



OVIVO
Bringing water to life

Aerobic Digesters with Membrane Thickening

Stephen Kennedy : Integrated Solutions Group Manager

Water Arabia 2011 Gulf Hotel : Kingdom of Bahrain 2/13/2011

Ovivo Digestion Expertise

WEFTEC 1997 - 2001



... recognized as the industry leader in aerobic digestion and thickening at high solids concentrations

Manual of Practice No. 11 Operation of Municipal WWTP

Volume III:

Solids Processes

Chapter 31:

Aerobic Digestion

Author: Elena Bailey



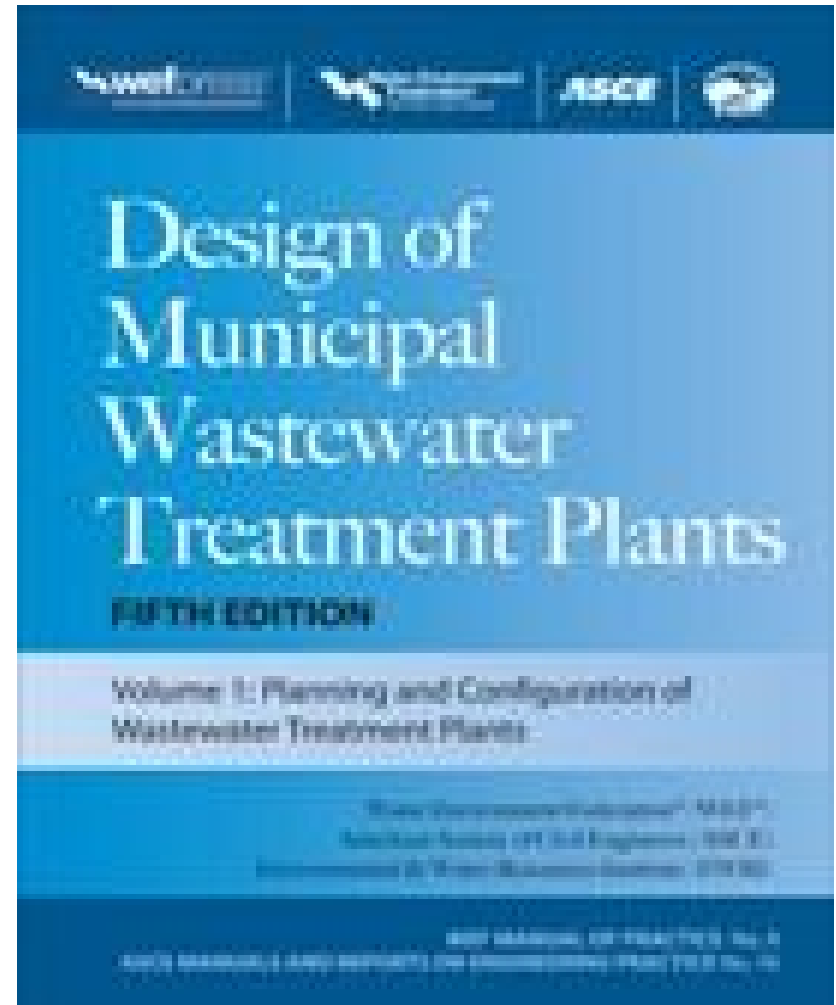
MOP No. 8 5th Ed., 2009
Design of Municipal WWTPs

Volume III: Solids Processing and Management

Chapter 25: Stabilization

Section 3 : **Aerobic Digestion**

Author: Miguel Vera



Why is the treatment of sludge important?

1. 40 – 60 % of both Operational and Capital Cost of Typical WWTP.
2. Land Application is being restricted.
3. Possible stringent limits on pollutants are being evaluated as a challenge to CFR Part 503.
4. Landfill / disposal fees are increasing.
5. Hauling distances are longer.

Why and how can sludge be treated?

1. Sludge is treated to

Remove Volatile Solids,
Reduce Pathogen Levels,
Manage Nutrients (Nitrogen and Phosphorus)

2. Sludge can be treated anaerobically or aerobically

Anaerobic digestion is carried out in the absence of Oxygen at either Thermophilic (55°C) or Mesophilic (35°C) temperatures. It generates biogas with a high proportion of methane.

Aerobic digestion is carried out in the presence of oxygen. In aerobic conditions bacteria consume organic matter and convert it to Carbon Dioxide. Once there is a lack of organic matter the bacteria die and are used as a food source by other bacteria. This is known as endogenous respiration and solids reduction occurs in this phase.

The Advantages and Disadvantages of Digestion Processes.

The key advantages of Anaerobic Digestion are

Biogas Production, Low Carbon Technology

The Key disadvantages of Anaerobic Digestion are

High Capital Cost, Unstable, Nutrient Release, Risk of Odours

The key advantages of Aerobic Digestion are

Simple, No odours, Nutrient Recovery

The key disadvantages of Aerobic Digestion are

High Energy Consumption, Could not thicken sludges easily.

In the United States, Aerobic digestion is generally the preferred method for the treatment of sludge while in Europe, Anaerobic Digestion is generally preferred.

Why use a membrane thickener?

BECAUSE IT IS A
SUSTAINABLE PROCESS
IN COMPARISON
WITH OTHER
THICKENING OPTIONS

Membrane Thickener Benefits

1. Improved thickening

1. Thickening of WAS without using polymer
2. Reduced chemicals and disposal cost
3. Thickening of WAS to 3% solids (5% with a dual step)
4. Independent of settling characteristics in a single step
5. Less sludge volume to handle or dispose.

2. Reduced operator attendance

1. No set-up or clean up time
2. No constant attendance while thickening.

Membrane Thickener Benefits

3. Reduced Foot Print.

1. Smaller tanks + No chemical storage = **Less Concrete**
2. DOES NOT REQUIRE A BUILDING
3. Could use existing digesters or SHT

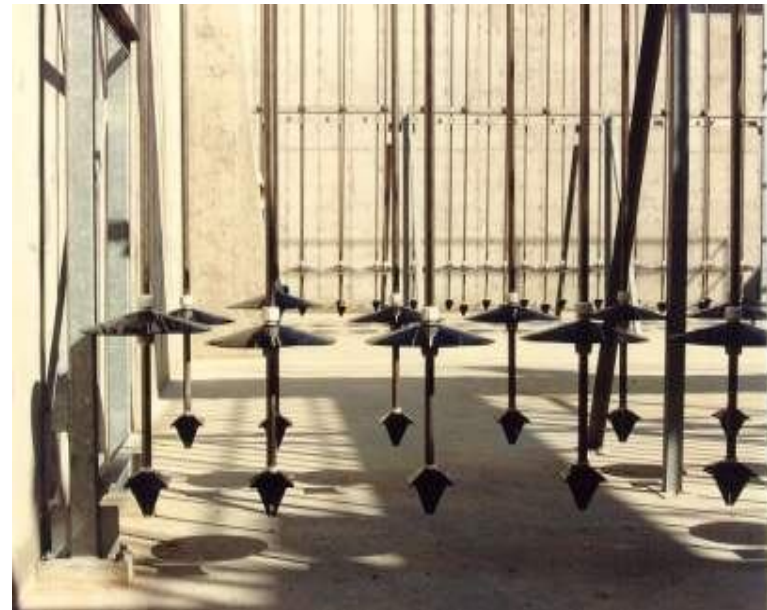
4. Produces a High Quality Permeate when used with an Aerated Digester or SHT.

1. Reduces Total N (NH₃/NO₃) and P in the permeate
2. Permeate can be combined with effluent without reducing quality.
3. Sludge for disposal has reduced Total N as well.

Membrane Thickening Processes Incorporate

Same submerged Kubota membranes used for the MBR process and the same aeration system used for all the other Digestion processes

Operates with 3 to 5% solids and capable of 30% - 40% VSS Reduction depending on the requirements



Membrane Thickening

Operational Experiences

Oldest Global Installation

Miyazaki WWTP, Japan

Oldest Installation using Membrane Thickener in the World
(Since 1999)

Miyazaki WWTP, Japan

Commissioned:	1999 (12 years)
Waste Type:	Municipal
Liquid Process:	SBR
MBT Size:	300 plates
MBT Flux:	9.0 l/mh
Air Scour:	0.60 Nm ³ /hr/plate
Solids Conc.:	3.1%
Chemical Cleaning:	4 / year
Diffuser Cleaning:	30 min /day

Oldest Ovivo Installation

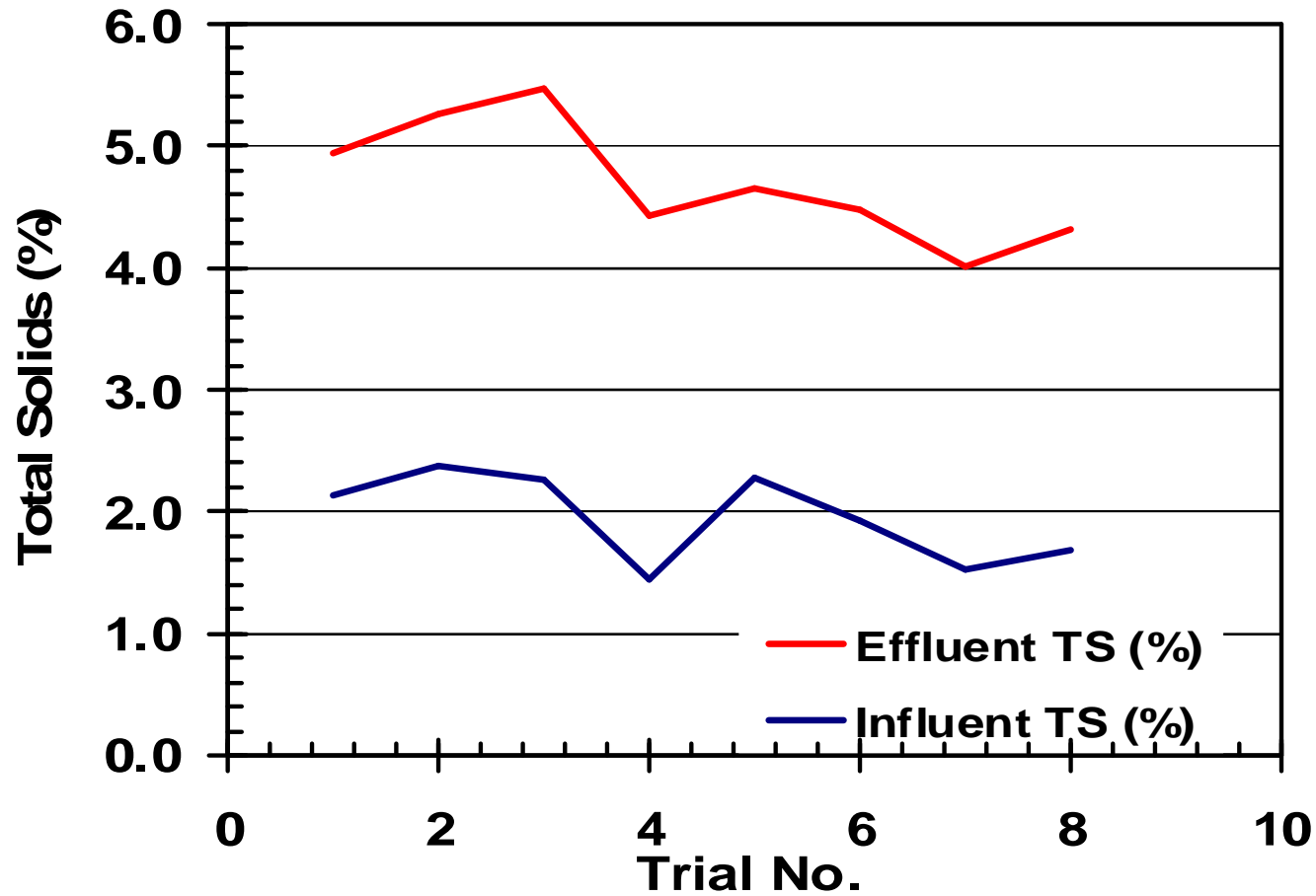
Minch Malt, Athy, Ireland

High Solids Concentrations Membrane Thickener (Since 2001)

Minch Malt WWTP, Athy, Ireland

Commissioned:	2001 (9 years)
Waste Type:	Industrial
Liquid Process:	MBR
MBT Size:	150 plates
MBT Flux:	6.6 – 16.3 l/mh
Air Scour:	0.83 Nm ³ /hr/plate
Solids Conc.:	4%-5.5%
Chemical Cleaning:	2 / year
Diffuser Cleaning:	30 min / day

Minch Malt WWTP, Athy, Ireland



Influent Flow – 45 m³/d

Minch Malt WWTP, Athy, Ireland



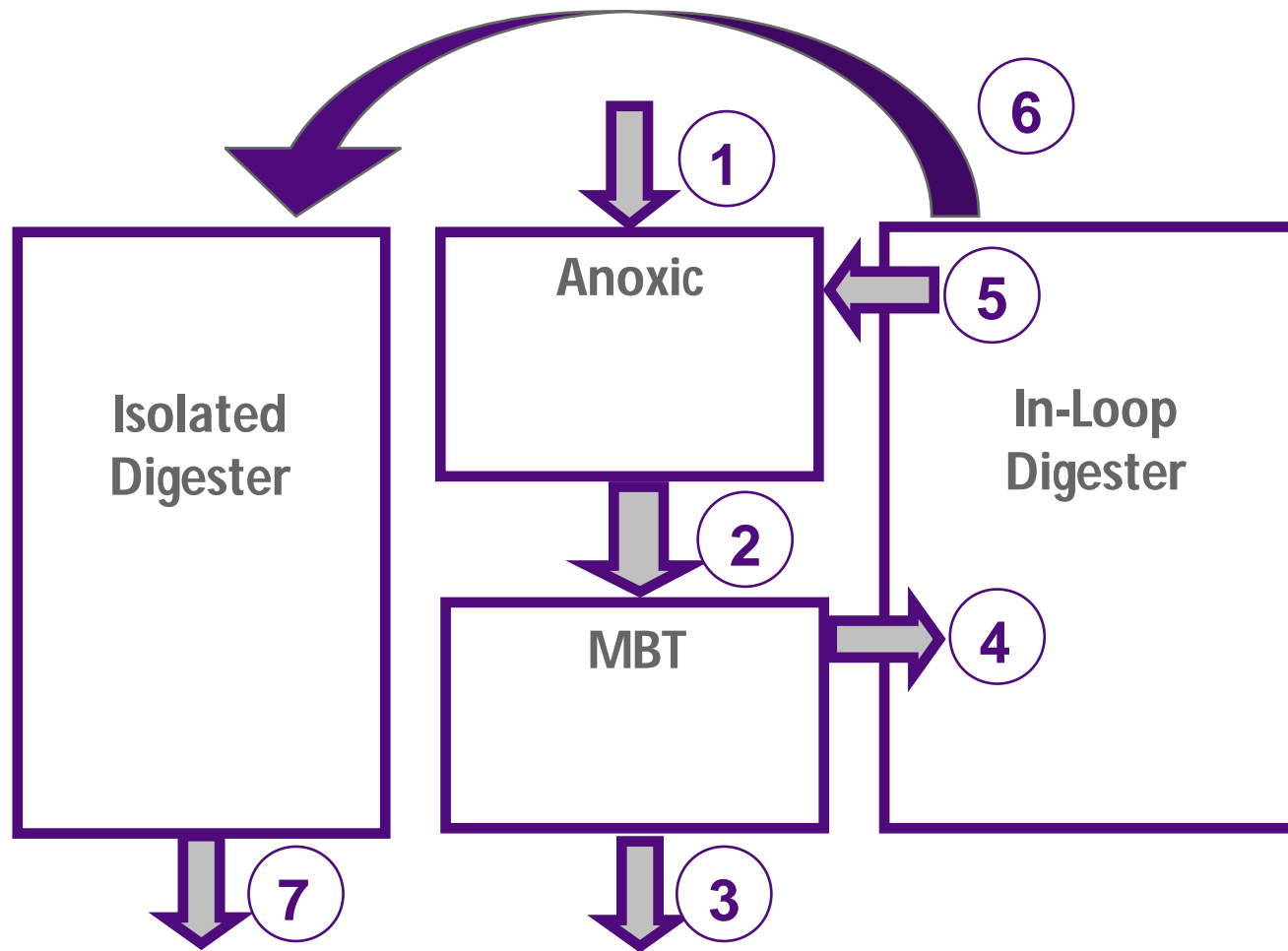
45,000 mg/L TSS

U.S. Installations

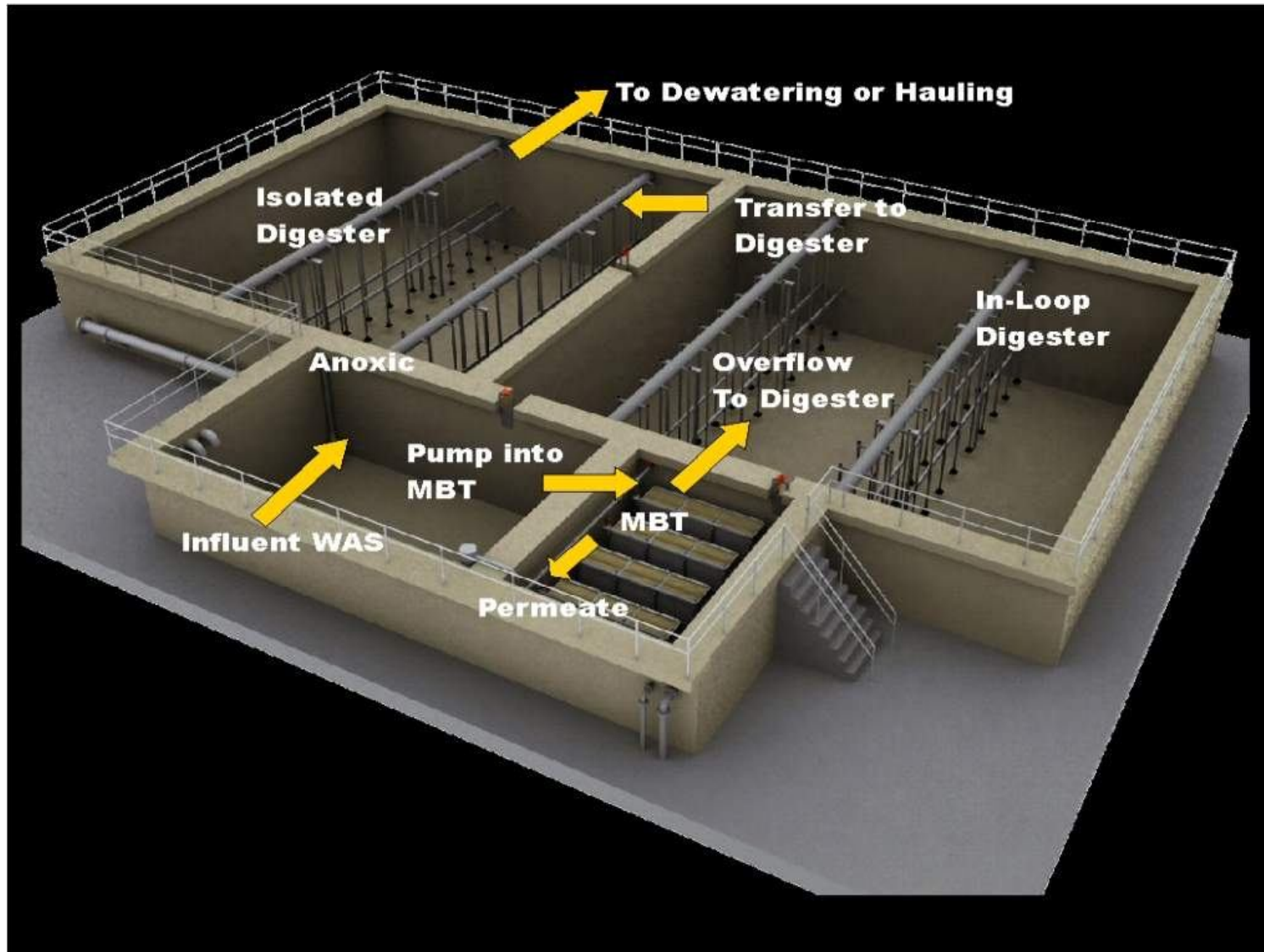
PAD-K, CAD-K and / MBT Installations

Date	Plant	City	State	Liquid Process	MBT/ PAD-K
Jun-04	Dundee WWTP	Dundee	MI	MBR	PAD-K
Jun-04	Arlington WWTP	Arlington	WA	SBR	CAD-K;MBT
Jul-04	Troy WWTP	Troy	MO	MBR	PAD-K
Aug-04	McFarland Creek WWTP	Chagrin Falls	OH	MBR	PAD-K
Nov-04	Gnadenhutten WWTP	Gnadenhutten	OH	MBR	PAD-K
Apr-05	Delphos WWTP	Delphos	OH	MBR	Stormmaster
Apr-05	Cottonwood WWTP	Manor	TX	MBR	PAD-K
Aug-05	Lewes WWTP	Lewes	DE	MBR	MBT
Nov-05	East Dundee WWTP	East Dundee	IL	Ox. D.	CAD-K-
Apr-06	Yakama IN Casino	Toppenish	WA	MBR	PAD-K
May-06	Woodside STP	Yaphank	NY	CAS	CAD-K
May-06	Stoutsville WWTP	Stoutsville	OH	MBR	MBT
Jun-06	North Lewisberg WWTP	North Lewisberg	OH	MBR	MBT
Jul-06	Harvest Monrovia	Hunstville	AL	MBR	MBT
Jul-06	Bob's Creek WWTP	Lincoln County	MO	MBR	PAD-K
Aug-06	Hamden WWTP	Hamden	OH	MBR	MBT
Aug-06	Shelton WWTP	Shelton	WA	MBR	MBT
Sep-06	Lake of the Pines WWTP	Auburn	CA	MBR	PAD-K
Nov-06	Concrete WWTP	Concrete	WA	MBR	PAD-K
Dec-06	Providence Estates	O'Fallon	MO	MBR	PAD-K
Feb-07	Westford-Acton WWTP	Acton	MA	MBR	MBT
Apr-07	Winlock WWTP	Winlock	WA	MBR	PAD-K
Jun-07	Burwell Road WWTP	Hunstville	AL	MBR	MBT
Jun-07	Highland Lake Estates WWTP	Monroe	NY	MBR	MBT
Apr-08	Alpine WWTP	Alpine	WY	MBR	PAD-K
Jul-08	Union Rome WWTP	Union Rome	OH	MBR	PAD-K
Oct-09	C'oeur d'Alene Casino	C'oeur d'Alene	ID	MBR	PAD-K
Dec-09	Cayce WWTP	Cayce	SC	Ox. D.	CAD-K

PAD-K Process Flow



PAD-K, Membrane Thickener/Digestion



CASE STUDIES

*Membrane Thickening applications with MBR
applications*

Dundee WWTP, MI, USA; MBR - 7,500 m³/d

Engineer : Arcadis

History : Objective was to reduce the hauling to 2 times per year. Tanks are designed to store 180 days at 3% solids.

Operator friendly when compared to other systems.

Ovivo's Aerobic Digestion experience rated higher when evaluated against other vendors/technologies.

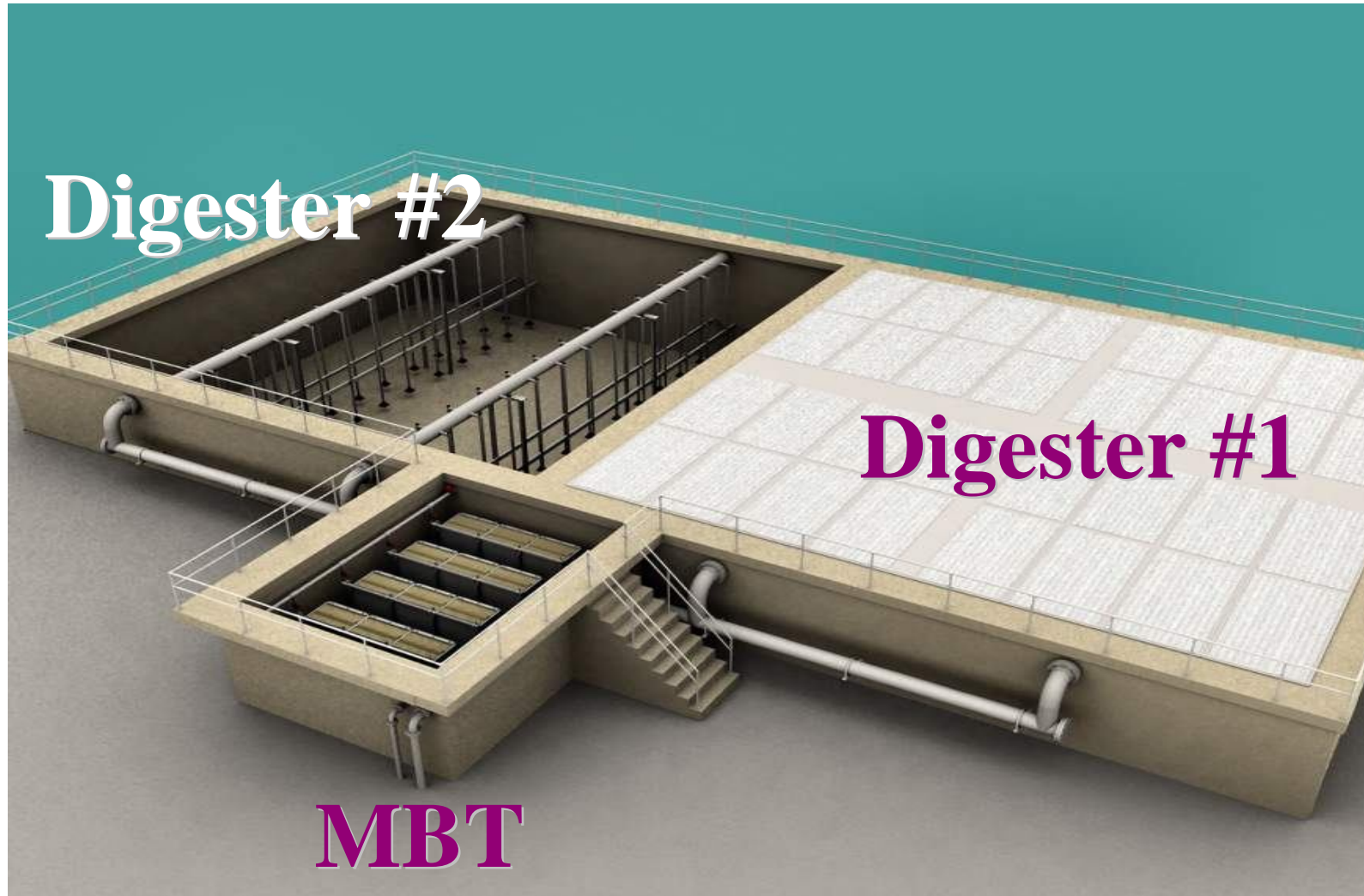
Dundee WWTP, MI, USA; MBR and PAD-K



Dundee WWTP, MI, USA; PAD-K

Commissioned:	2005
Liquid Process:	MBR
MBT Size:	800 plates
MBT Flux:	7.5 l/mh Design at 4.5 degrees C
Air Scour:	0.60 Nm ³ /hr/plate
Solid Conc.:	3%-5.25%
Chemical Cleaning:	2-3 / year (scheduled)
Diffuser Cleaning:	30-45 min / day

Dundee WWTP, MI, USA; PAD-K



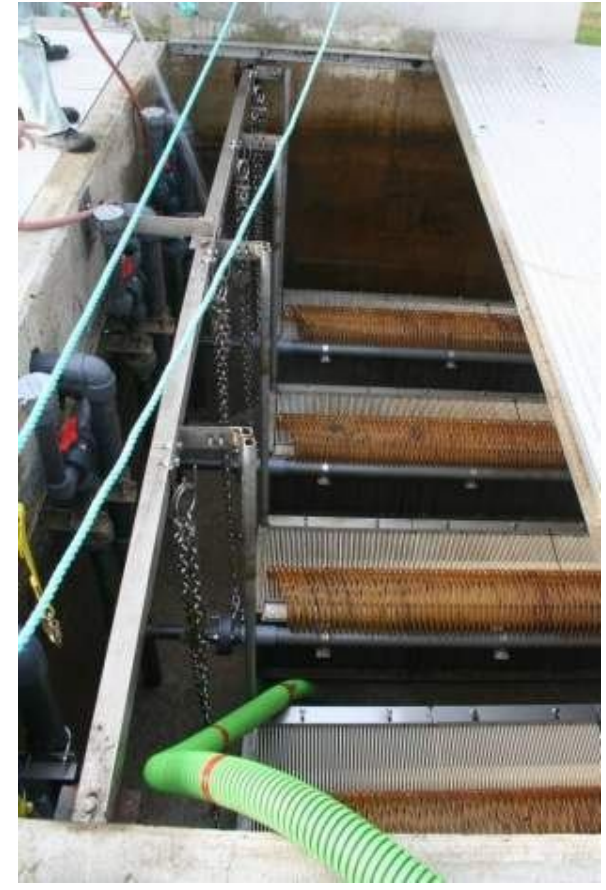
Aerobic Digester for PAD-K
Dundee, MI





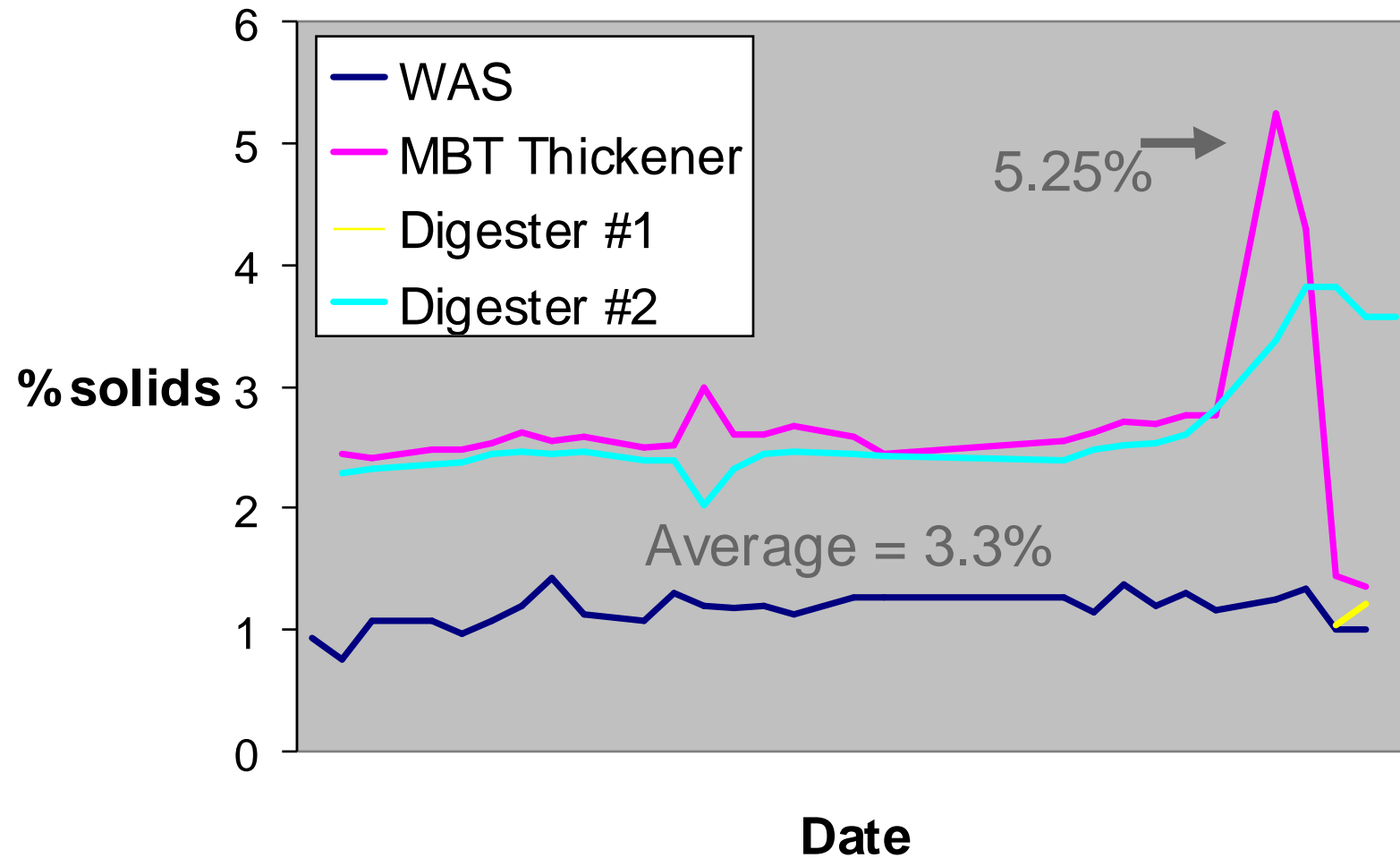
**Membrane Thickener for PAD-K
Dundee, MI, USA.**

Dundee WWTP, MI, USA; Membrane Thickener



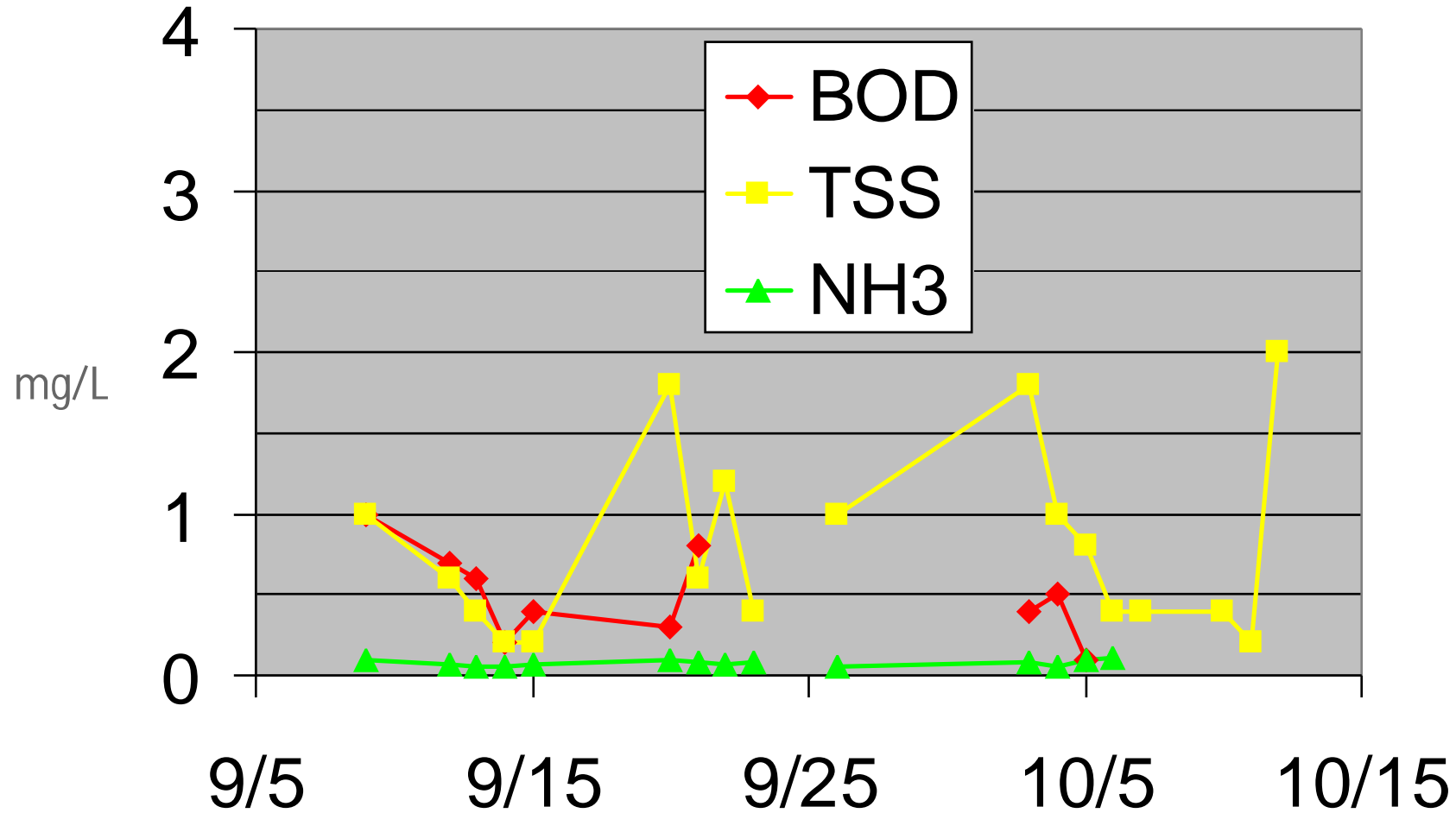
Dundee WWTP, MI, USA; PAD-K % Dry Solids

Sep & Oct 2005 Operation



Dundee WWTP, MI, USA; PAD-K Permeate Quality

September & October 2005



Dundee WWTP, MI, USA; PAD-K Permeate Quality 2006 Data

Sustainable Permeate Quality

before it's blended with MBR effluent

BOD:	<1.0 mg/l
TSS:	<2.0 mg/l
NH ₃ -N:	<0.12 mg/l
NO ₃ -N:	<3.0 mg/l
TP:	<7.0 mg/l

* Highest solids concentration achieved in MBT to date 5.25%

Dundee WWTP, MI, USA; PAD-K Permeate Quality January 2007 to June 2008

Sustainable Permeate Quality before it's blended with MBR effluent

BOD:	1.12 mg/l
TSS:	2.00 mg/l
NH ₃ -N:	0.22 mg/l
NO ₃ -N:	0.03 mg/l
TP:	1.09 mg/l

*Highest solids concentration achieved in MBT to date 5.25%

Dundee WWTP, MI, USA; PAD-K Sludge Handling Costs

Years	Gallons Hauled	Dry Tons	Yearly Cost
2001	1,483,200	125.53	\$35,258 – No Belt
2002	1,425,600	114.55	\$43,196 – No Belt
2003	313,000 – Belt 1,102,600 – Truck 1,415,600 - Total	24.80 – Belt 80.05 – Truck 104.85 - Total	\$21,290 – Belt \$35,590 – Truck \$56,880 - Total
2004	248,885 – Belt 943,200 – Truck 1,192,100 - Total	22.67 – Belt 99.39 – Truck 122.06 - Total	\$16,850 – Belt \$30,088 – Truck \$46,938 - Total
2005 MBT operational for 2 nd half of year only	572,400 – Belt 432,000 – MBT 1,004,400 - Total	55.62 – Belt 47.55 – MBT 103.17 - Total	\$39,135 – Belt \$14,623 – MBT \$53,758 – Total
2006	887,400 - MBT	130.48 - MBT	\$32,739 - MBT

Belt press was needed for years 2003 -05 due to lack of storage space.

Sludge Hauling costs for first full year of operation of MBT in 2006 was \$32,739 which is cheaper than the last 5 years

CASE STUDIES

Conversion of Conventional plants to Membrane
Thickening Digestion
1st Installation in 2004

Gnadenhutten WWTP, OH, USA – 943 m³/d

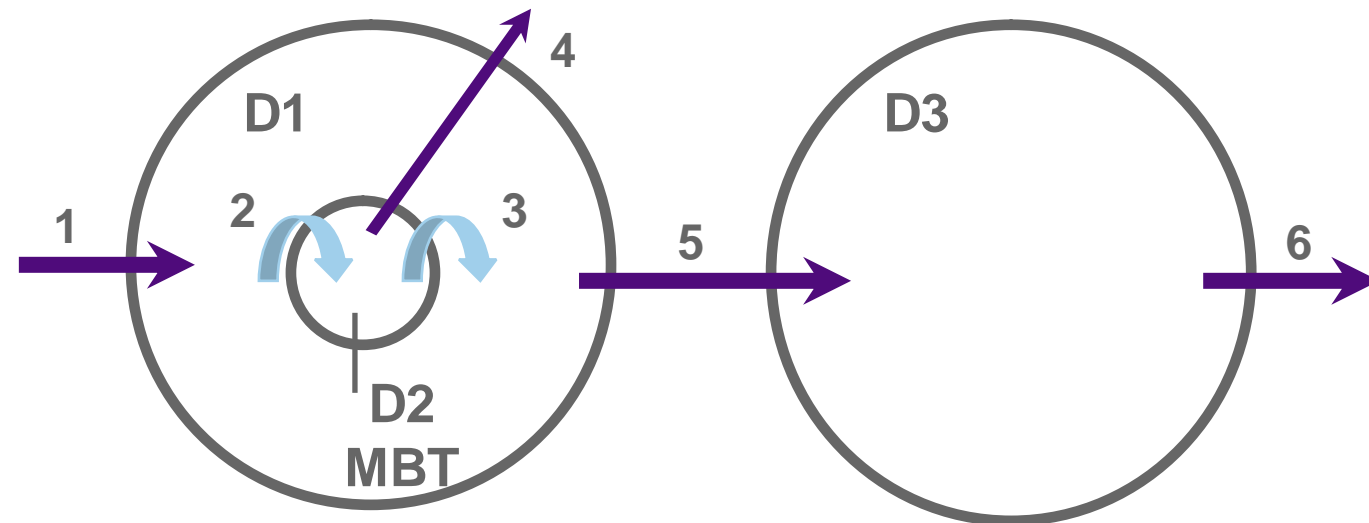
Engineer: Quicksall

History: Engineer designed projects using Ovivo's PAD-M processes and aerobic digesters in the past.

Results: Our experience in providing solutions with good sound digester processes gave the comfort level required for the engineer to accept membranes in Aerobic Digestion

Gnadenhutten WWTP, OH, USA; PAD-K

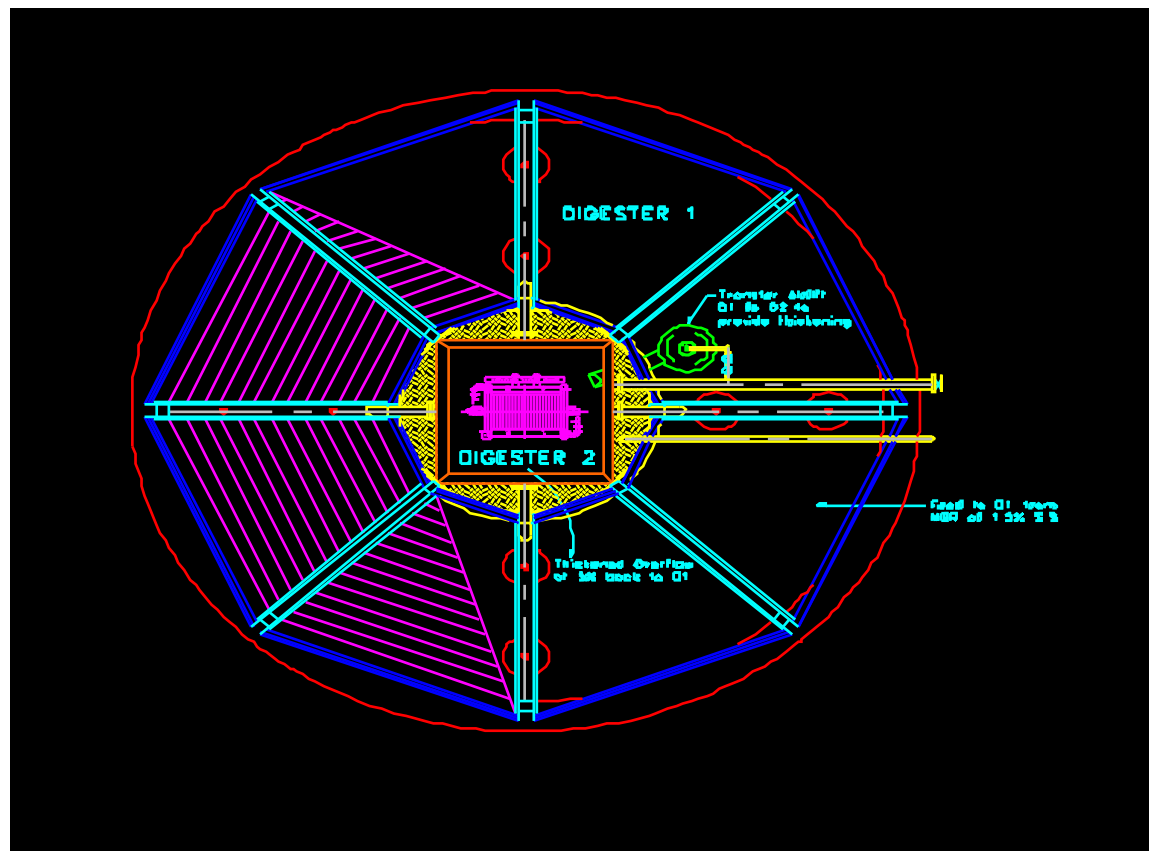
Secondary Clarifiers converted to the PAD-K process



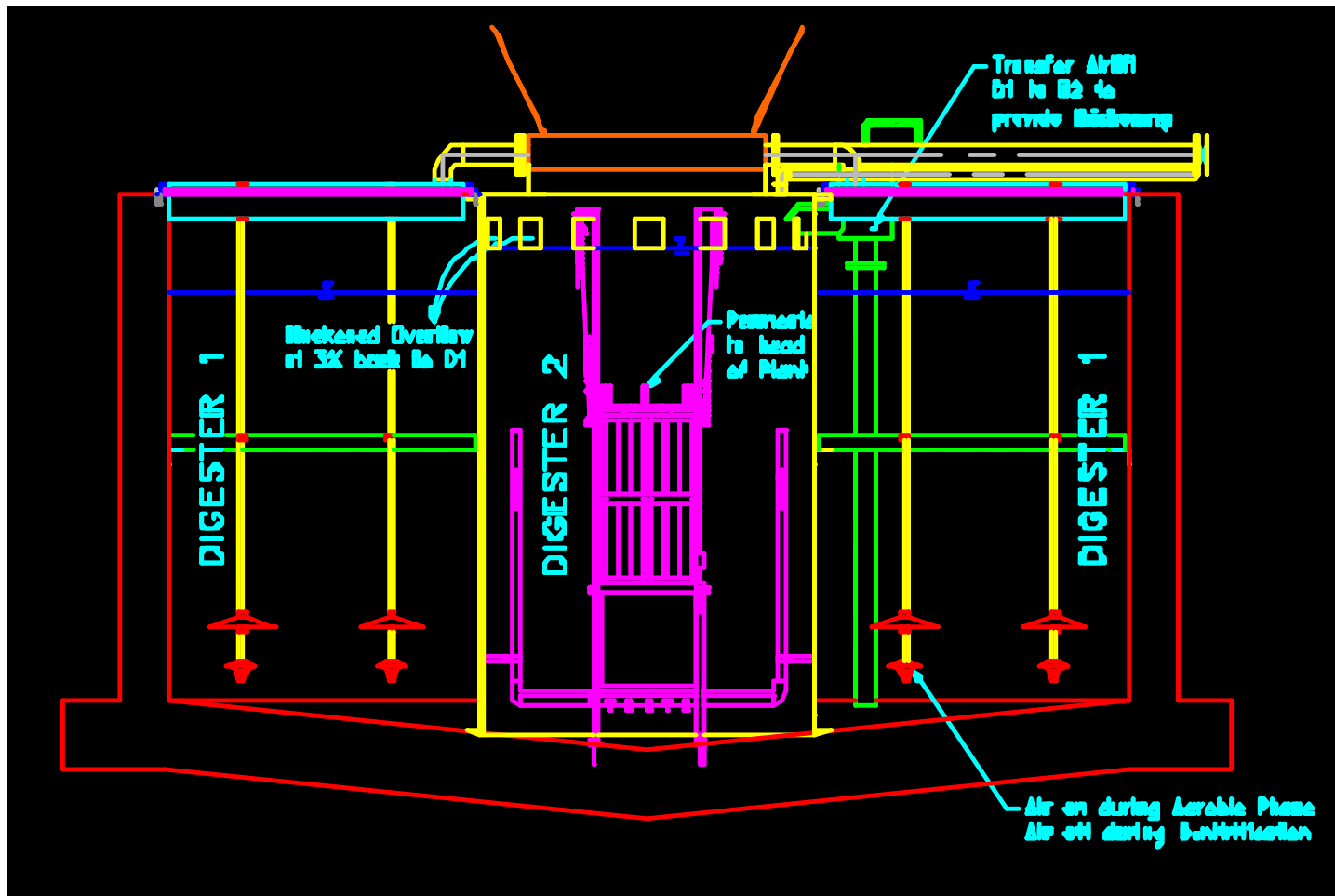
- 1 – Flow from MBR at 1 - 1.5% solids
- 2 – Flow from D1 to D2 via airlift
- 3 – Thickened overflow from D2 to D1 at 3%
- 4 – Permeate pumped to head of plant
- 5 – D1 to D3
- 6 – D3 to sludge holding

Note: Air in D1 is ON during Nitrification & OFF during Denitrification.

Gnadenhutten WWTP, OH, USA; PAD-K



Gnadenhutten WWTP, OH, USA; PAD-K



CASE STUDIES

Membrane Thickening Application Following
Conventional Processes
1st installation 2004

Arlington WWTP, WA, USA; CAD-K with ECO-MAT™

OVIVO
Bringing water to life

7560 m³/d SBR Facility

Evaluation of Short-Term Methods for Handling Solids

By Kennedy/Jenks Consultants

Completed 2004

Arlington WWTP, WA, USA; CAD-K with ECO-MAT™



Arlington WWTP, WA, USA; Solids Handling Issues

SBR WWTP @ 7560 m³/d ADF

Holding Tanks for (WAS)

- Insufficient Storage
- Odors During Decant
- Limited Decant = Thin Sludge
- Low SRT = Little Stabilization

Belt Filter Press (BFP)

- Overtime Operation
- Relatively Low Cake Solids (~12%)



Table 2: Comparison of Sludge Thickening Alternatives

Parameter	Gravity	Dissolved Air Flotation	Centrifugal	Gravity Belt	Rotary Drum	Membrane
Operation	Continuous	Continuous or Intermittent	Intermittent	Intermittent	Intermittent	Continuous
Continuous Monitoring Required?	No	No	Yes	Yes	Yes	No
Typical Thickened Solids Concentration	2-3%	3-4% (up to 5% with polymer)	4-6%	4-7%	3-9%	2-3%
Typical Solids Capture Efficiency	Up to 99%	85-95% (up to 99% with polymer)	95-99%	95-98%	93-99%	100%
Performance with WAS	Fair	Fair to Good	Good	Good	Variable	Fair to Good
Estimated Eqpt. Space Requirements ^(a)	36' Diameter	9.5' x 32'	4'x14'	9' x 20'	15' x 6'	13'x14'
Operational Costs	Low	High	High	Medium	Medium	Low
Odor Control	Odor potential unless covered	Odor potential unless enclosed in building	Enclosed process and in building	Odor potential unless enclosed in building	Odor potential unless enclosed in building	Limited odor potential due to continual aeration
Budgetary Equipment Cost ^(a)	\$205,000 (uncovered tank)	\$290,000	\$305,000	\$100,000	\$125,000	\$230,000
Installation	In-tank	Building space optional	Building space required	Building space required	Building space required	Skid mounted
Polymer Required?	No	Optional	No	Yes	Yes	No
Capacity (gpm)	70 - 100	70	200	300	250	70
Equalization Needed?	No	Yes	Yes	Maybe	Yes	Yes
Ease of Operation/Maintenance	Simple	Moderate	Complex	Moderate	Moderate	Simple to Moderate

Source: Report by Kennedy-Jenks Consultants

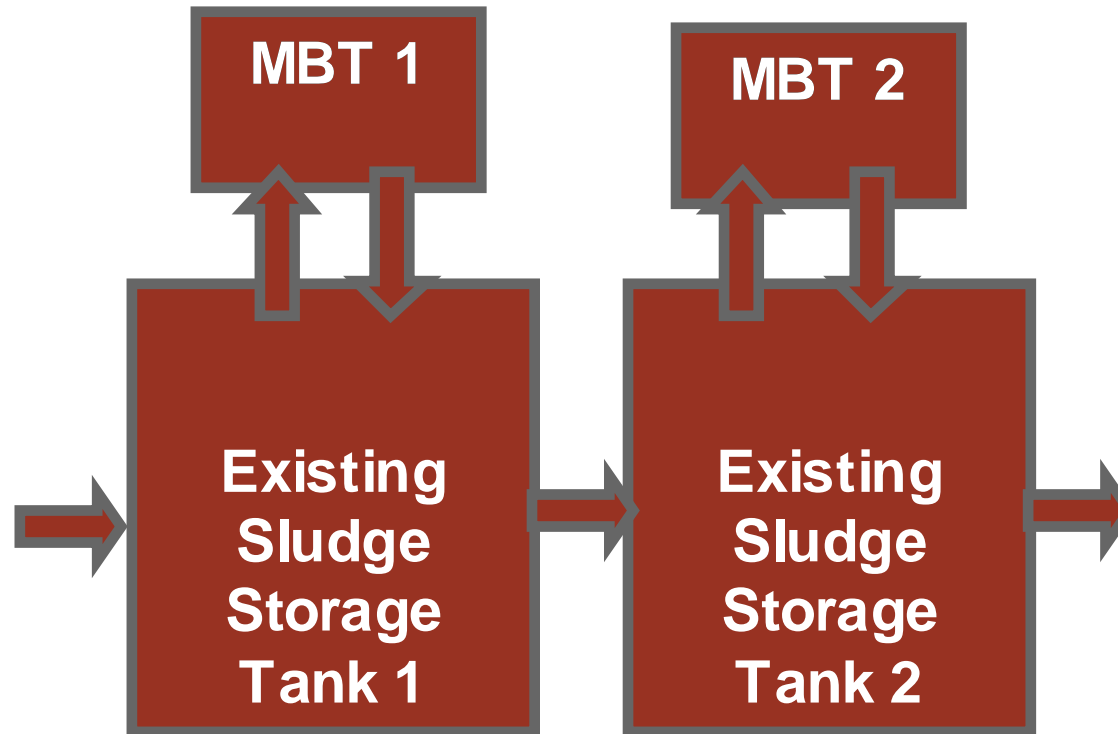
Table 4: 20-Year Life Cycle Cost Comparison

Parameter	Units	Gravity Belt Thickener	Membrane Thickener
Design Parameters			
Target Thickened Sludge Concentration	%	4	3
Design WAS Flow	gpd	103,000	103,000
Design Solids Loading	lbs/day	4,100	4,100
Labor Cost			
Weekly Labor	hrs/week	18	7
Labor Rate	\$/hr	\$40.00	\$40.00
Annual Labor Cost	\$	\$37,400	\$14,600
Power Cost			
Power Requirement	HP	12	20
Daily Runtime	hrs/day	8	24
Power Use	kWh/day	72	358
Power Cost	\$/kWh	\$0.07	\$0.07
Annual Power Cost	\$	\$1,800	\$9,100
Polymer Cost			
Polymer Use	lbs/dry ton	5	0
Polymer Cost	\$/lb	\$2.00	\$2.00
Annual Polymer Cost	\$	\$7,500	\$0
Maintenance Cost			
Annual Equipment Maintenance Cost	\$	\$2,000	\$4,300
Annual Membrane Replacement Cost	\$	\$0	\$1,600
Total Annual Maintenance Cost	\$	\$2,000	\$5,900
Annual O&M Cost Estimate		\$48,700	\$29,600
Capital Cost Estimate		\$839,000	\$1,115,000
20-year Life Cycle Cost		\$1,813,000	\$1,707,000

Note: All costs are in 2005 dollars.

vs. actual 14 lbs/ DT or \$13,500 more per year
or \$270,000 more @ 20 Yr life cycle cost

Source: Report by Kennedy-Jenks Consultants



Provide membrane thickening to increase solids concentration in the sludge storage from 1.0 (by decanting) to up to 3%.

ECO-MAT™ - Package Thickener



Sludge Screen



Pilot Summary Comparison

Process	GBT	MBT
Achieve Target Solids?	Yes	Yes
Solids Capture	~96%	~99.99%
Odor Concerns	Yes	No
Eliminate Overtime/Weekends?	Yes	Yes
Weekly Labor	28 hours	14 hours
Improve BFP Operation?	No	Yes
Polymer Required?	Yes	No
Increased Stabilization?	No	No

Arlington WWTP, WA, USA; CAD-K with ECO-MAT™

1. Both Processes Achieved Target Concentration
2. Both Processes Eliminated Dewatering Overtime
3. Costs highly favored the MBT even tough initial capital expenditure is higher
4. Advantages of MBT:
 - Eliminated Odor Issues
 - Increased Belt Filter Press Loading Capacity
 - Less Operator Time Required

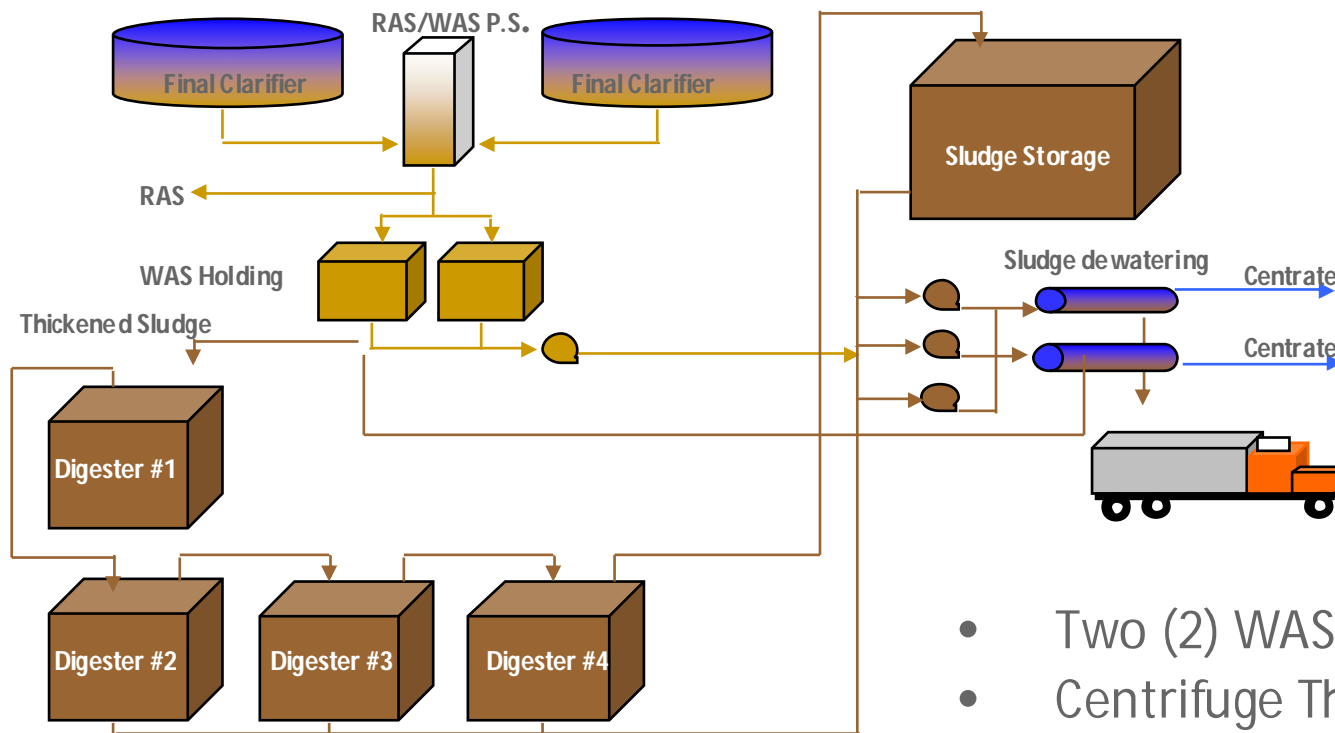
SIGNIFICANT DIFFERENCES vs. OTHER TECHNOLOGIES

East Dundee WWTP, IL, USA; CAD-K

- 4,350 m³/d Oxidation Ditch Extended Aeration Facility - 1998
- 8,690 m³/d expansion to include CAD-K - 2003

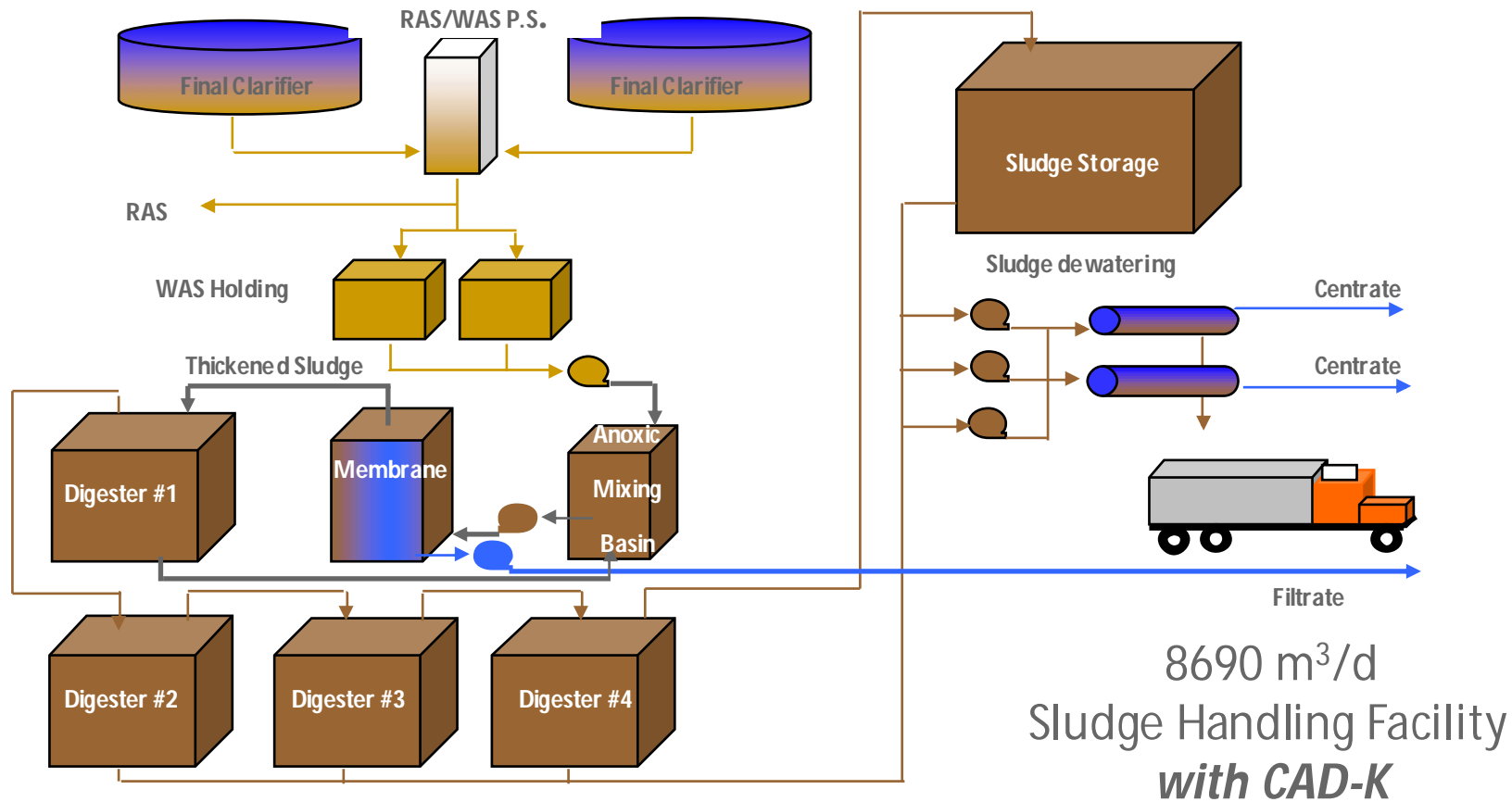


East Dundee WWTP, IL, USA; Sludge Handling



- Two (2) WAS Holding Tanks
- Centrifuge Thickening
- Four (4) STD Aerobic Digesters
- Sludge Holding Tank
- Centrifuge Dewatering

East Dundee WWTP, IL, USA; CAD-K



Also added Fine Screen on top of Anoxic Tank

Issues and Solutions after CAD-K Installation

1. Centrifuges Relied on for Double Duty
 - **Install Dedicated Membrane Thickening System**
2. Fine Bubble Diffuser System could not handle 4% solids
 - **Replace Fine Bubble Membranes w/ Medium Bubble**
3. Increased Solids Loading Due the Expansion & BNR
 - **Operate at Higher Temperature**
4. Digestion Facility Being Operated in Batch Mode
 - **Reconfigure for Continuous Process**

East Dundee WWTP, IL, USA; CAD-K

CAD-K is a Success

1. Better Process Control
2. Improved Thickening with Multi-pass system
3. Higher Digester Temperatures
4. Better Burn Down
5. Greater Sludge Reduction in Less Volume

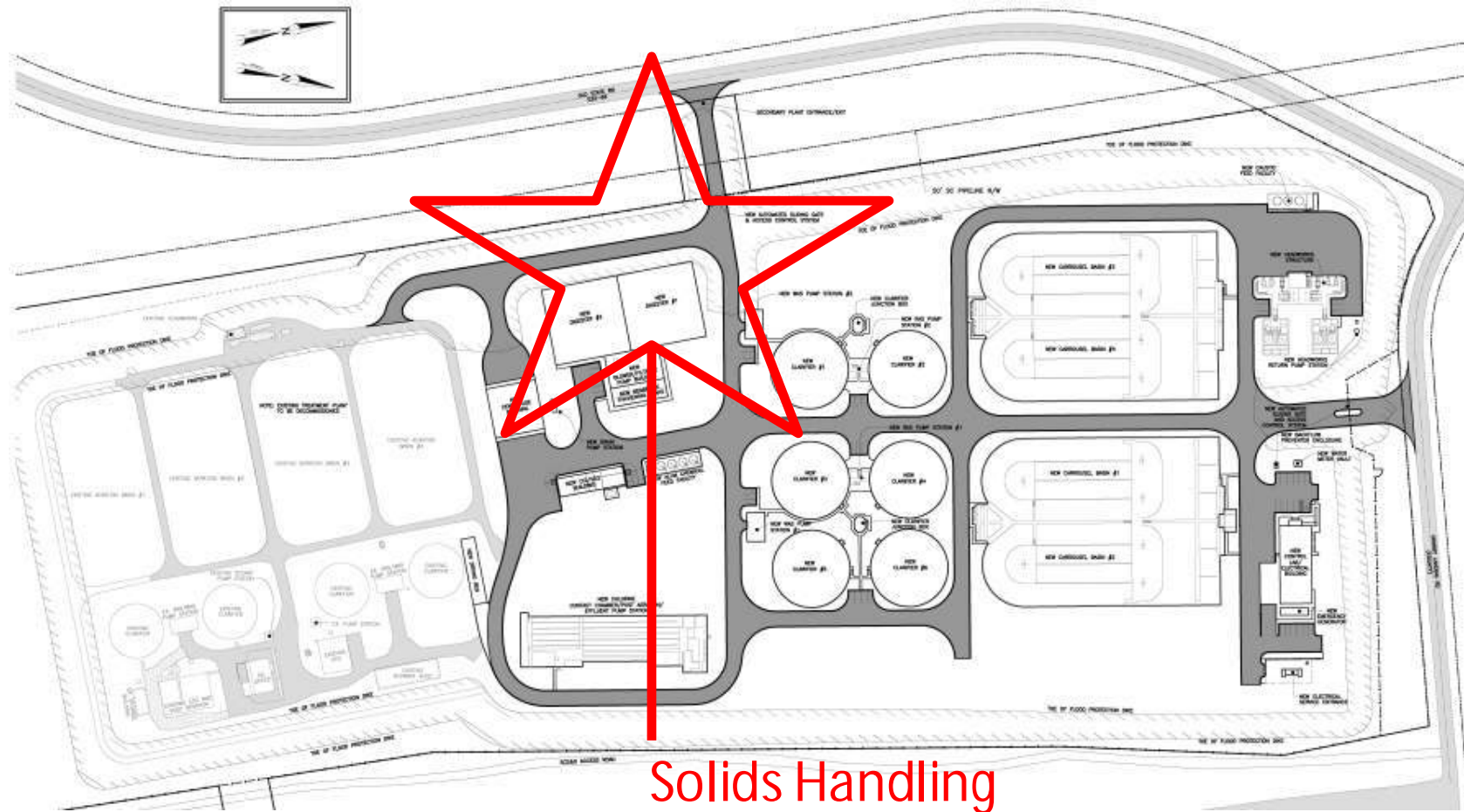
Scott Trotter PE, Trotter & Assoc. Cons. Eng. for the city.

Cayce WWTP, SC, USA; 30,240m³/d

Current Site

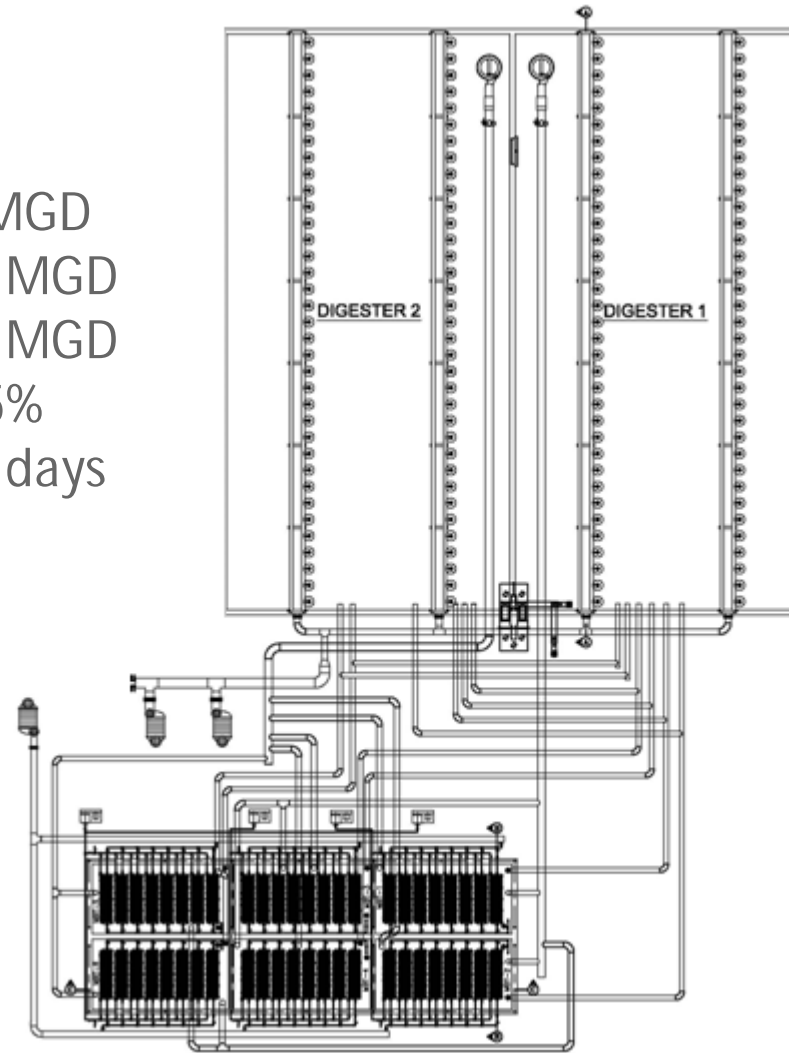


Cayce WWTP, SC, USA; Expanded to 94,500 m³/d with CAD-K



Cayce WWTP, SC, USA; CAD-K

Start-up Plant Flow=	8 MGD
Intermediate Plant Flow=	12 MGD
Design Influent Plant Flow=	25 MGD
WAS concentration=	0.5%
Design digestion SRT=	20 days



Cayce WWTP, SC, USA; CAD-K

Benefits:

1. Eliminated Construction of a thickener building
2. Reduced number and size of digesters by operating at 4% TS
3. Provided flexibility for a gradual flow increase.
4. Reduced O&M costs by eliminating use of polymer for thickening
5. Reduced O&M costs due to lesser aeration / energy needs.
6. Reduced O&M costs due to lesser supervision needs.

Summary of CAD-K Advantages

1. Ovivo's Flat-Plate technology is being used as a simple and reliable way to thicken sludge and post-thicken digested product without polymer.
2. Membrane Thickeners are ideal devices for processes where strict effluent nutrient limits are to be enforced.
3. The process provides total nitrogen removal, zero TSS and reduced P in the permeate.
4. The CAD-K process provides small footprint, energy savings, a temperature increase, in addition to nutrient control.