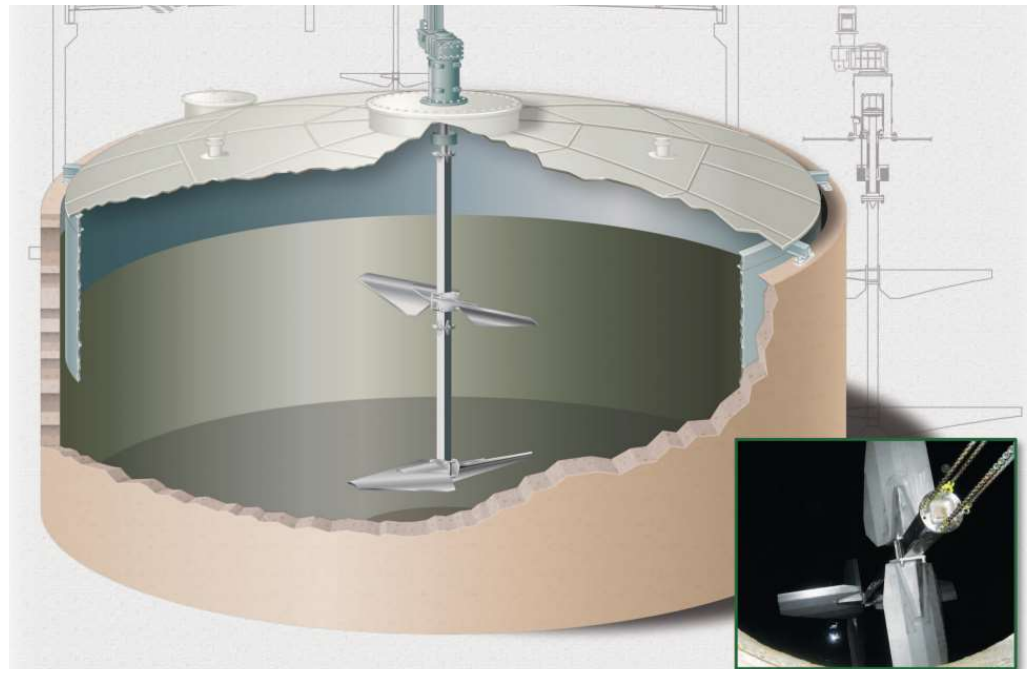
Evaluation of Mixing Alternatives – Vertical Shaft Agitation

- M4: Vertical Shaft Agitation Mixers
  - Mounted to top of gas dome
  - Low HP
  - Installations in Harlan, IA, and Webster City, IA, other locations in IL, MN and OH



Source: Walker Process

Evaluation of Mixing Alternatives – PW Cost and Recommendation

	Alternative M1–Draft Tube Mixing	Alternative M2–Pumped Recirculation Mixing	Alternative M3–Linear Motion Mixing	Alternative M4–Vertical Agitation Mixing	Alternative M5–Replace as Existing
Capital Cost	$5,229,000[4]	$3,927,000	$4,591,000	$4,976,000	$4,219,000[5]
Annual O&M					
Maintenance[1]	$58,000	$29,000	$43,000	$48,000	$45,000
Power[2]	$44,000	$71,000	$28,000	$24,000	$53,000
O&M Present Worth Cost	$1,571,000	$1,541,000	$1,420,000	$1,109,000	$1,510,000
Replacement	$0	$450,000	$0	$0	$0
Salvage Value	($20,000)	$0	($130,000)	($130,000)	($30,000)
Total Present Worth Cost[3]	**$6,780,000**	**$5,918,000**	**$5,881,000**	**$5,955,000**	**$5,699,000**

[1]Labor cost at $50 an hour.
[2]Power costs at $0.061 per kilowatt per hour (kWh).
[3]Costs in January 2023 dollars with a discount rate of 2.625 percent.
[4]Capital cost is $3,900,000 if only draft tube mixer and motors are replaced. Present worth cost is $5,450,000.
[5]Capital cost is $3,438,000 if only draft tube mixer and motors are replaced. Present worth cost is $4,840,000.

Table 4.02-1 Digester Mixing Alternatives Present Worth Summary

Anaerobic Digester Complex – Digester Covers

- Age of Covers:
  - Thermos – 2001, fixed stainless
  - Mesos Stage 1 – 2001, floating SS
  - Mesos Stage 2 – 1990, floating steel
  - Storage – 1990, Alum dome

- Problems with existing?
  - Insulation replacement on TPAD covers
  - New seals for Thermos
  - Updates for all gas management fixtures

Digester Covers

Rehabilitate and reinsulate newer stainless-steel covers

Replace old covers with new SS covers

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Digester Covers

Item	Capital Cost
Demolition	$50,000
Rehabilitation and Insultation (T8101 through T8401)	$479,000
New Digester Covers (T8601, T8701)	$1,797,000
Subtotal	$2,326,000
Piping and Mechanical	$582,000
Electrical	$116,000
Subtotal	$3,024,000
Contractor Profit, Bonds, and Insurance (10%)	$302,000
Contingencies, Legal, and Engineering (40%)	$1,210,000
Total Capital Costs (January 2023 Dollars)	**$4,536,000**

Table 4.03-2 Digester Cover Improvements Opinion of Capital Cost

Digester Heating System

Digester	Heat Exchanger	Type	Material	Fluid	Rated Transfer Capacity (kBTU/hour)	Year Installed
Raw Sludge	HEX8501	Spiral	Carbon Steel	Sludge/Sludge	4,501	2001
	HEX8502	Spiral	Stainless Steel	Sludge/Sludge	4,501	2017
T8101	HEX8101	Spiral	Carbon Steel	Sludge/Water	3,000	2001
T8201	HEX8201	Spiral	Carbon Steel	Sludge/Water	3,000	2001
T8301	HEX8301	Spiral	Carbon Steel	Sludge/Water	1,180	2001
T8401	HEX8401	Spiral	Carbon Steel	Sludge/Water	1,180	2001
T8601	HEX8601	Spiral	Stainless Steel	Sludge/Water	575	2011
T8701	HEX8701	Spiral	Stainless Steel	Sludge/Water	575	2011
T8601 and T8701	HEX8802	Spiral	Stainless Steel	Sludge/Water	1,800	2011

kBTU/hour = thousand British thermal units per hour

Table 4.03-3 Digester Sludge Heat Exchangers

- Replace older carbon steel heat exchangers with stainless steel units
- T8401 replaced in 2023

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Digester Heating - Costs

Item	Capital Cost
Demolition	$200,000
Sludge Macerators (4)	$229,000
Sludge Circulation Pumps (9)	$554,000
Spiral Heat Exchangers (4)	$819,000
Plate and Frame Heat Exchangers (3)	$123,000
Boilers (2)	$1,181,000
Hot Water Pumps (8)	$105,000
Subtotal	$3,211,000
Piping and Mechanical	$803,000
Electrical	$963,000
Subtotal	$4,977,000
Contractor Profit, Bonds, and Insurance (10%)	$498,000
Contingencies, Legal, and Engineering (40%)	$1,991,000
Total Capital Costs (January 2023 Dollars)	**$7,466,000**

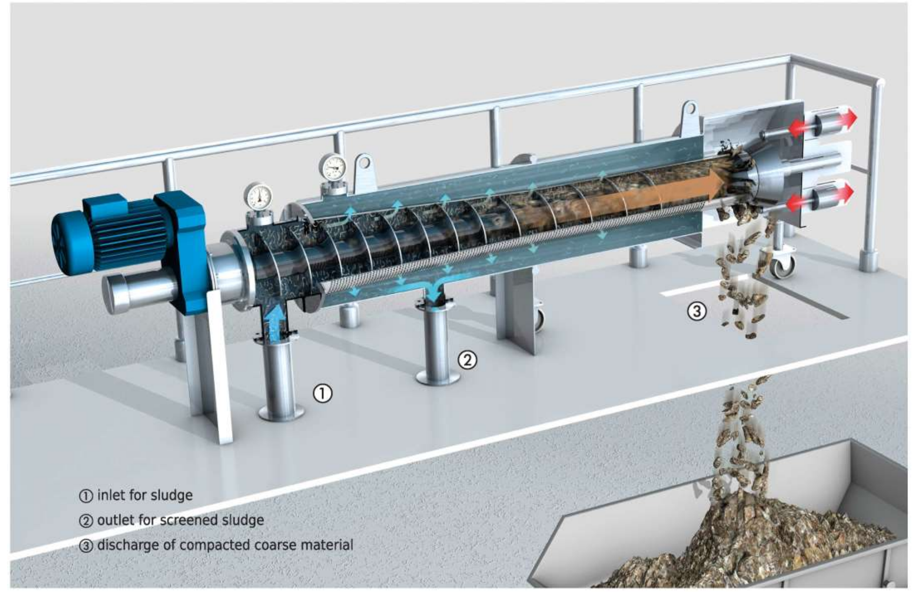
Table 4.03-4 Digester Heating System Improvements Opinion of Capital Cost

Sludge Transfer Pumps - Costs

Item	Capital Cost
Demolition	$50,000
Sludge Macerators (5)	$286,000
Raw Sludge Pumps (2)	$133,000
Sludge Transfer Pumps (9)	$599,000
Subtotal	$1,068,000
Piping and Mechanical	$267,000
Electrical	$320,000
Subtotal	$1,655,000
Contractor Profit, Bonds, and Insurance (10%)	$166,000
Contingencies, Legal, and Engineering (40%)	$662,000
Total Capital Costs (January 2023 Dollars)	**$2,483,000**

Sludge Screening

- Screen Perforation 2-10 mm, typically 5 mm
- Removes coarse material (hair, fiber, plastic)
- Huber installations in WI, IL, MN, and IA (Osceola)
- Hydro installations in WI (Milwaukee, Wausau)



Source: Huber (Left) and Hydro-Dyne (Right)

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Sludge Screening

Item	Capital Cost
Demolition	$50,000
Building	$288,000
Screened Sludge Tank	$64,000
Screened Sludge Tank Pumped Mixing System	$150,000
Sludge Screens (2)	$413,000
Digester Feed Pumps (2)	$133,000
Subtotal	$1,098,000
Sitework	$51,000
Piping and Mechanical	$275,000
Heating, Ventilation, and Air Conditioning (HVAC)	$165,000
Electrical	$329,000
Subtotal	$1,922,000
Contractor Profit, Bonds, and Insurance (10%)	$192,000
Contingencies, Legal, and Engineering (40%)	$769,000
Total Capital Costs	**$2,883,000**

Table 4.04-1 Sludge Screening Opinion of Capital Cost

Summary of Costs

Item	Capital Cost
Digester Covers	$4,536,000
Digester Heating System	$7,466,000
Sludge Transfer Pumps	$2,483,000
Sludge Screening	$2,883,000
Credit for Removing Macerators[1]	($1,200,000)
Mixing (Alternative M3)	$4,591,000
Total Capital Costs (January 2023 Dollars)	**$20,759,000**

[1]Deduction for macerators includes associated work (electrical, mechanical, piping, engineering, and construction).

Table 4.06-1 Digestion Improvements Opinion of Capital Cost

Struvite Mitigation

Struvite Mitigation Benefits

- Reduces struvite related O&M costs
- Improves equipment life
- Increases digester usable capacity
- Reduces total P in recycle streams and in effluent
- Helps meet nutrient reduction goals as required by DNR

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Struvite Mitigation – Alternatives

- Alternative S1: Add Ferric to Thermophilic Digesters (Continue TPAD)
- Alternative S2: Convert to All Mesophilic Digestion and add Ferric
- Alternative S3: Bio-P, Struvite Sequestration with WAS P-release
  - Ostara
  - Magprex
  - NuReSys
  - Elovac-P

Alternative S1: TPAD with Iron Addition

- Existing iron storage uses non-permanent storage tank
- Currently injecting in sludge equalization tank prior to thermos digesters
- Construct more permanent chemical feed building and systems
- Add ~400 gpd of Ferric Chloride

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Alternative S2: Conversion to Mesophilic Digestion with Iron Addition

- All Mesophilic Digestion eliminates drop in temperature and struvite precipitation in sludge heat exchangers
- Does not meet Class A Biosolids requirements
- Construct more permanent chemical feed building and systems
- Add ~250 gpd of Ferric Chloride

Alternative S3: Bio-P, Struvite Sequestration with WAS P-release

OSTARA

cnp
CARBON | NITROGEN PHOSPHORUS
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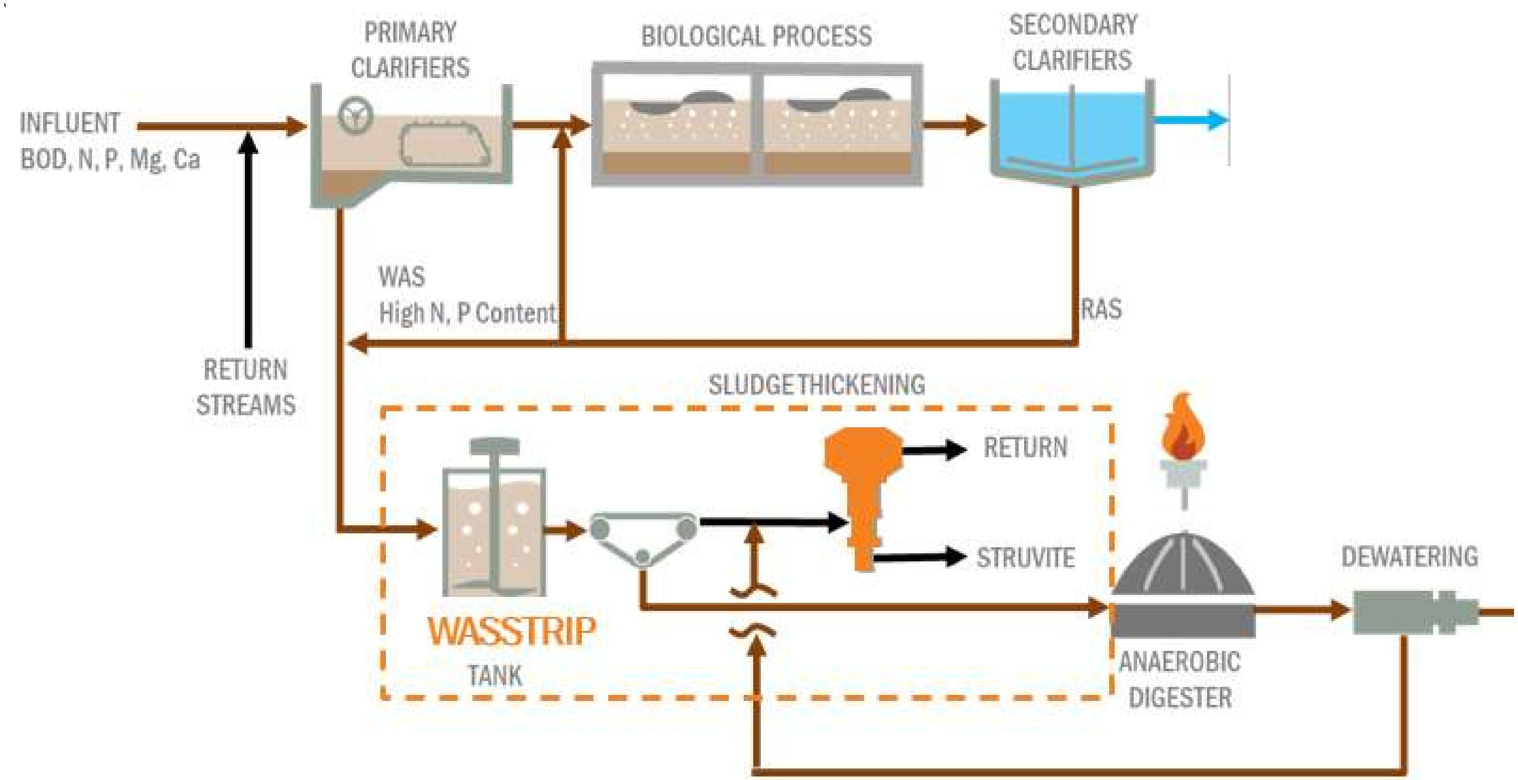
NuReSys

OVIVO

Alt. S3 – Struvite Mitigation

- Minimize M



Struvite Mitigation – Present Worth Cost Analysis

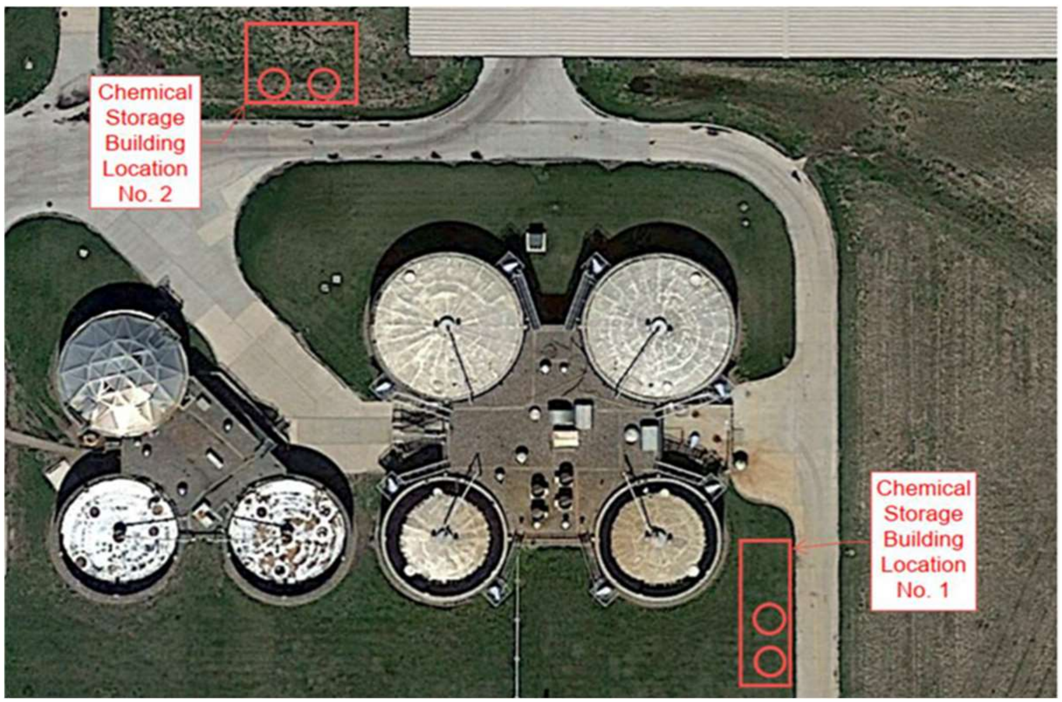
Table 5.05-1 Struvite Mitigation Alternatives–Opinion of Present Worth Cost Analysis

	Alternative S1 TPAD with Iron Addition	**Alternative S2 Conversion to Mesophilic Digestion with Iron Addition**	**Alternative S3 BPR with Struvite Recovery and WAS P-Release**
Total Capital Costs	$1,373,000	$1,373,000	$13,223,000
Average Annual O&M Costs, Year 20			
Value of Additional Power Required[1]	$1,200	$1,200	$4,000
Labor	$3,000	$3,000	$31,000
Chemicals[2]	$197,000	$123,000	$28,500
Polymer and Biosolids Disposal[3]	$26,000	$13,000	$-
Struvite Revenue[4]	$-	$-	$21,600
Maintenance and Supplies	$12,000	$12,000	$70,000
Natural Gas Purchased[5]	$-	$13,000	$1,000
Subtotal Opinion of Annual O&M, Year 20	**$239,000**	**$152,000**	**$156,000**
Present Worth of O&M	$3,684,000	$2,344,000	$2,404,000
Present Worth of Future Equipment	$76,000	$76,000	$48,000
Present Worth of Salvage	$(123,000)	$(123,000)	$(254,000)
Total Present Worth[6]	**$5,010,000**	**$3,670,000**	**$15,421,000**

Notes:

Struvite Mitigation – Comparisons

- Selected Alternative S1 – Keep TPAD and add iron
- Pilot testing proved successful with lower than projected iron doses
- Construct permanent ferric chloride storage and feeding facilities



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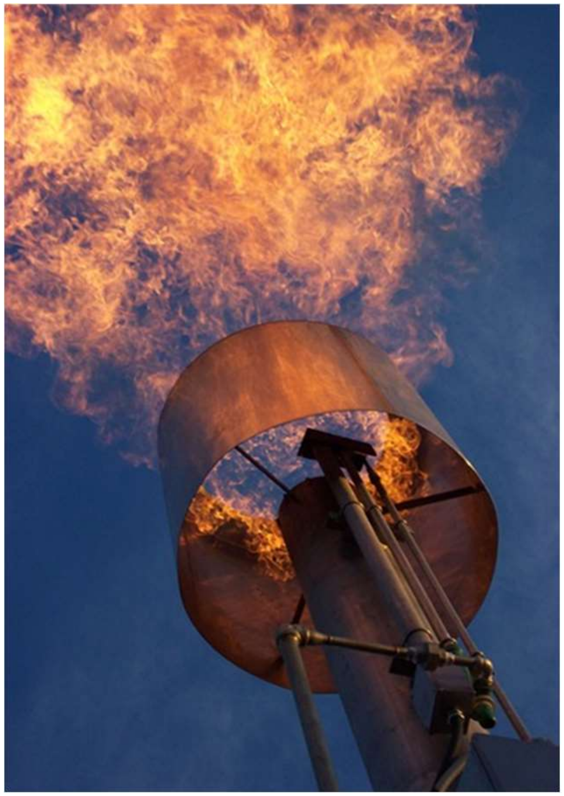
Digester Gas Reuse - Alternatives

1. Building and process heat
2. Cogeneration – engines or microturbines
3. Pipeline quality gas (Renewable Natural Gas; RNG)
4. High-strength waste impacts



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Digester Gas Reuse – Gas Cleaning

Gas Conditioning	Boilers	Engines	Micro-turbines	Renewable NG
Hydrogen Sulfide Removal		X	X	X
Moisture Removal		X	X	X
Siloxane Removal		X	X	X
Carbon Dioxide Removal				X
Compression (3 to 5 psi)		X		
Compression (75 to 110 psi)			X	X

H2S and Siloxane Removal

Media Based H_2S and Siloxane Removal

Biological H_2S Removal

Engines and Microturbines – Cogeneration

- Microturbines are typically more expensive and less electrically efficient than gas engines
- Microturbines have a large parasitic load for compression

Fond du Lac Biogas Engine

Dubuque microturbines

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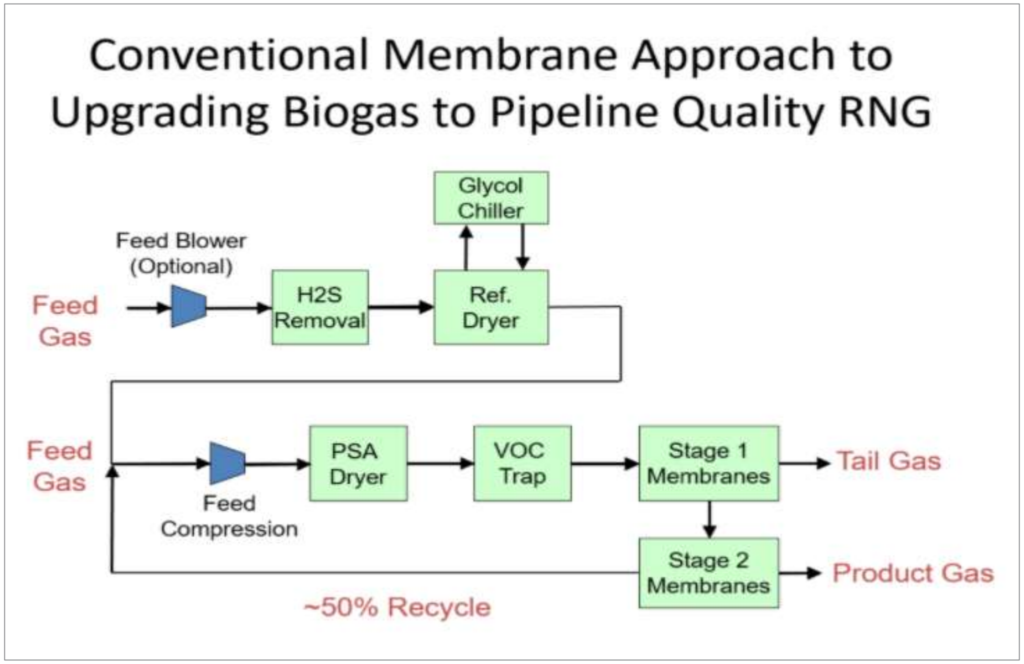
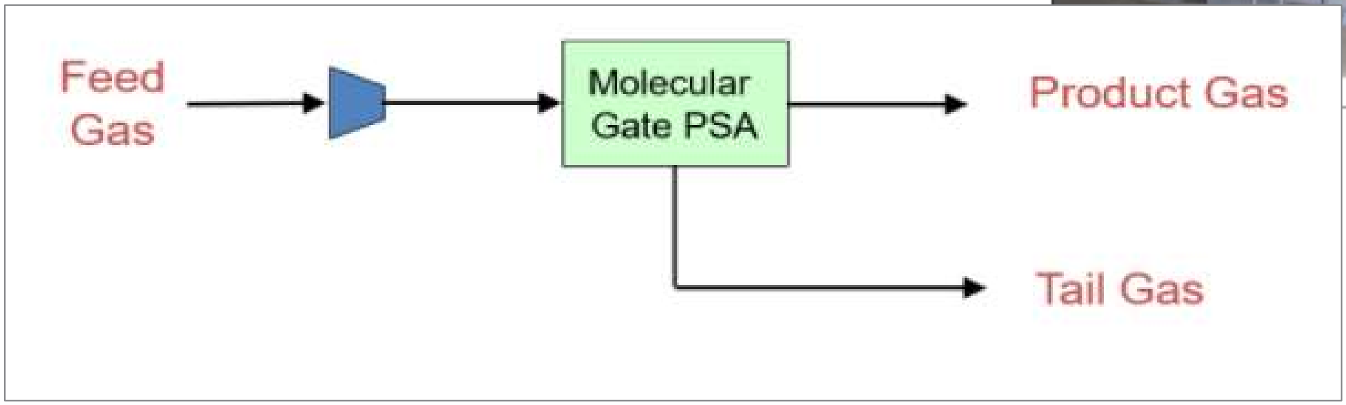
CO_2 Removal - Membranes



CO2 Removal – Pressure Swing Adsorption (PSA)



Dubuque PSA and Pipeline Injection

Codigestion Receiving Stations

- Type(s) of feed stock
  - Heating
  - Screening/grinding
  - Other processing

Alternative DR-1: Use Digester Gas in Boilers (current operations)

- Replace existing two boilers within next 5+ years

Iowa City Boilers

Alternative DR-2: CHP with Reciprocating Engines

- Install one new 760-kW engine in new building (or 2 smaller engines)
- Boilers continue to be maintained to supply supplemental heat

Fond du Lac Biogas Engine

Alternative DR-3: Microturbines

- Install one new 600-kW Microturbine system (3x 200-kW) in weather-proof enclosure
- Boilers continue to be maintained to supply supplemental heat for process and facilities

Dubuque microturbines

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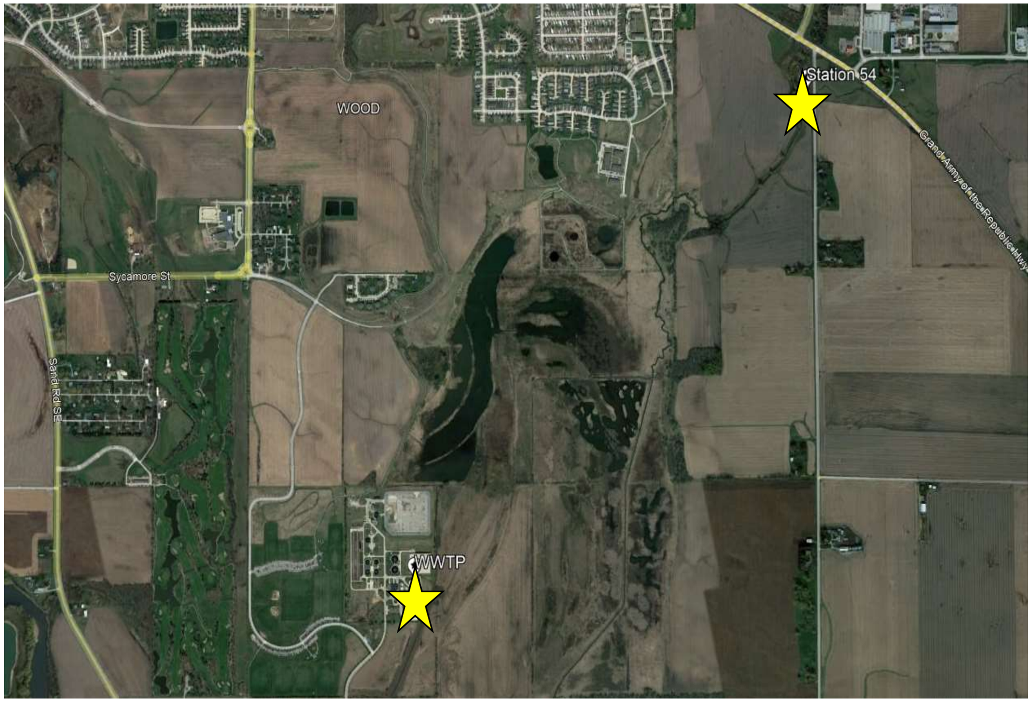
Alternative DR-4: Pipeline Injection

- Install gas conditioning system to produce high-value renewable natural gas (RNG) that can be sold

- Connection point: 2.5 miles of 4” pipe



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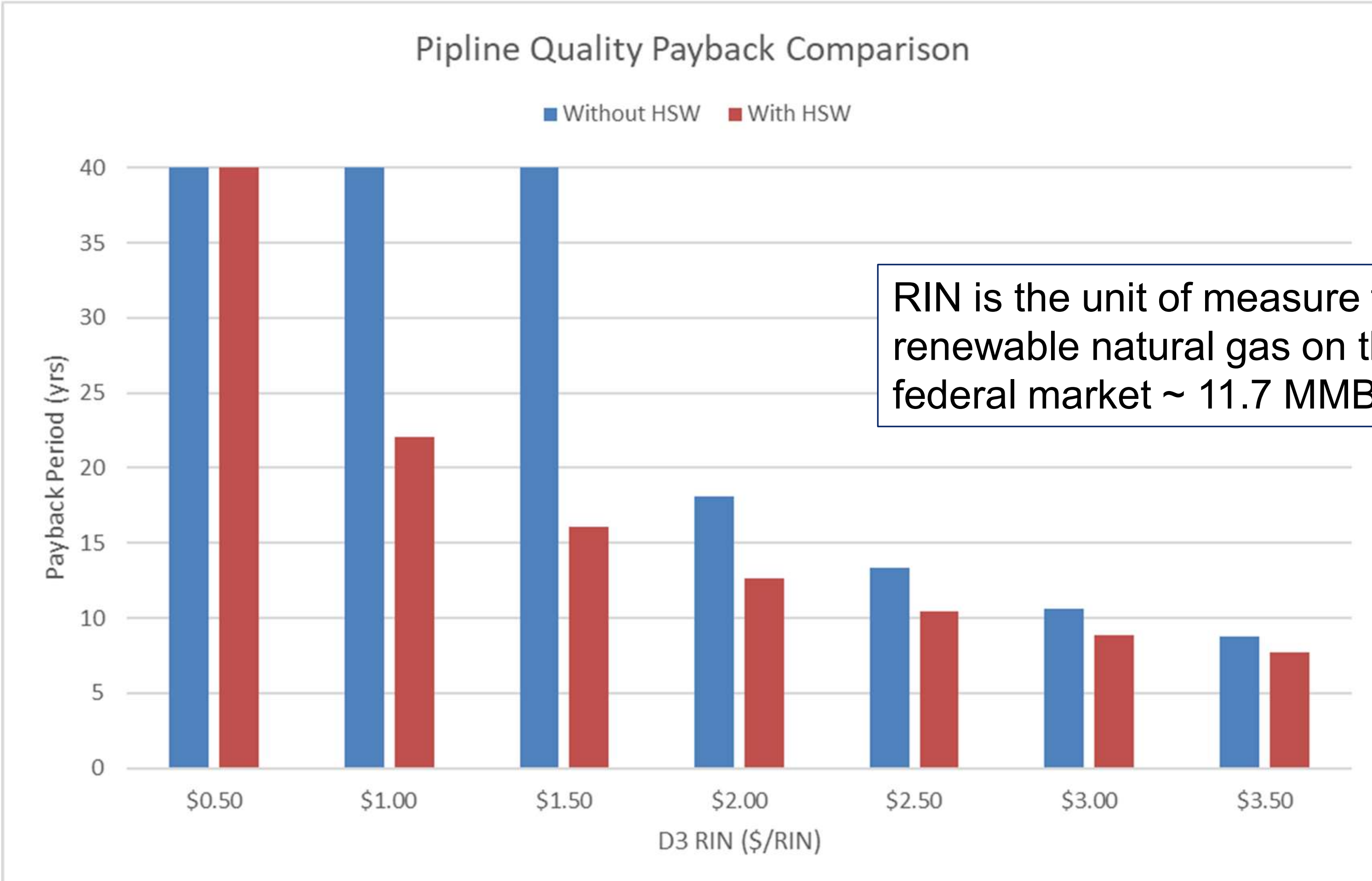
Digester Gas Reuse – Present Worth Analysis w/ HSW

	Alternative DR-1– New Boilers with HSW	Alternative DR-2– New Engines with Gas Conditioning with HSW	Alternative DR-3– New Microturbines with Gas Conditioning with HSW	Alternative DR-4– Pipeline Quality Natural gas with HSW
Total Capital Costs	**$6,070,000**	**$9,925,00**	**$11,022,000**	**$13,812,000**
Average Annual O&M Costs, Year 20				
Value of Additional Power Required[1]	$-	$24,000	$55,000	$96,000
Value of Electrical Production or RINs[2]	$-	$(378,000)	$(305,000)	$(1,013,000)
Value of Brown Gas Sales[3]	$-	$-	$-	$(281,000)
Gas Conditioning Equipment and Media Replacement	$-	$52,000	$52,000	$56,000
Equipment Maintenance and Overhaul[4]	$32,000	$149,000	$120,820	$21,000
Natural Gas Purchased[5]	$-	$66,000	$56,000	$215,000
Local Utility Charge	$-	$-	$-	$60,000
Tipping Fee Revenue[6]	$(159,000)	$(159,000)	$(159,000)	$(159,000)
Subtotal Opinion of Annual O&M, Year 20[7]	**$(127,000)**	**$(246,000)**	**$(180,000)**	**$(1,005,000)**
Present Worth of O&M	$(3,103,000)	$(4,796,000)	$(4,017,000)	$(15,982,000)
Total Present Worth[8]	**$2,967,000**	**$5,129,000**	**$7,005,000**	**$(2,170,000)**
Subtotal Opinion of Annual O&M, Equivalent Annual	**$(201,000)**	**$(311,000)**	**$(261,000)**	**$(1,037,000)**
Direct Payback=Capital Cost/Equivalent Annual Savings (years)	**30**	**32**	**42**	**13**

Notes:

Digester Gas Reuse – RIN Sensitivity



RIN is the unit of measure for renewable natural gas on the federal market ~ 11.7 MMBTU

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Summary - Capital Cost and Phasing

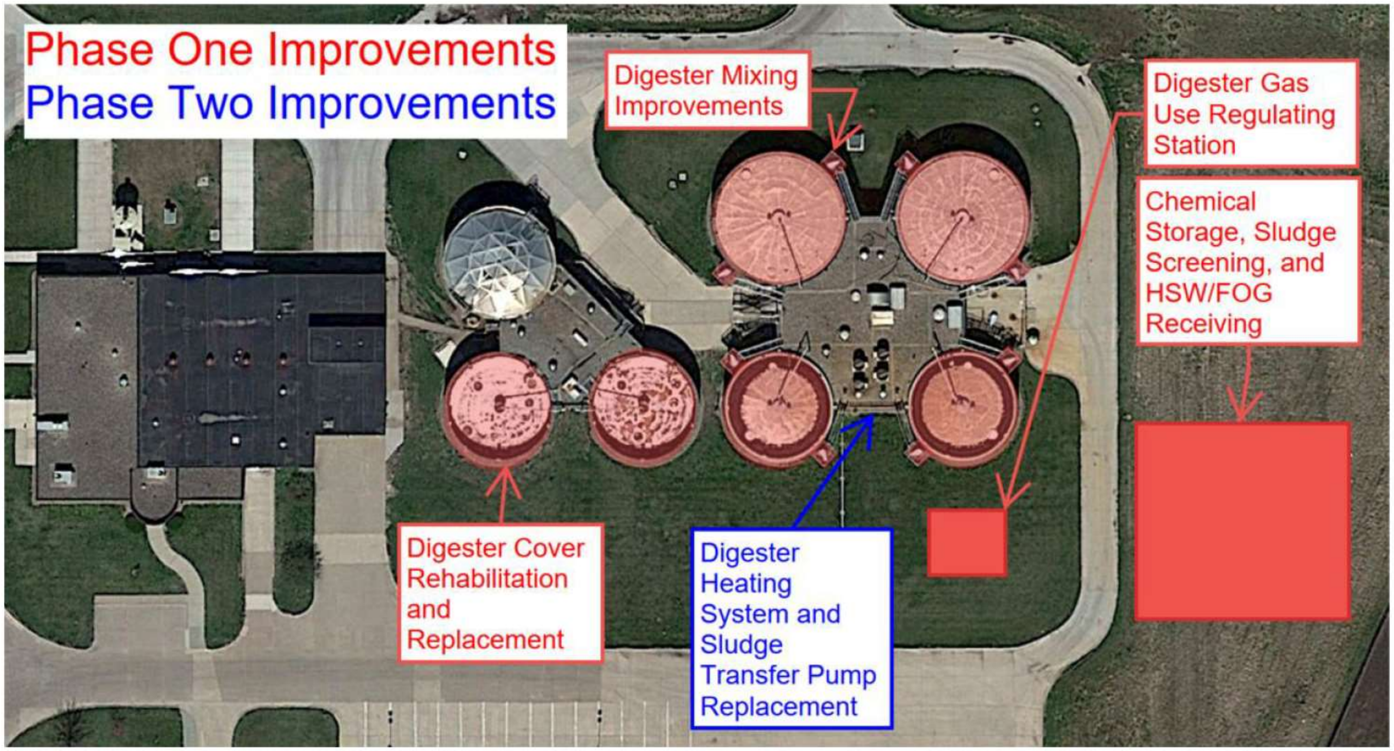

Figure 7.03-1 Recommended Improvements

Capital Cost and Phasing

Component	Phase 1	Phase 2
Digestion Improvements		
Alternative M3-Linear Motion Mixing	$4,591,000	
Digester Cover Rehabilitation and Replacement	$4,536,000	
Digester Heating System Replacement		$7,466,000
Sludge Transfer Pumps Replacement		$2,483,000
Sludge Screening Improvements	$2,883,000	
Struvite Mitigation		
Alternative S1-TPAD with Iron Addition	$1,373,000	
Digester Gas Use Improvements		
Alternative DR-4-Pipeline Quality Natural Gas with HSW	$13,812,000	
Total Opinion of Capital Costs	**$27,195,000**	**$9,949,000**

Notes:
All costs are in January 2023 dollars.

Acknowledgements

- City of Iowa City
  - Tim Wilkey, Superintendent
  - Steve Flake, Operations Manager
  - Ben Clark, Engineering

- Brown and Caldwell
  - Nancy Andrews
  - Don Esping

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Question and Answer

Thank you for coming!

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Excellence in Engineering SM

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