AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERS & SCIENTISTS®

14 Excellence in Environmental Engineering & Science Conference

Membrane Thickening - A Sustainable Solution

Presented By:

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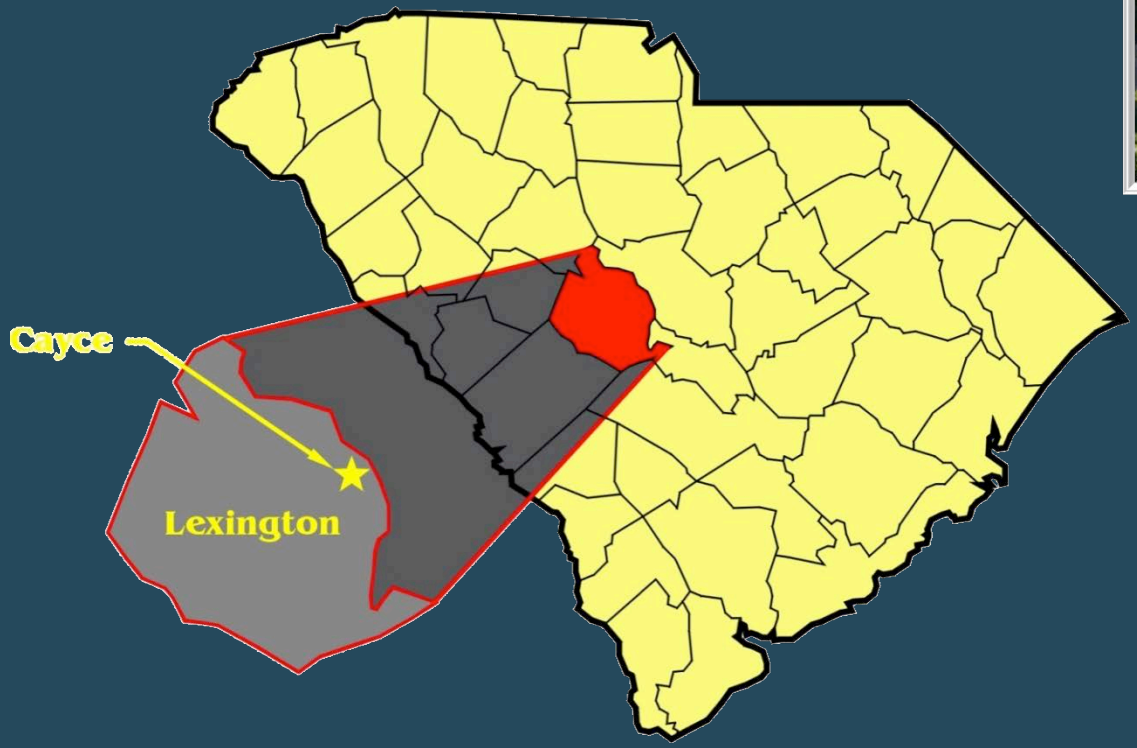
AMERICAN ENGINEERING CONSULTANTS, INC.

REDISCOVER CAYCE a new kind of city

City Of Cayce Regional WWTP



City Of Cayce Regional WWTP

- New 25 MGD Plant / Greenfield Site Adjacent To Congaree River
- Construction Started Dec. 2009
- Discharge Began In Oct. 2012
- Total Construction Cost = $54.1 Million/ $2.17 Per Gal.

City Of Cayce Regional WWTP

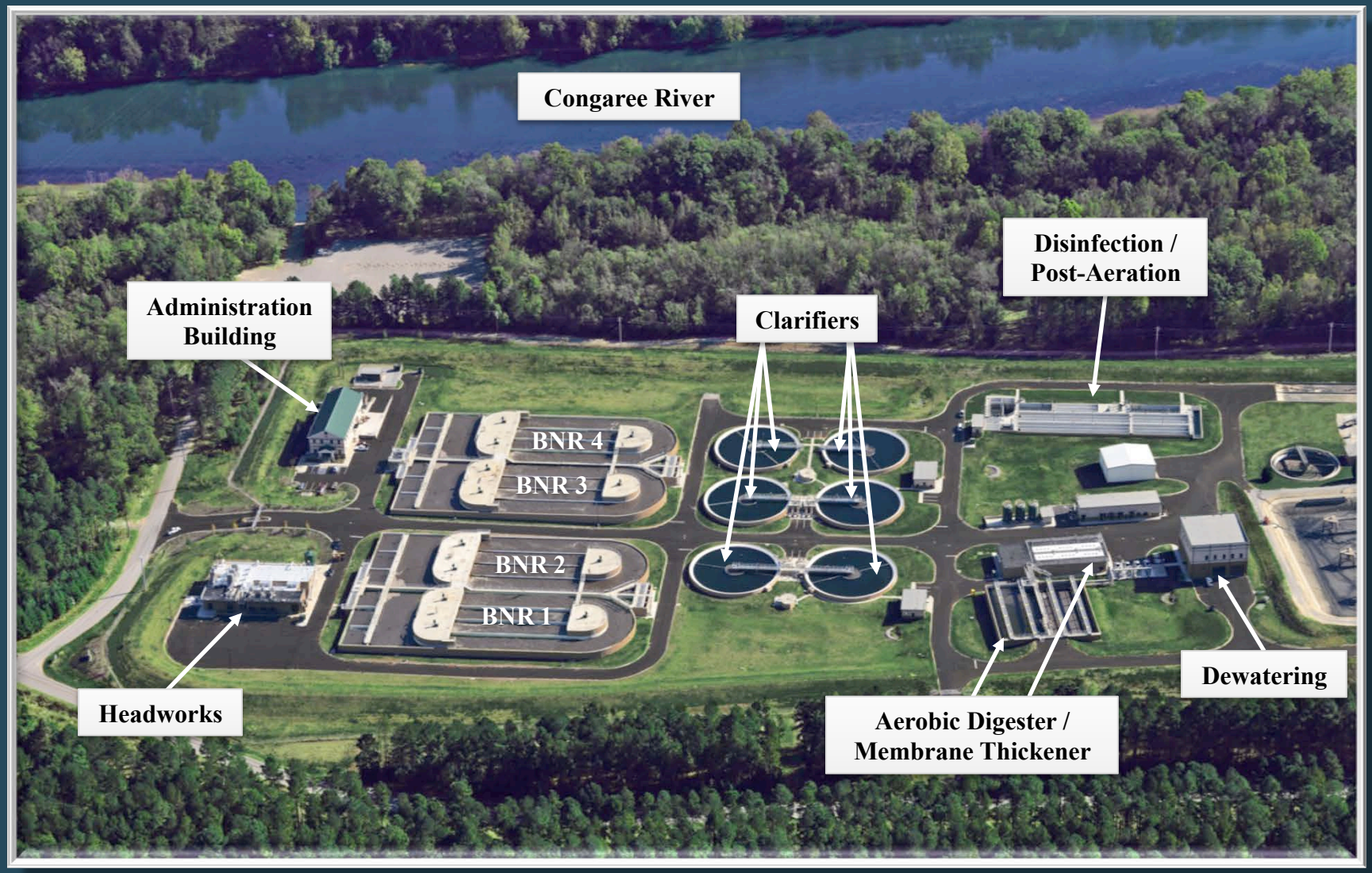
- Effluent Limits:
  - BOD & TSS = 30 mg/L Monthly Avg.
  - NH_3-N= 20 mg/L Monthly Avg.
  - UOD = 15,444 Lbs/Day Monthly Avg.
    UOD=[(BOD*1.5)+(NH_3-N*4.57)]*Q(MGD)*8.34

City Of Cayce Regional WWTP

- Effluent Limits:
  - Total Phosphorus (P) = 2 mg/L Monthly Avg.
  - Total P (Mass) = 208 PPD Monthly Avg. (or 269 PPD When Upstream Plant Is De-commissioned)
  - At 25 MGD → P Conc.= 1.0 mg/L to 1.3 mg/L
  - Phosphorus Limits Important Factor In Selection Of Solids Handling Process

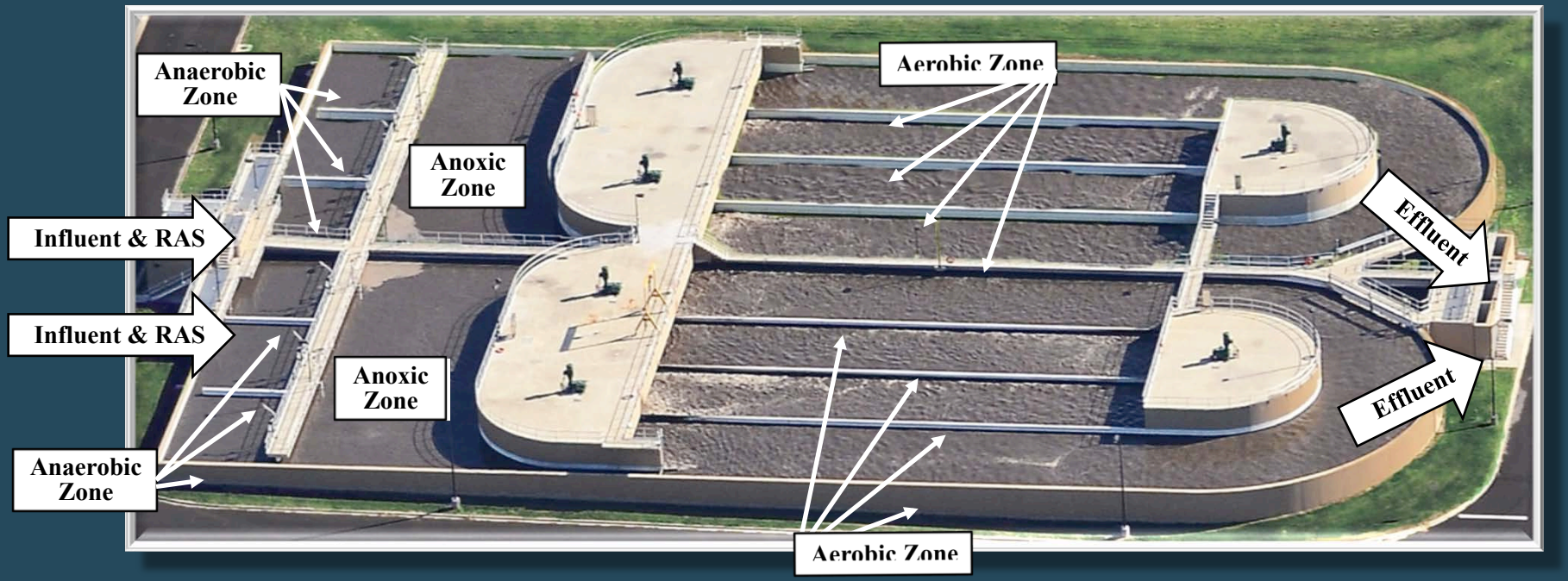
City Of Cayce Regional WWTP

Process Overview



City Of Cayce Regional WWTP

BNR Process



- Anaerobic Selector & Anoxic Zones with Carrousel Aeration (A^2O Process)
- Nitrification / Denitrification Critical for Success of Biological Phosphorus Removal
- Phosphorus Accumulation Organisms (PAO) Release P In Anaerobic Zone and Take Up P In Aerobic Zone

Solids Handling Process

Design Considerations

- Process To Complement BNR Design For Phosphorus Removal – Minimize Phosphorus Release During Digestion, Thickening, and Dewatering
- Minimize Operator Involvement
- Avoid Chemicals for Phosphorus Removal or Thickening
- Efficient Process / Reduce Operating Costs
- Sustainable / Environmental Benefits

Solids Handling Process

Process Selection

- Anaerobic Digester – Releases 60-80% of Phosphorus removed in BNR – Operator intensive
- Conventional Aerobic Digester w/Settling & Decanting Cycles – Releases 5-10% of Phosphorus removed in BNR – Gravity Thickening to only ~2% or Chemical Thickening to ~4% – Operator Intensive Batch Process
- Aerobic Digestion With Continuous Membrane Thickening – Releases 1% of Phosphorus removed in BNR – Thickens to 4% – Minimal Operator Attention

Aerobic Digestion/Membrane Thickening

Process Benefits For Cayce WWTP

- Process Minimizes Phosphorus Release In Digester by Providing Continuous Aeration while Thickening through Membrane Units
- No Chemicals Required to Treat Phosphorus released
- Allows Continuous Sludge Wasting (No Settling Cycle)
- Allows Continuous Withdrawal Of Permeate (No Decant)

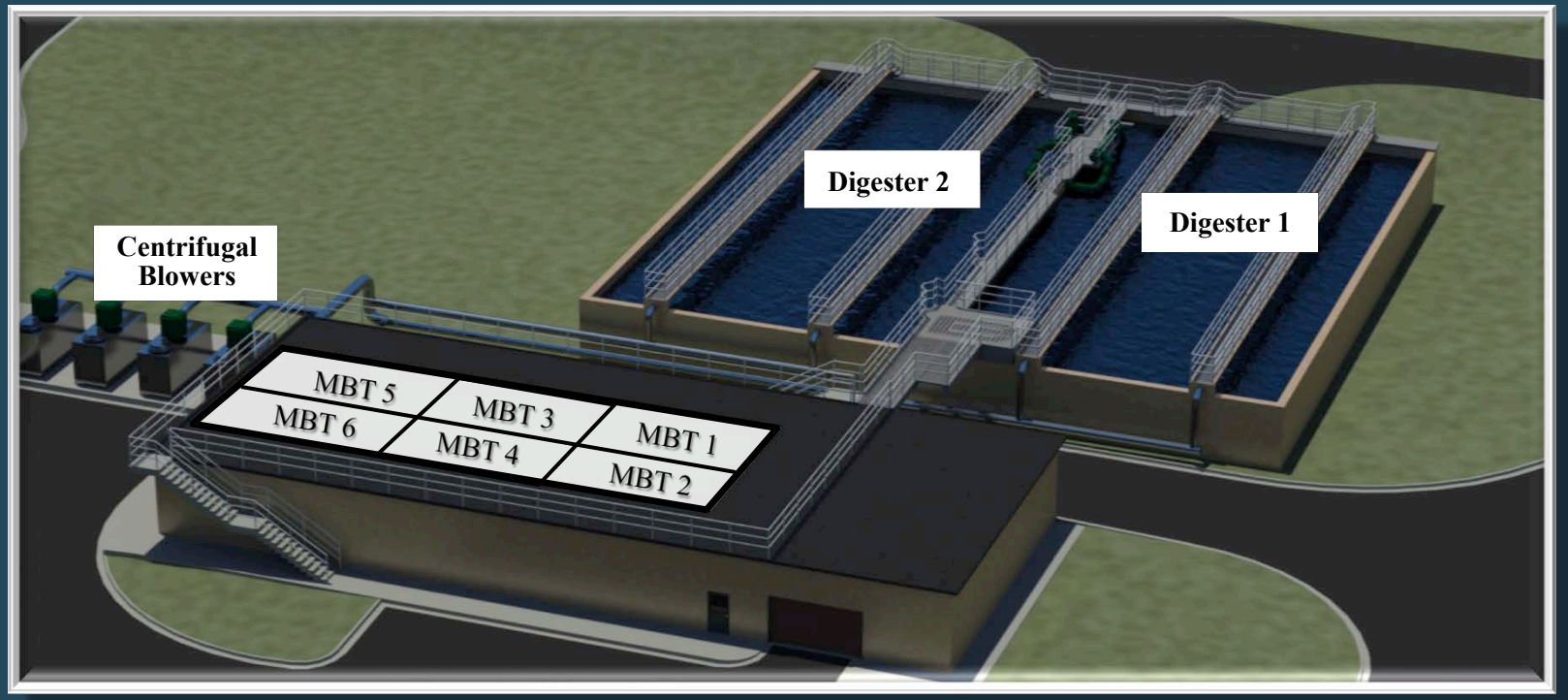
Aerobic Digestion/Membrane Thickening

Process Benefits For Cayce WWTP

- Thickens To 4% - Reduces Volume Of Biosolids To Process & Tank Footprint = Cost Savings
- No Polymers Or Other Chemicals Required For Thickening = Cost Savings
- Produces Class B Biosolids - Sustainable
- Permeate Can Be Re-Used - Sustainable

Aerobic Digestion/Membrane Thickening

Major System Components



- Influent Screening
- Two (2) Stage Digester w/Two (2) 1,000,000 Gal. Tanks
- Six (6) Membrane Thickening Tanks
- Four 300 HP Centrifugal Blowers

Aerobic Digestion/Membrane Thickening

Influent Fine Screening

- All Influent WAS Is Screened
- Two (2) Bar Screens – 1200 GPM Capacity Each
- Opening Size = 2 mm

Aerobic Digestion/Membrane Thickening

Aerobic Digester

- Two (2) ≈ 1.0 MG Tanks
- Air Delivery Via Two (2) Air Bridges In Each Tank
- (70) 2” Drop Pipes/Diffusers In Each Tank

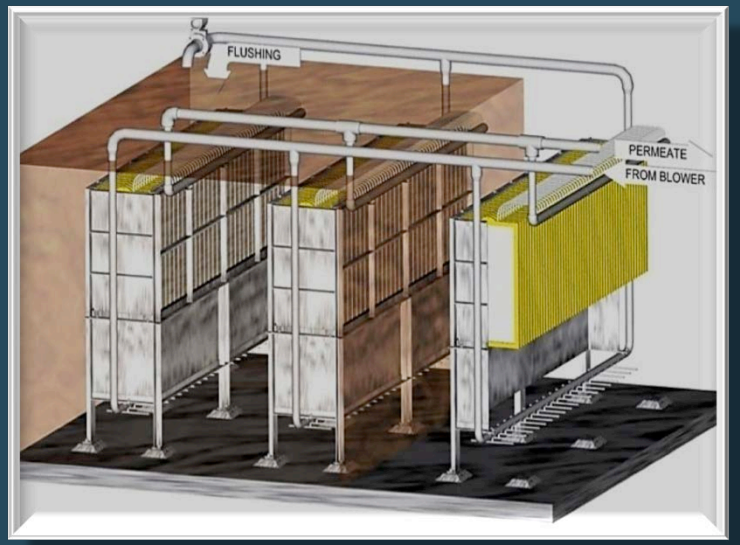
Aerobic Digestion/Membrane Thickening

Aerobic Digester

- Shear Tubes At Each Diffuser Aid Digester Mixing
- Recycle Pumps Loop Each Digester W/Membrane Tanks
- Stage 1 Tank Overflows Into Stage 2 Tank Via Weir Gate
- Stage 1 Digester Thickened To 2%
- Stage 2 Digester Thickened To 4%

Aerobic Digestion/Membrane Thickening

Membrane Thickening Overview

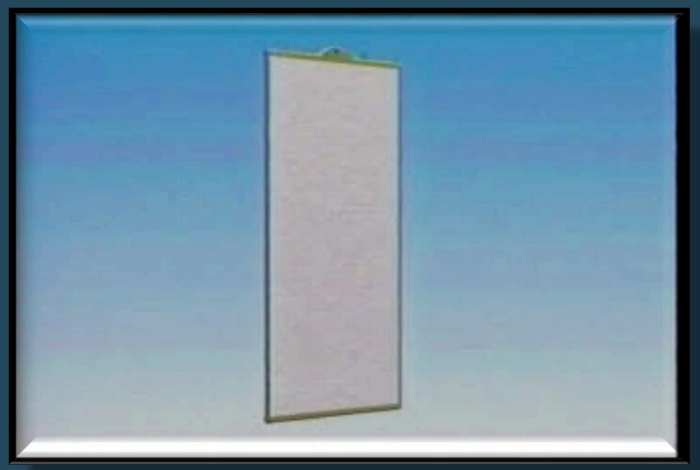


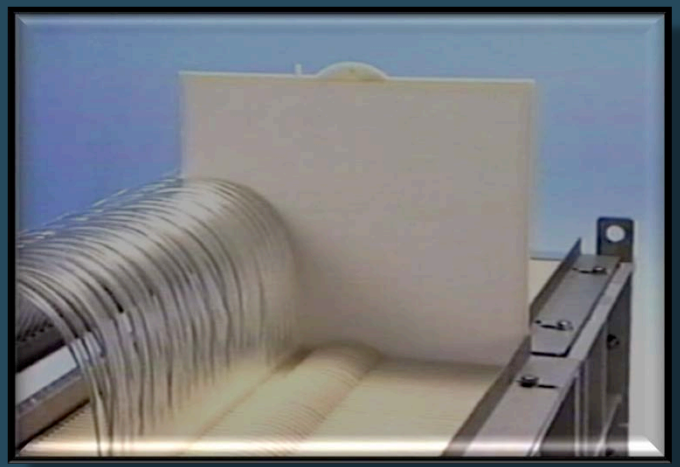
How Is Sludge Thickened W/Membranes?

- Submerged Membrane Thickening (MBT) Unit Used To Create Physical Barrier Across Which Clear Water (Permeate) Is Extracted W/Solids Left Behind
- Air Diffuser Incorporated On Lower Part Of Unit For Membrane Scouring & Aeration Of MBT Tank

Aerobic Digestion/Membrane Thickening

Membrane Plates

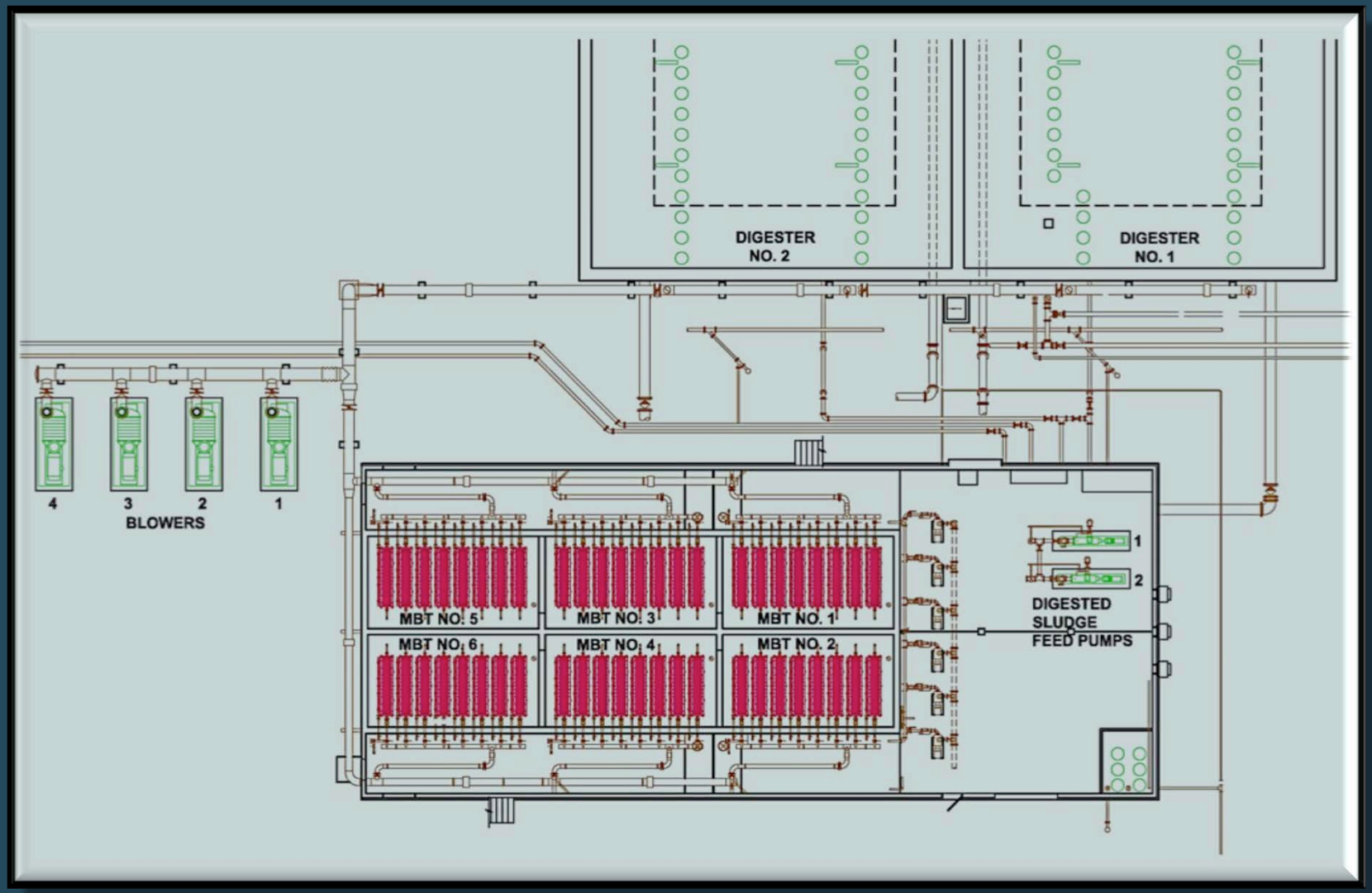




- 1600 Flat Plate Membranes (FPM) In Each Tank (200 FPM x 8 SMUs x 6 Tanks) = 9600 Total FPM
- Effective Air Filtration Area = 8.6 ft^2 Per Plate
- 0.4 Micron Nominal / 0.1 Micron Effective Pore Size
- Stage 1 MBT Design Flux = 15 gpd/ft^2
- Stage 2 MBT Design Flux = 5 gpd/ft^2

Aerobic Digestion/Membrane Thickening

Membrane Thickener (MBT)



Membrane Thickener Building Layout

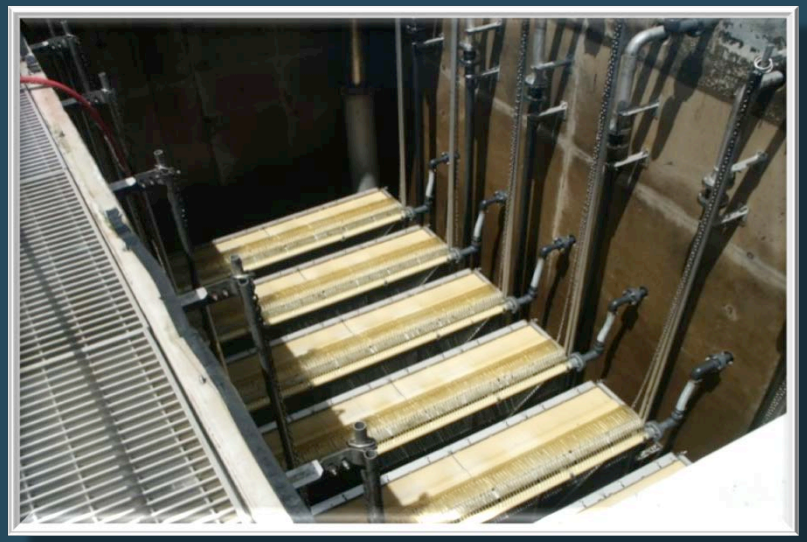
Aerobic Digestion/Membrane Thickening

Membrane Thickener (MBT) Building

- Building Arranged Around Six (6) MBT Tanks
- Building Contains Air/Permeate Piping & Valves, Permeate Pumps, Controls, Digested Sludge Pumps (Centrifuge)
- Roof Access to MBT Tanks, Diffuser Cleaning Valves, & Digester

Aerobic Digestion/Membrane Thickening

Membrane Thickener Tanks



MBT Tank w/o Cover

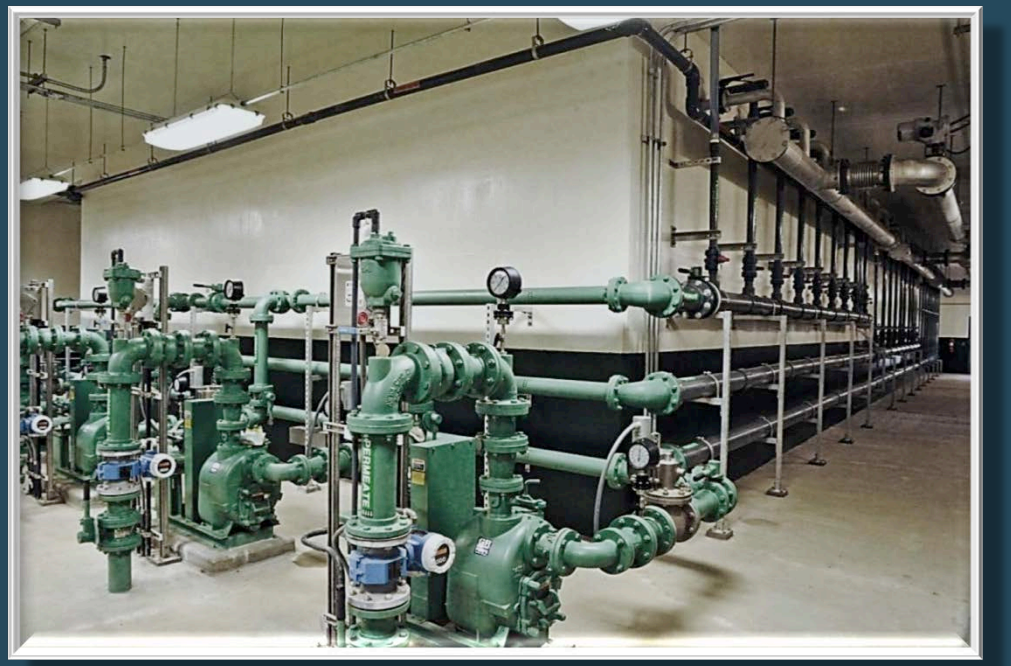
MBT Tank During Construction

MBT Tanks w/Covers

Aerobic Digestion/Membrane Thickening

Membrane Thickener

Permeate Pumps/West Pipe Gallery



- Six (6) Permeate Pumps – One For Each Tank
- Equipped w/VFDs To Control Permeate Withdrawal Rate
- Operator Enters Permeate Flow At Control Interface

Aerobic Digestion/Membrane Thickening

Membrane Thickener

Permeate Pumps

- Automatic Controls Start/Stop Pumps For Membrane Relax Cycles & Diffuser Cleaning
- Membrane Relax Cycle Approx. 3 Min. Out Of Every 10 Min.
- Diffuser Clean Several Times Daily

Aerobic Digestion/Membrane Thickening

Centrifugal Blowers

- Four (4) – 300 HP Centrifugal Blowers w/VFDs
- Discharge To Common Header w/Distribution To Two (2) Digesters & Six (6) MBT Tanks
- Allows Air Demands To Be Met w/Minimum Number of Blowers & Provides Redundancy

Aerobic Digestion/Membrane Thickening

Centrifugal Blower Control

- Operator Enters Flow For Each Tank Through Control System & Automatic Control Valves Modulate To Maintain Desired Flow @ Each Location (8 Valves)
- Control Algorithms Adjust Blower Speed and Stage On and off the Number of Blowers operating To Maintain A Pressure Set Point On Air Header

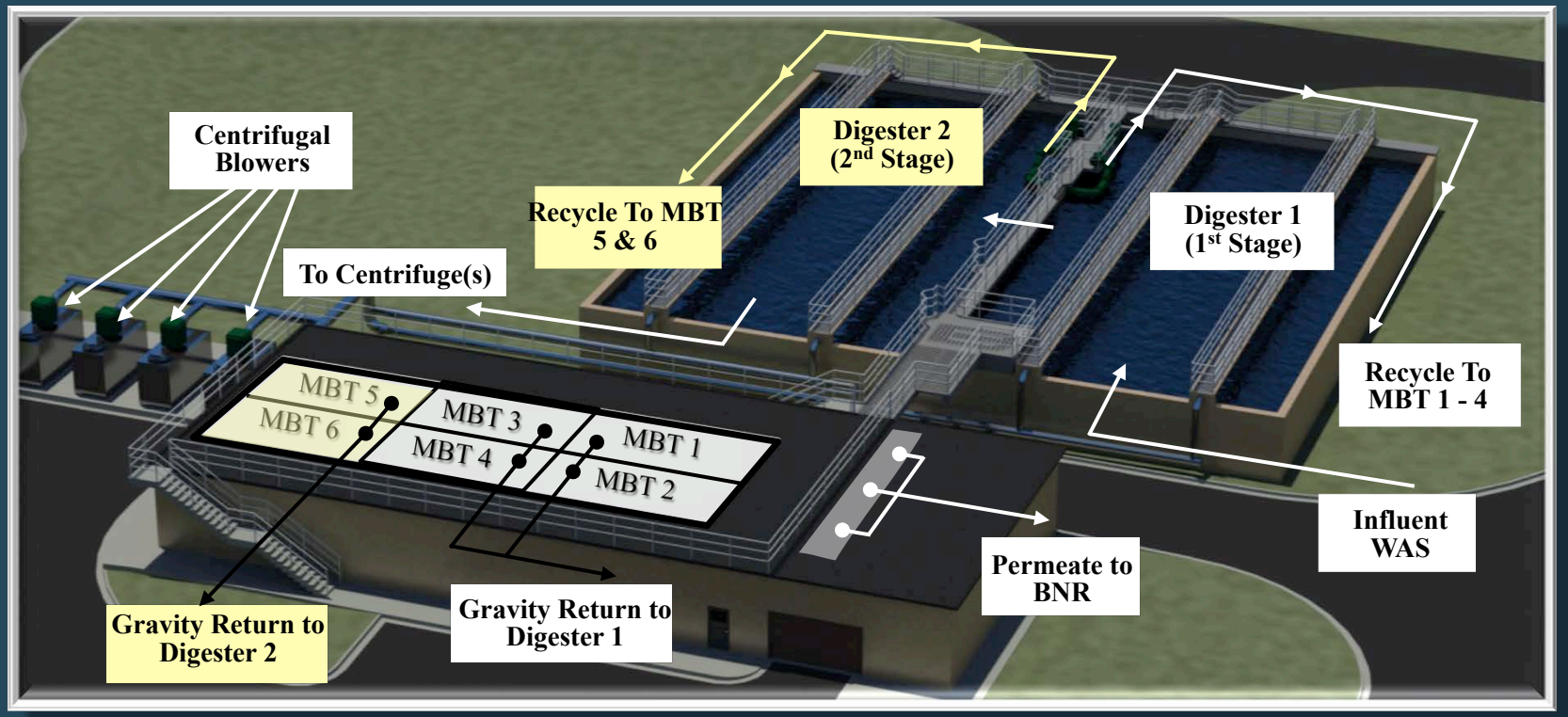
Aerobic Digestion/Membrane Thickening

Centrifugal Blowers

- Secondary Most Open Valve (MOV) Control Logic Adjusts the Pressure Setpoint Up Or Down Based On the Valve Positions Until at Least One Valve Reaches Fully Open Representing the Minimum Headloss Possible on the Air System
- Blower Configuration & Control Methodology Allow The System To Operate Over A Wide Range Of Flows And Tank Levels To Achieve Maximum Efficiency at all Operating Points

Aerobic Digestion/Membrane Thickening

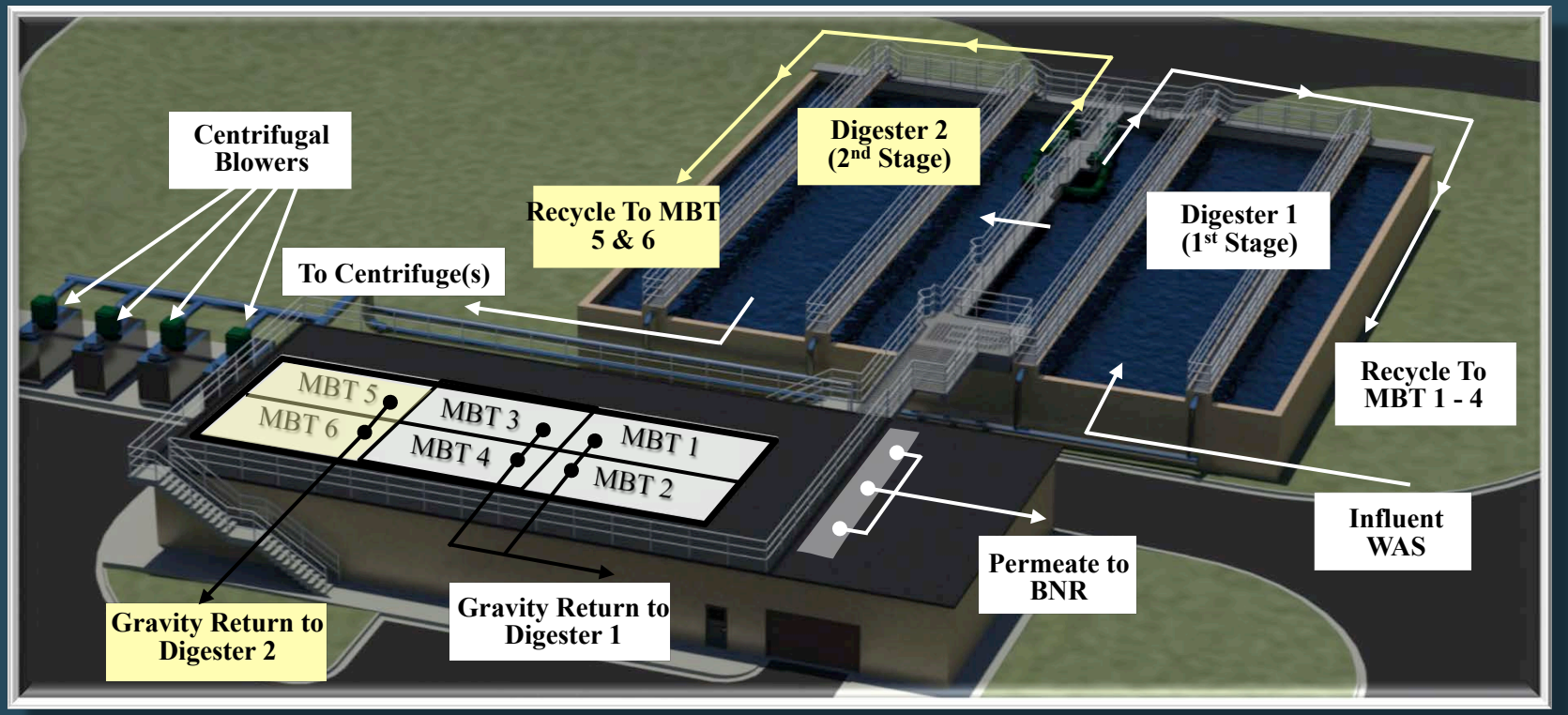
Typical Mode Of Operation



- Dig. 1 Loops w/MBT 1 – 4 Thickening To 2%
- Dig. 2 Loops w/MBT 5 & 6 Thickening To 4%
- Pumped To MBTs Using Digester Recycle Pumps

Aerobic Digestion/Membrane Thickening

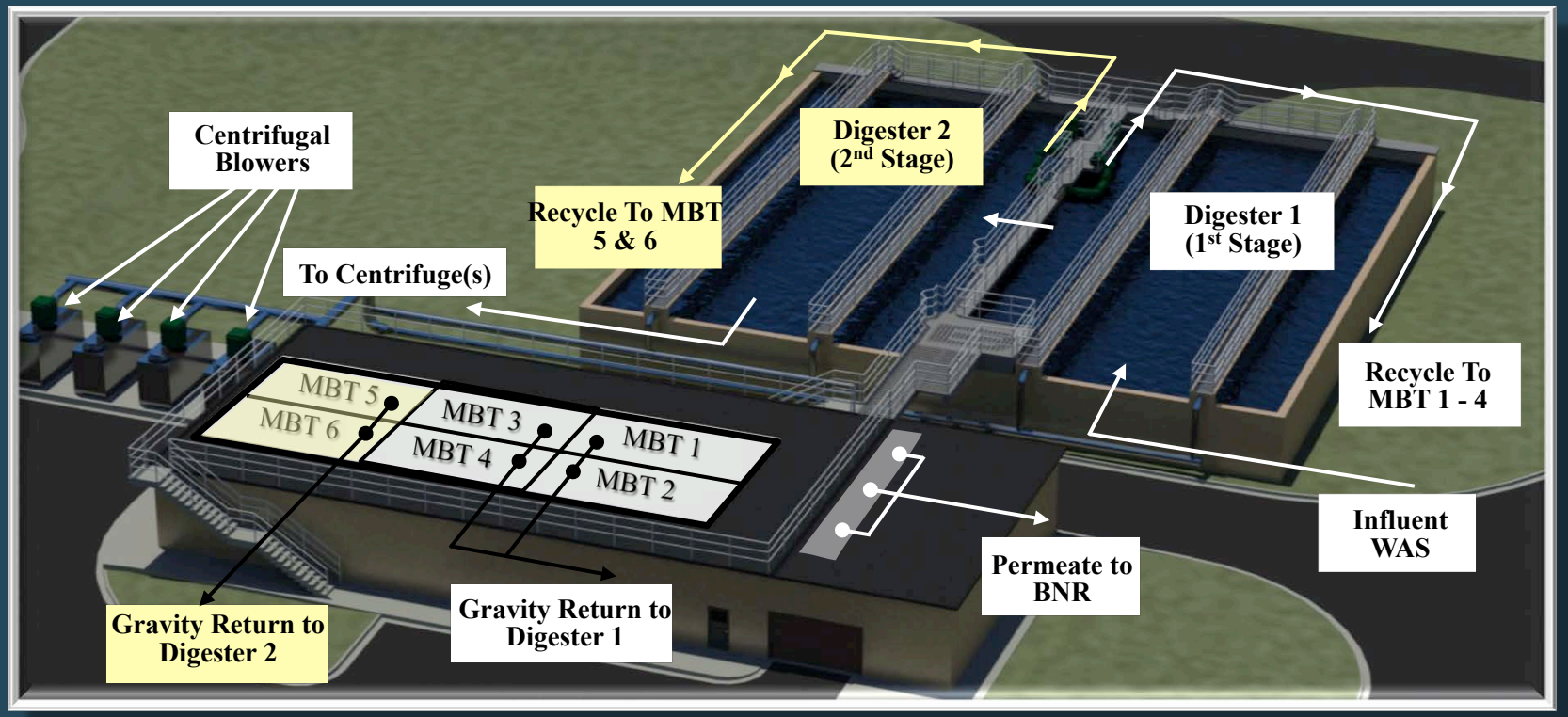
Typical Mode Of Operation



- Gravity Return To Digester Via Telescoping Valves
- Permeate Pumped To Main BNR Process
- Digested Sludge Pumped From Dig. 2 To Centrifuges

Aerobic Digestion/Membrane Thickening

Typical Mode Of Operation



- Piping Design & Controls Allow For Much Flexibility
- Can Operate One (1) Digester w/Any Number of MBT Tanks
- Saves Operating Cost At Low Flows When One Digester Provides Needed SRT & Two Digesters Provide No Add'l Digestion

Aerobic Digestion/Membrane Thickening

Conclusion/Process Benefits

- Process Permits Continuous Aeration Thus Minimizing Phosphorus Release from Digestion of BNR Sludge. Sampling Indicates < 1 % Release At Cayce with ≈ 3 mg/L Phosphorus in the Dewatering Side Streams
- Eliminates Chemical Removal of Phosphorus
- Thickening Process Is Continuous And Independent Of Wasting Schedules
- Sophisticated Control System Allows Automatic Process Control And Monitoring With Minimal Operator Attention
- Semi-Annual Chemical Cleaning Of Membranes Does Not Require Tanks To Be Drained Or Taken Out Of Service

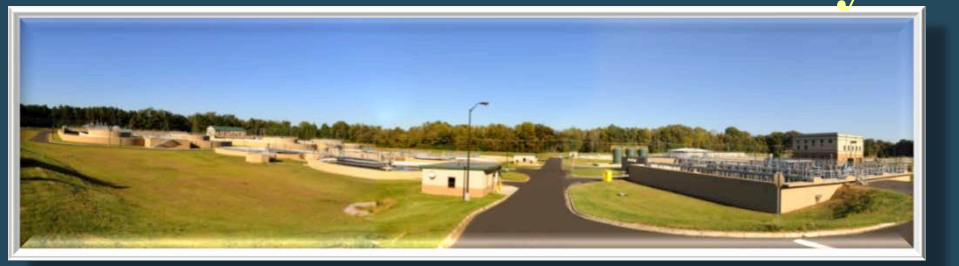
Aerobic Digestion/Membrane Thickening

Conclusion/Economic Benefits

- Thickening Minimizes Sludge Volume To Be Processed, Resulting In Energy Savings From Reduced Process Air Requirements
- No Chemical Addition Required For Nutrient Removal Or Sludge Thickening
- Reduced Sludge Disposal Costs
- Four Centrifugal Blowers Connected To A Single Manifold Header Are Automatically Controlled Providing Maximum Efficiency And Minimum Power Consumption at all Operating Points

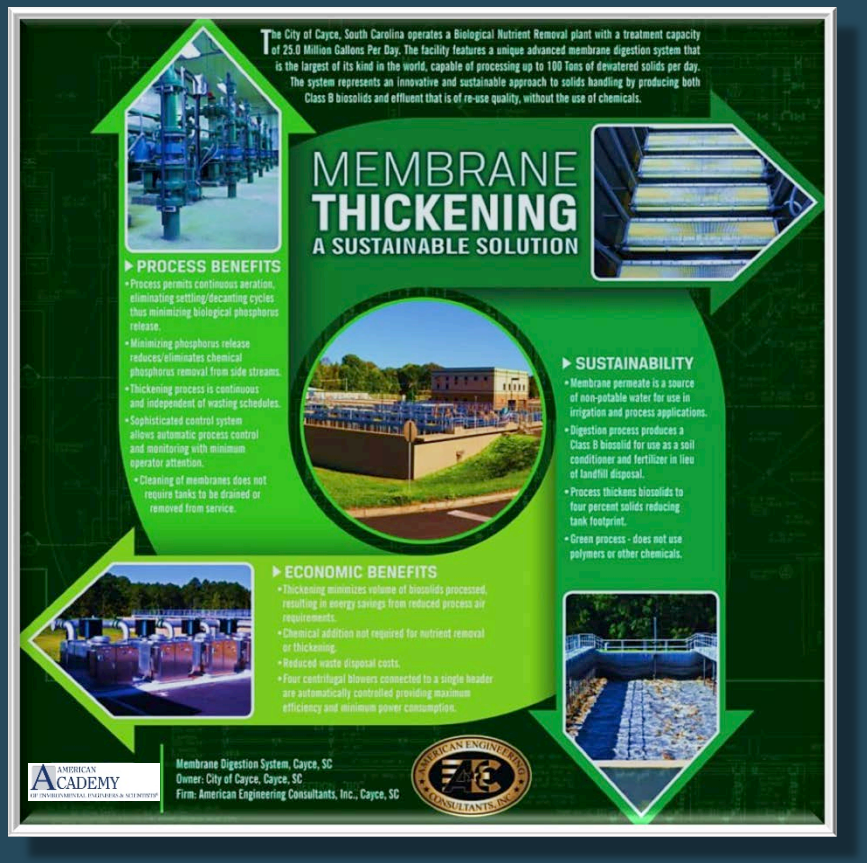
Aerobic Digestion/Membrane Thickening

Conclusion/Sustainability



- Membrane Permeate is a Source of Non-Potable Water For Use in Irrigation and Process Applications
- Digestion Process Produces a Class B Sludge for Use as a Soil Conditioner and Fertilizer in Lieu of Landfill Disposal.
- Process Thickens Sludge to Four Percent Solids Without the Use of Polymers or Other Chemicals

Questions?



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