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History of Wastewater Treatment in the US

1800s

- US population grew from 5 million to 75 million
- Primary Development: Collection Systems
- Purpose: Disease Prevention
    - Pit privies and open ditches replaced by buried sewers
    - Treatment was mostly dilution into receiving waters

Early Management Practices

Trends: Awareness and control of impacts of sewage discharge on receiving waters through standards, regulation and simple treatment

- 1886 – Standards for discharge loading and treatment developed at Lawrence, MA experiment station and for Chicago
- 1887 – First biological treatment, an intermittent sand filter installed in Medford, MA

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History of Wastewater Treatment in the US

Early Management Practices cont…

- 1899 – First federal regulation of sewage, Rivers Harbors Appropriations (Refuse Act) prohibited discharge of solids to navigational waters without permit from US Army Corps of Engineers

Trend: Development of Secondary (biological treatment)

- 1901 – First trickling filter operated in Madison, WI
- 1909 – First Imhoff tank (solids settling)
- 1914 – First liquid chlorination process for effluent disinfection
- 1916 – First activated sludge plant, San Marcos, TX

Trend: Protection of Receiving Water Quality

- 1974 – The Clean Water Act primary objective is to restore and maintain the integrity of the nation's waters. The had two goals:
- 1) Eliminate the discharge of pollutants into waters
- 2) achieve water quality levels that are fishable and swimmable

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New opportunities in an old industry

- Treatment plants are facing capital, technical, and regulatory challenges.
- Federal funding to address these challenges continues to decrease[1]
  - State and local governments account for 96% of all public spending on water and wastewater utilities[2].
- During the same period, wastewater utility rates have more than doubled. [1]
- Treatment plants consume 4% of the total US energy demand[5].
- Biosolids have the potential to produce 12% of the US electric demand![1]

1. Source: NACWA, WERF, and WEF The Water Resources Utility of the Future pages 25 and 14
2. Source: Environmental Finance Center "Four Trends in Government Spending on Water and Wastewater Utilities"
3. Source: Cleveland Plain Dealer "Regional Sewer District Discussing 9.5% Annual Rate Hikes"
4. Source: Cleveland Plain Dealer "Akron Water Bill too High?"
5. Source: Energy Power Research Institute "Water and Sustainability – US Electricity Consumption for Water Supply and Treatment"

Note: 4% covers both water and wastewater treatment

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Infrastructure Upgrades

- 1960's and 1970's infrastructure investments in 1950's stabilization technologies are nearing the end of their useful life
  - $105.3 billion[1] needs to be invested in these facilities over the next 20 years
- Anaerobic digested sludge with co-digestion can provide a solution to the capital required via self-funding mechanisms including;
  - Return on investment through self generation of electricity or renewable natural gas (RNG)
  - Tipping fees from outside biomass (new customer base)
- A complete analysis of the treatment plant's existing infrastructure, the energy potential of on-site biosolids, and the availability of outside regional feedstocks needs to be completed to determine if co-digestion is appropriate.

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1. Source: USEPA Clean Watersheds Needs Survey

The Utility of the Future

The Utility of the Future transforms itself into a manager of valuable resources, a partner in local economic development, and a member of the watershed community seeking to deliver maximum environmental benefits at the least cost to society.

It does this by:

- reclaiming and reusing water
- extracting and finding commercial uses for nutrients
- capturing heat and latent energy in biosolids

Not Enough for Energy Neutrality

- Most WRRFs do not have enough energy potential to achieve energy neutrality based on the biogas potential of their residual biosolids alone
- To achieve energy neutrality more energy dense outside material such as FOG and food waste is often needed

Facility Size	Load (kW)	Energy Potential Biosolids Only (kW)	Percent Electric Covered with Biogas
4 MGD	198	69	35%
4.6 MGD	760	84	11%
11 MGD	900	377	42%
12 MGD	1196	260	22%
13 MGD	1600	859	54%
22.5 MGD	1500	314	21%

Sampling of WRRF facilities quasar evaluated for biogas utilization and co-digestion potential

Co-digestion Benefits

- Co-digestion presents a significant solution for many wastewater treatments to improve infrastructure without increasing rate payer costs.
- Increased energy generation can lead to net neutrality
- Access to a new revenue stream to offset capital costs
- Economic development tool
- Lowers volume of local waste being sent to landfills

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Value of Co-digestion

- Enhanced energy production; can take the WWTP off the grid
- Tipping fees supports the operational budget of the WWTP
- Supports land-fill footprint reduction
- Provides local businesses with a sustainable waste management solution

	Facility A	Facility B	Facility C
Average Annual Volume (wet tons)	31,468	41,884	31,560
Tip Fee ($/ton)	36	32	50
Total Tip Fee Revenue	$1,132,848	$1,340,288	$1,690,560
Energy Generated (kW)*	550	730	550
Energy Value ($/kW)	$0.08	$0.08	$0.08
Energy Revenue	$385,440	$511,584	$385,440
Total Revenue	$1,518,288	$1,851,872	$2,076,000

* The chart assumes an electric generator efficiency of 38%.

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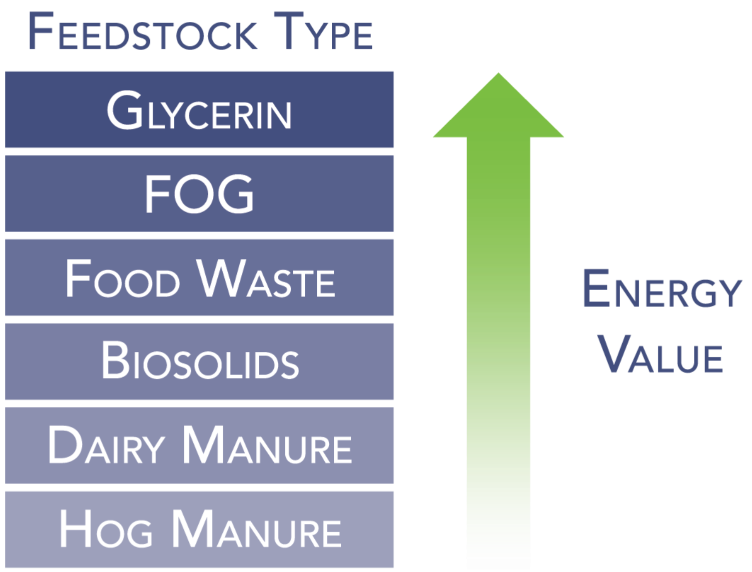
Comparison of Biosolids, FOG and Food Waste

- The energy potential per dry ton of material is significantly higher for food waste and FOG compared to biosolids.
- High strength material (food waste and FOG) can increase energy production of an onsite digester to an output that can offset a greater portion of the WWTP's demand.
- The higher volatile solids rate indicates a greater portion of the solid fraction of the material is available to be broken down during anaerobic digestion.
- The high gas potential illustrates that, on a per pound of volatile solids basis, more gas can be produced from these feedstock.

Material	Total Solids	Volatile Solids	Biogas Potential m3/kg VS
Digested Sludge	2 - 6%	70 - 85%	.6
Waste Activated Sludge	0.5 - 1%	55 - 65%	.5
Primary Sludge	2 - 5%	40 - 60%	0.25 - 0.4
Food waste	6 - 20%	80 - 95%	0.6 - 0.9
Fats, oils, and greases	3 - 6%	90 - 95%	0.7 - 1.2



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Biogas and Electricity Made From Cow Manure

Manure Wet Tons/Day	# of Holstein Cows	Biogas/Day (MMBtu)	Electric kWh/Day
54.0	1,300	35.2	3,921
58.1	1,400	37.9	4,222
62.3	1,500	40.6	4,524
66.4	1,600	43.3	4,825
70.6	1,700	46.0	5,127
74.7	1,800	48.7	5,428
78.9	1,900	51.5	5,730
83.0	2,000	54.2	6,032
87.2	2,100	56.9	6,333
91.3	2,200	59.6	6,635
95.5	2,300	62.3	6,936

Co-digestion at Ohio Wastewater Treatment Plants

Two Ohio wastewater treatment plants have adopted the co-digestion model to upgrade aging infrastructure, expand capacity and achieve energy neutrality without increasing costs to the community.

Eastern Ohio Regional Wastewater Authority (EORWA)
Bellaire, OH

Lucas County Water Resource Recovery Facility
Waterville, OH

Case Study I: Lucas County, Ohio

Average Flow: 15 MGD
Digestion Capacity: 3M gallons
Project Goals:

- ✓ **Required digester maintenance and upgrades to extend asset life**
- ✓ **Achieve energy neutrality**
- ✓ **Earn tip fees from merchant material to finance improvements instead of raising rates**
- ✓ **Produce Class A biosolids material for more flexibility in beneficial reuse**

Case Study I: Lucas County, Ohio

Scope of project

- Project started as digester upgrades, evolved to full codigestion project to make plant energy neutral (1.5 MW)
- Feedstocks include Lucas Co. biosolids and regional food waste, biosolids and FOG
- Installation/Construction of New:
  - Centrifuges and centrifuge building
  - Sludge storage building
  - Flexible membrane roofs
  - Solids/ liquids receiving
  - Mixing, flare, heat exchangers, and CHPs
  - Process piping, electrical, etc.
  - Front end Class A process (Lucas Co. currently produces Class B)

Long term, quasar will be contracted by Lucas Co. to manage the incoming biomass to the plant.

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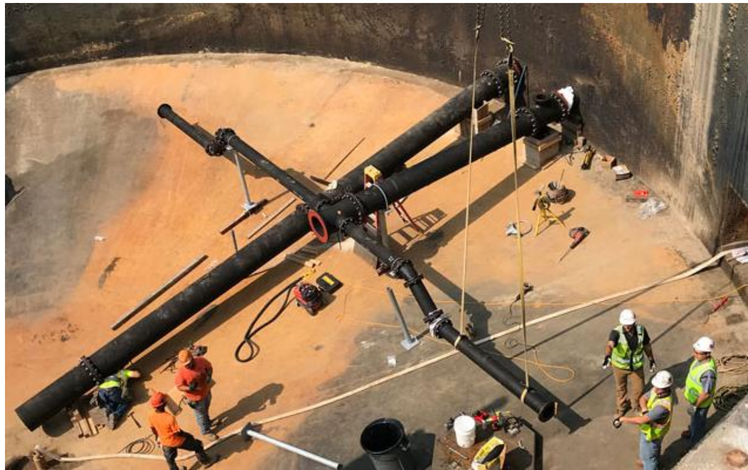
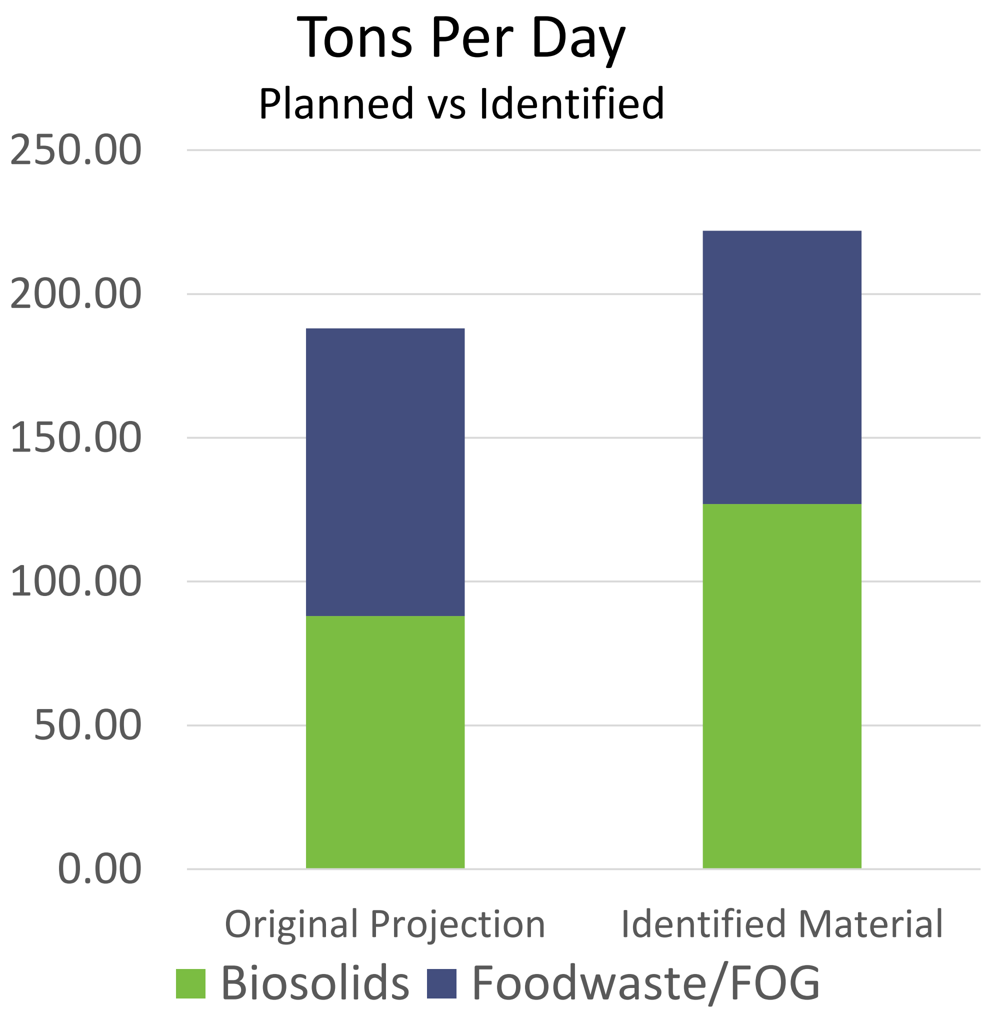
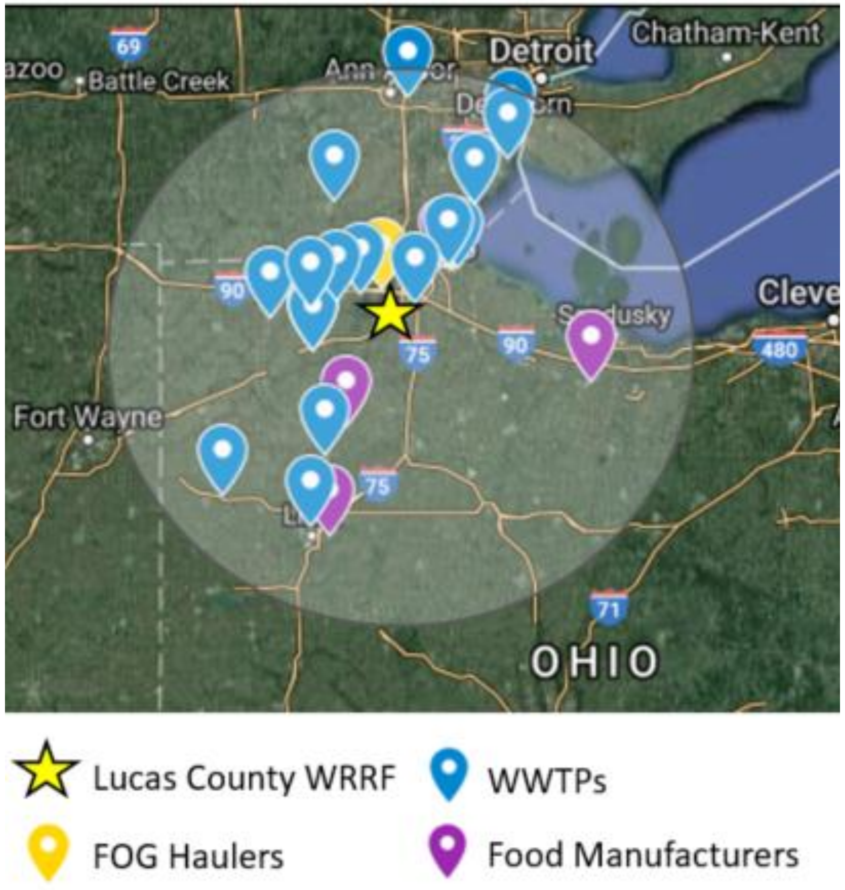


Case Study I: Lucas County, Ohio



Regional Organic Waste



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Case Study I: Lucas County, Ohio

Customer/Biomass Inputs per Day	Wet Tons	%TS	%VS	Dry Tons
Lucas Biosolids	233.6	4%	68%	9.1
Outside Biosolids	127.3	21%	58%	26.7
FOG and Septage	43.1	11%	92%	4.5
Food & Processing Waste	51.5	22%	81%	11.3
Total Blended Biomass	**455.5**	11%	**68%**	**51.6**

High energy density recipe

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Case Study I: Lucas County, Ohio

Projected Outcome

Once complete, the new **energy neutral** Lucas County digester will

- Provide the plant with a contingency plan for biosolids processing,
- Save over $700,000 per year in energy costs,
- Produce $128,000 worth of sellable Renewable Energy Credits (RECs) annually
- Generate $1,240,000 in revenue from tipping fees

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Case Study I: Lucas County, Ohio

Roof Before Construction

Case Study I: Lucas County, Ohio

Roof Under Construction

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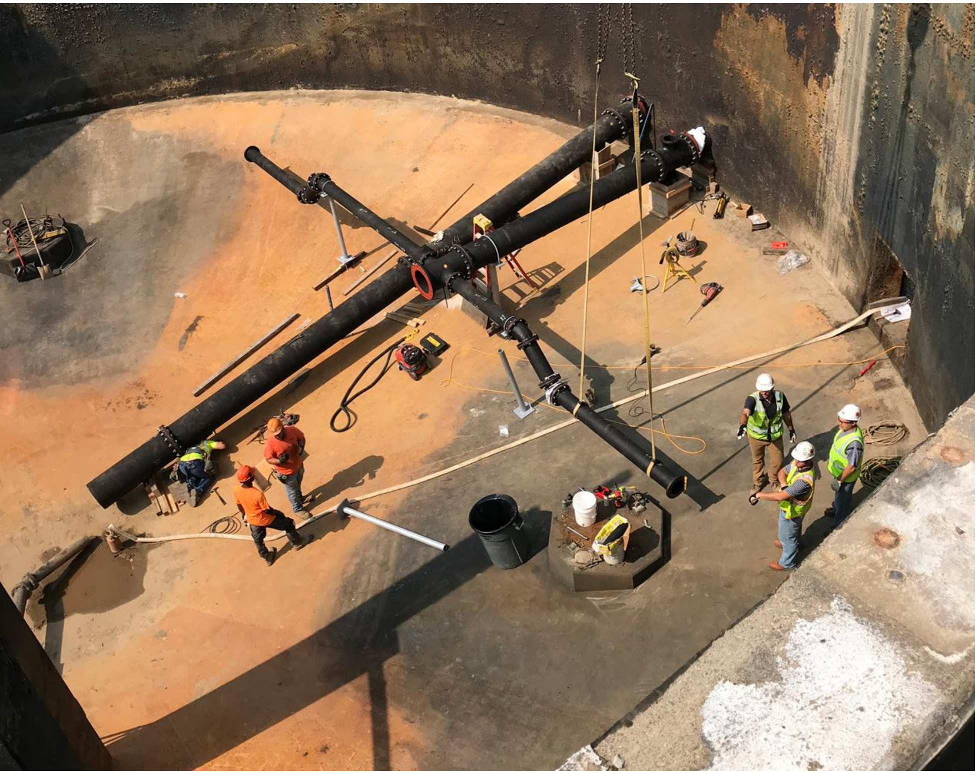
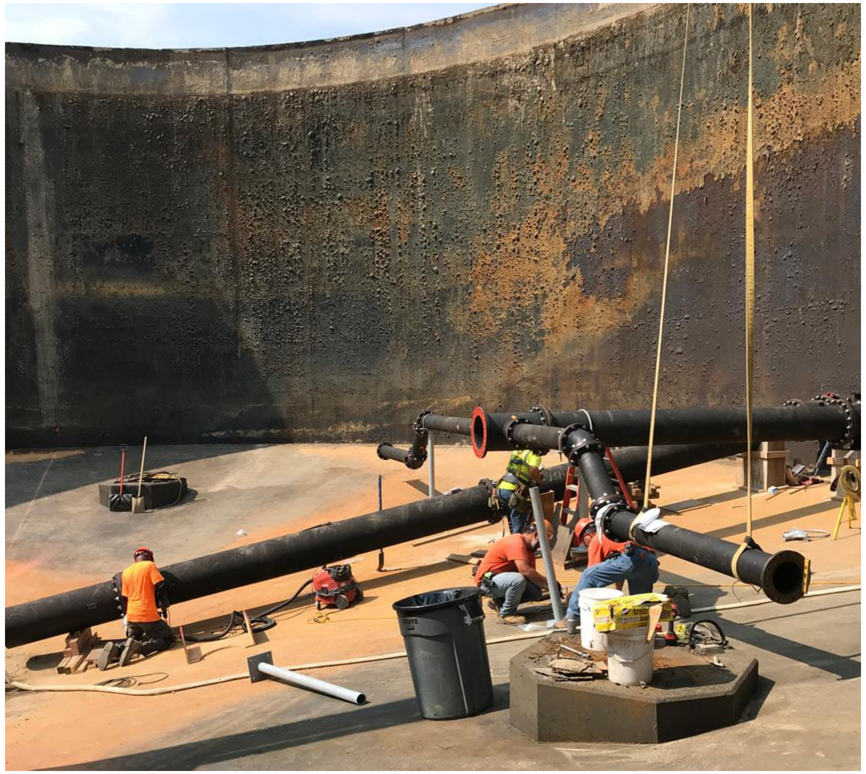
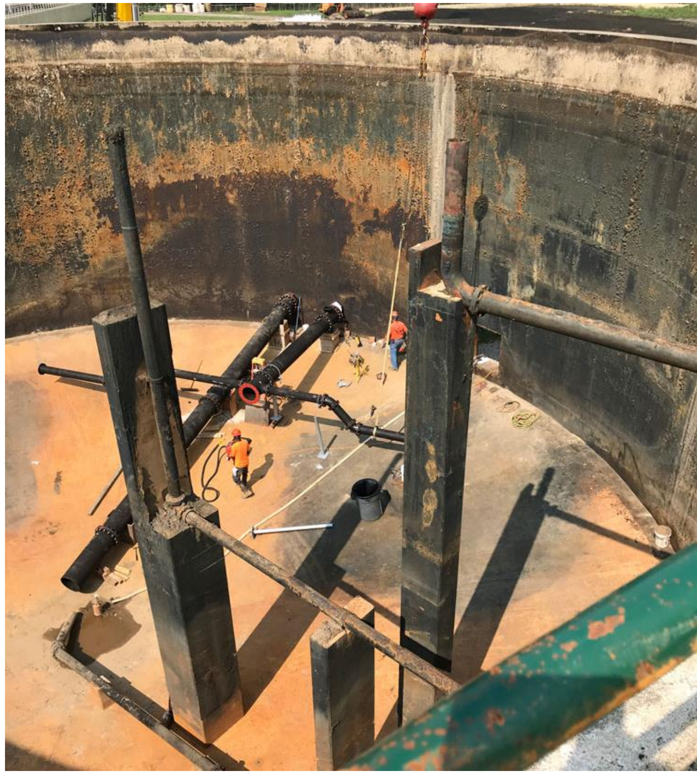
Case Study I: Lucas County, Ohio

Digester Piping Construction







Case Study I: Lucas County, Ohio

Solids Receiving Pit

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Case Study I: Lucas County, Ohio

Belt Press/Centrifuge

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Case Study I: Lucas County, Ohio

Biosolids Storage

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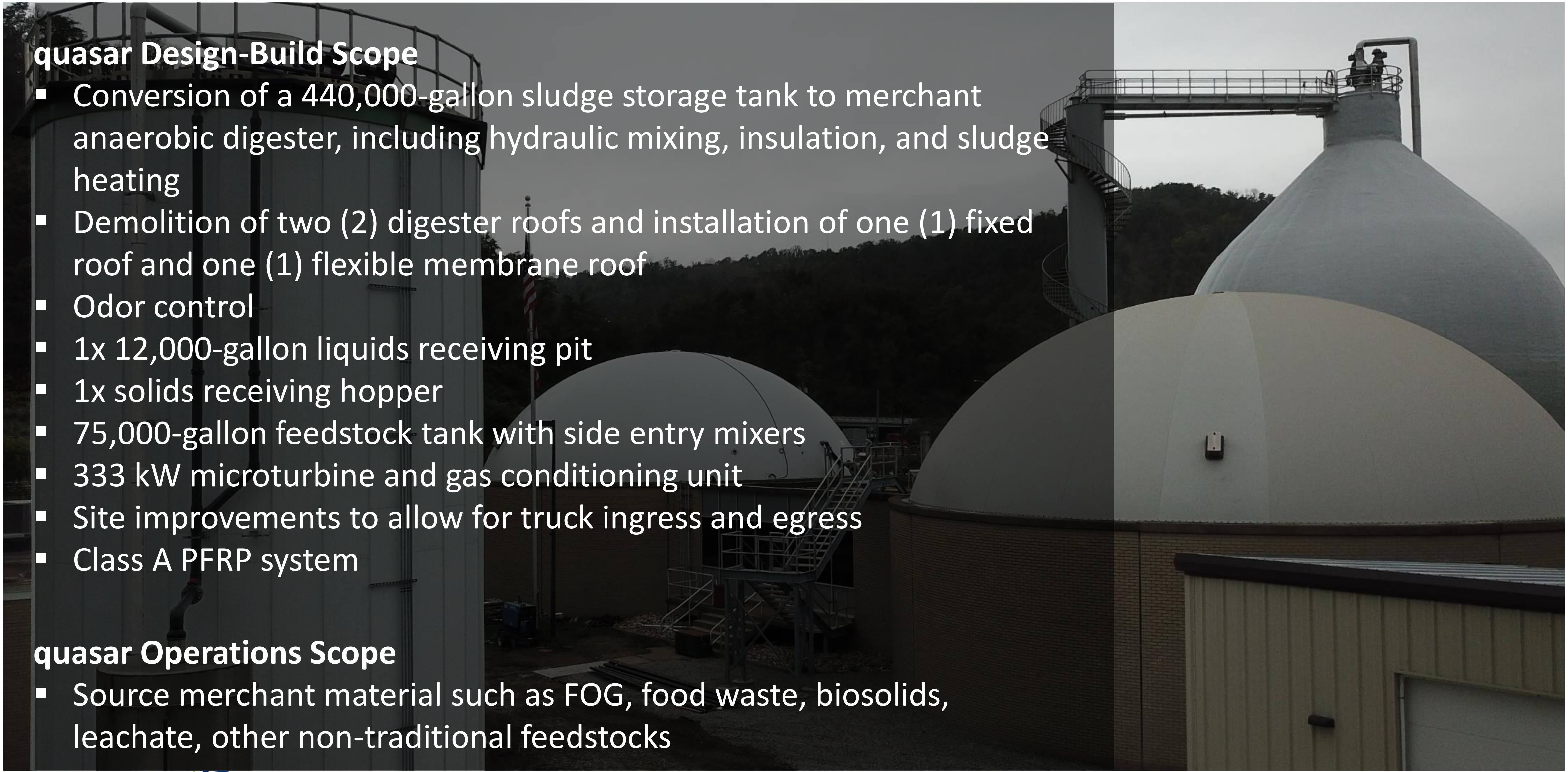
Case Study II: (EORWA) Bellaire, Ohio

Average Flow: 4 MGD
Digestion Capacity: 1M gallons
Project Goals:

- ✓ **Achieve energy neutrality**
- ✓ **Earn tip fees from merchant material to finance improvements instead of raising rates**
- ✓ **Produce Class A biosolids material for more flexibility in beneficial reuse**
- ✓ **Retrofit existing asset to future proof facility when older equipment reaches end of useful life**

Case Study II: (EORWA) Bellaire, Ohio



quasar Design-Build Scope

- Conversion of a 440,000-gallon sludge storage tank to merchant anaerobic digester, including hydraulic mixing, insulation, and sludge heating
- Demolition of two (2) digester roofs and installation of one (1) fixed roof and one (1) flexible membrane roof
- Odor control
- 1x 12,000-gallon liquids receiving pit
- 1x solids receiving hopper
- 75,000-gallon feedstock tank with side entry mixers
- 333 kW microturbine and gas conditioning unit
- Site improvements to allow for truck ingress and egress
- Class A PFRP system

quasar Operations Scope

- Source merchant material such as FOG, food waste, biosolids, leachate, other non-traditional feedstocks

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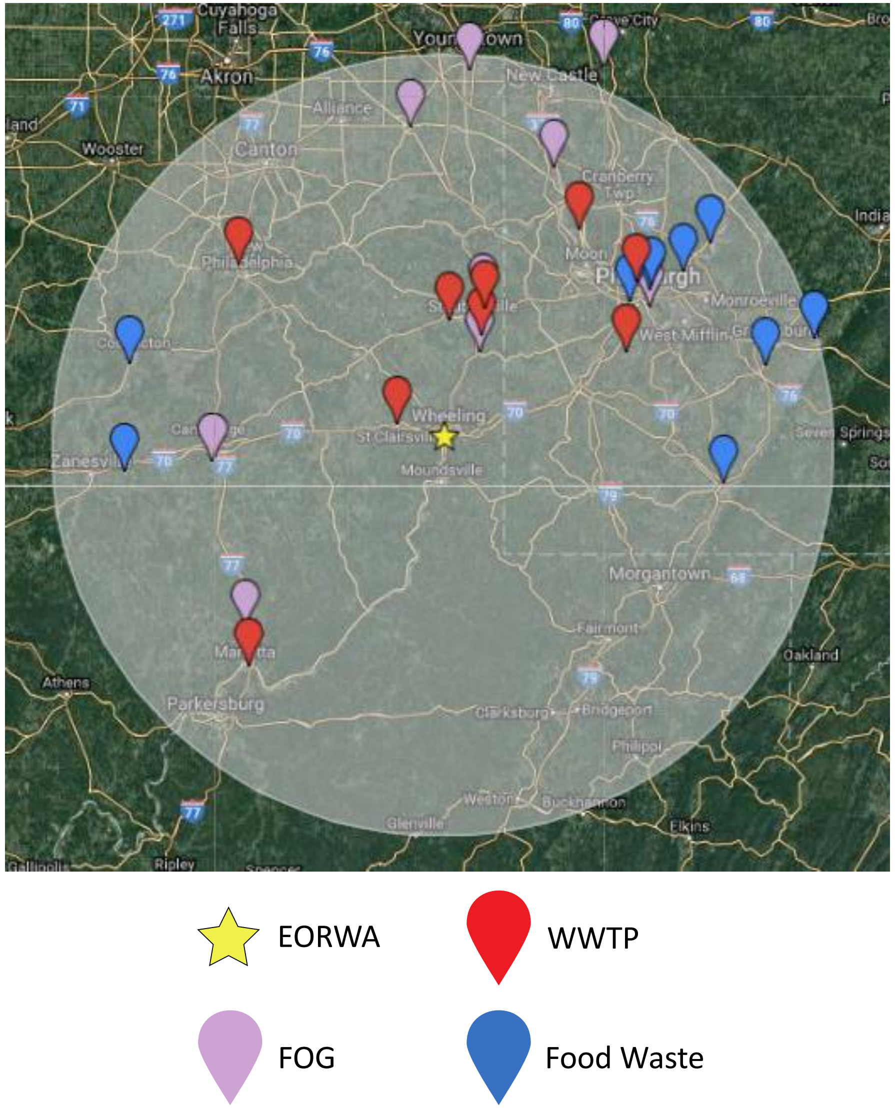
Case Study II: (EORWA) Bellaire, Ohio



Biomass Feasibility Study

- 75 mile radius from the existing facility (gray circle)
- Alterative disposal outlets evaluated as competition
- Regional food processors, FOG generators, WWTPs were evaluated
- Identification of possible “anchor tenants” for long term contacts, potentials include:
    - 2 large WWTPs
    - 1 large bacon production facility
    - 1 large soup production facility
    - 40 small WWTPs over 1 MGD
    - Food waste and FOG generators

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Case Study II: (EORWA) Bellaire, Ohio

Feedstock recipe developed from regional biomass to meet EORWA's average electric demand when combined with the existing egg shaped digester.

Customer / Biomass Inputs per Day	Wet Tons	%TS	%VS	Dry Tons
Outside Biosolids	41	19%	70%	8.0
Soap wash	5	4%	81%	0.2
Vegetable Based industrial oil	3	15%	93%	0.5
FOG Hauler Material	6	3%	93%	0.2
Merchant FOG	7	3%	93%	0.2
Wastewater Plant Dilution	13	0%	0%	0.0
Total Blended Biomass	75.65	12.0%	72.5%	9

High energy density recipe

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Case Study II: (EORWA) Bellaire, Ohio

Projected Outcome

Once complete, the new **energy neutral** EORWA digester will

- Combined, the existing egg shaped digester and the new system can generate 333 kW – achieving energy neutrality for EORWA!
- Provide the plant with a contingency plan for biosolids processing
- Save over $145,000 per year in energy costs
- Generate $570,000 in revenue from tipping fees
- Keep utility rates stable

Electric Cost Savings

	Current $	Projected $
Month 1	$17,133	$3,267
Month 2	$17,723	$3,190
Month 3	$17,996	$3,216
Month 4	$17,367	$3,356
Month 5	$16,763	$3,009
Month 6	$14,285	$2,837
Month 7	$12,538	$2,855
Month 8	$13,073	$3,450
Month 9	$15,386	$3,328
Month 10	$13,264	$3,078
Month 11	$14,297	$3,221
Month 12	$14,155	$3,213
Total Cost	$183,980	$38,010
Projected Annual Savings		$145,969

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Case Study II: (EORWA) Bellaire, Ohio

Roof Before Construction

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Case Study II: (EORWA) Bellaire, Ohio

Roof Demolition

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Case Study II: (EORWA) Bellaire, Ohio

Roof Installation

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Case Study II: (EORWA) Bellaire, Ohio

Roof Completion

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Case Study II: (EORWA) Bellaire, Ohio

DIGESTER DOSING RATE CALCULATOR	
Project:	EORWA
Date Created:	5/6/17
Today's Date:	5/13/19

Sheet Key:
User Input
Calculation

OVERALL DIGESTER SIZE CALCULATIONS		
Cylinder Volume	64,741	ft^3
Cone Volume	5,281	ft^3
Total Digester Volume	70,022	ft^3
	523,804	gal

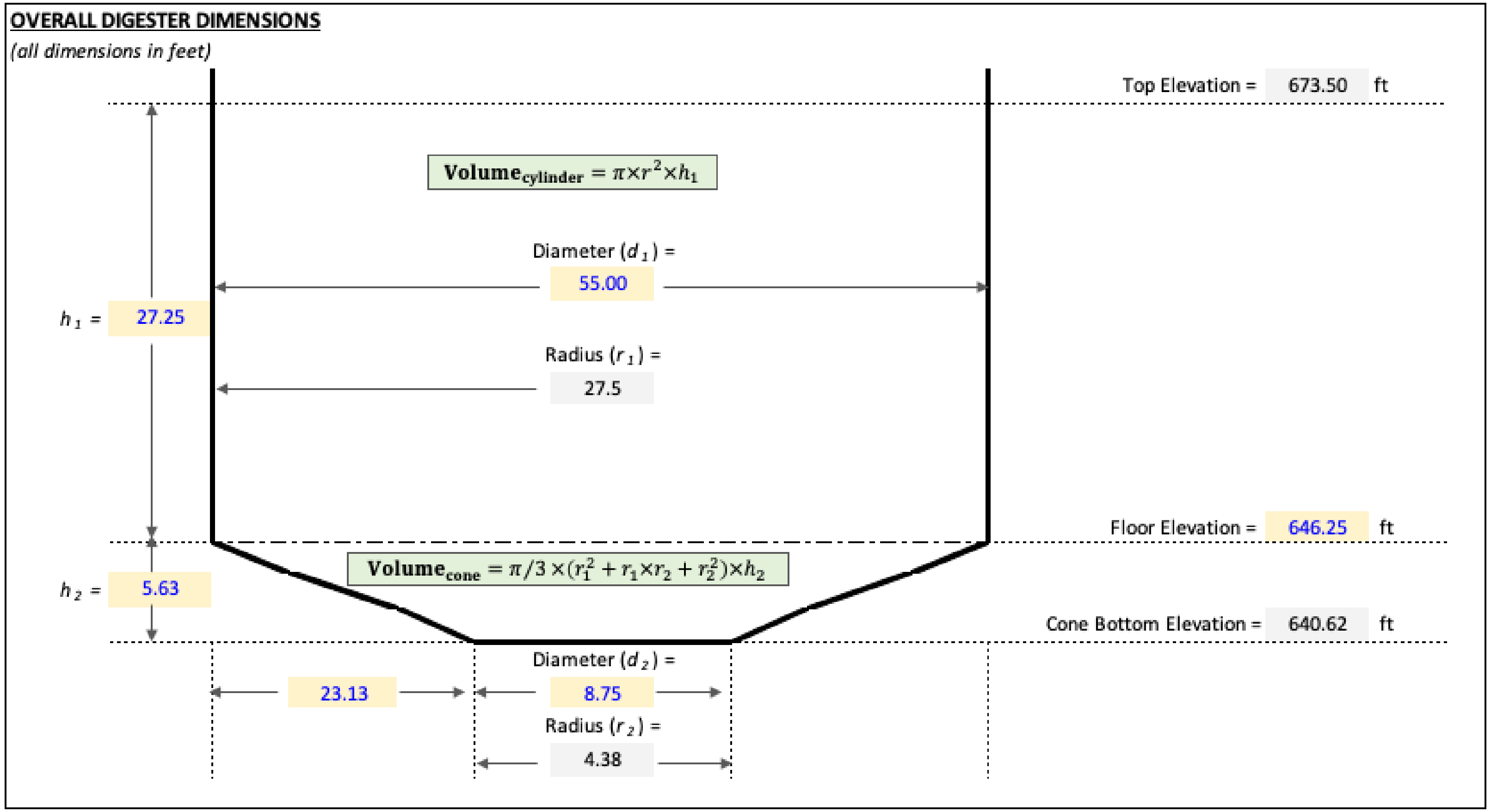
CURRENT DIGESTER VOLUME		
Current Digester Level	13.71	ft
Current Digester Volume	37,854	ft^3
	283,165	gal

DOSING RATE CALCULATION - COD		
Measured COD	187,000	mg/L
Loading Rate	6	kg COD/m^3 day
Digester Dosing Rate	**9,086**	GPD

$$\text{Dosing Rate (COD)} = \frac{\text{Digester Volume} \times \text{Loading Rate}}{\text{Measured COD}}$$

MAXIMUM DOSING RATE - Retention Time		
Max Allowable Digester Volume	450,000	gal
Max Allowable Digester Level	23.10	ft
Retention Time	20	days
Max Digester Dosing Rate	**22,500**	GPD

$$\text{Max Dosing Rate (Retention Time)} = \frac{\text{Total Digester Volume}}{\text{Retention Time}}$$



Class A System

- Both Lucas County and EORWA projects will have a Class A system installed
- Incorporates a thermal process prior to digestion that reduces pathogens and vector attraction to meet US EPA 40 CFR Part 503 regulations
- It produces a Class A digester effluent where biosolids are present
- Minimizes disposal challenges for biosolids
- Batch process utilizes waste heat where possible, minimizing operational cost

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Class A System EPA Requirements & Calculations

Throughput Calculations		
Gallons/day		40,000
Tank Volume	gal	8,000
Volume Left in Tank After Draining	gal	0
Batches/Day Required		5
Hold Time Required	min/batch	288
	hr/batch	4.8
Sludge Flow Rate from Pump	gal/min	27.8
Estimated Fill Time	min	288

Manual User Input (EPA Calculations)		
Minimum Treatment Temperature	°F	145.38
Hold Time Required	min	288
	hours	5
	days	0.2
	°F	145.38

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Class A System EPA Requirements & Calculations

EPA OAC 3745-40-04 Table & Equations

Temperature Variable		Hold Time (D)										Minimum Treatment Temperature (t)
Temperature Increments from EPA OAC 3745-40-04 Table / B-1		Input directly from EPA OAC 3745-40-04 / Table B-1			Calculated per equation in EPA OAC 3745-40-04			Temperature input in °F			Hold Time output in minutes (Temp input in °F)	Temperature output in °F
Inputs		Inputs			$D = 131{,}700{,}000 / 10^{0.1400(T)}$			$D = 131{,}700{,}000 / 10^{0.1400[(T-32)*(5/9)]}$			$D = (5.84571 \times 10^{13}) \times (0.8360307)^{t}$	$t = 177.002 - 5.58379 \times \ln(D)$
Temperature		Hold Time			Hold Time			Hold Time			Hold Time	Temperature
°C manual entry	°F converted from °C	Days manual entry	Hours manual entry	Minutes manual entry	Days calculated column	Hours converted from days	Minutes converted from min	Days calculated column	Hours converted from days	Minutes converted from min	Minutes calculated column	°F calculated column
50	122	14	--	--	13	316	18965	13	316	18965	18965	122.0
52	125.6	7	--	--	7	166	9953	7	166	9953	9953	125.6
54	129.2	4	--	--	4	87	5223	4	87	5223	5223	129.2
56	132.8	2	--	--	2	46	2741	2	46	2741	2741	132.8
58	136.4	--	24	--	1	24	1439	1	24	1439	1439	136.4
60	140	--	13	--	1	13	755	1	13	755	755	140.0
62	143.6	--	7	--	0	7	396	0	7	396	396	143.6
64	147.2	--	4	--	0	3	208	0	3	208	208	147.2
66	150.8	--	2	--	0	2	109	0	2	109	109	150.8
68	154.4	--	--	57	0	1	57	0	1	57	57	154.4
70	158	--	--	30	0	1	30	0	1	30	30	158.0
72	161.6	--	--	20	0	0	20	0	0	20	20	160.3
74	165.2	--	--	20	0	0	20	0	0	20	20	160.3
76	168.8	--	--	20	0	0	20	0	0	20	20	160.3
78	172.4	--	--	20	0	0	20	0	0	20	20	160.3
80	176	--	--	20	0	0	20	0	0	20	20	160.3
82	179.6	--	--	20	0	0	20	0	0	20	20	160.3
84	183.2	--	--	20	0	0	20	0	0	20	20	160.3

Class A System – Alliance, OH WWTP

- Produced Class B biosolids for beneficial reuse
- Facing regulatory constraints for land application, quasar installed pre-digestion Class A system
- Designed to treat 72,000 gallons of sludge per day
- Benefits the City of Alliance by increasing disposal flexibility and reducing disposal costs
- Class A material is effectively reused for agronomic benefit on area farms

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FUN FACT

Average person emits 75cc CH_4/Fart
or 0.0025486 Ft^3
127 Ft^3 geg = 49,831 Farts = 1 gal. of gas

Google says we average 10 to 20 farts/Day
49,831/15 = 3,322 days or 9.1 years

THANK YOU.
QUESTIONS?

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