

December 6, 2012

CSO REDUCTION USING EXPRESS SEWERS AND SATELLITE TREATMENT

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Upper Hocking Water Pollution Control Facilities

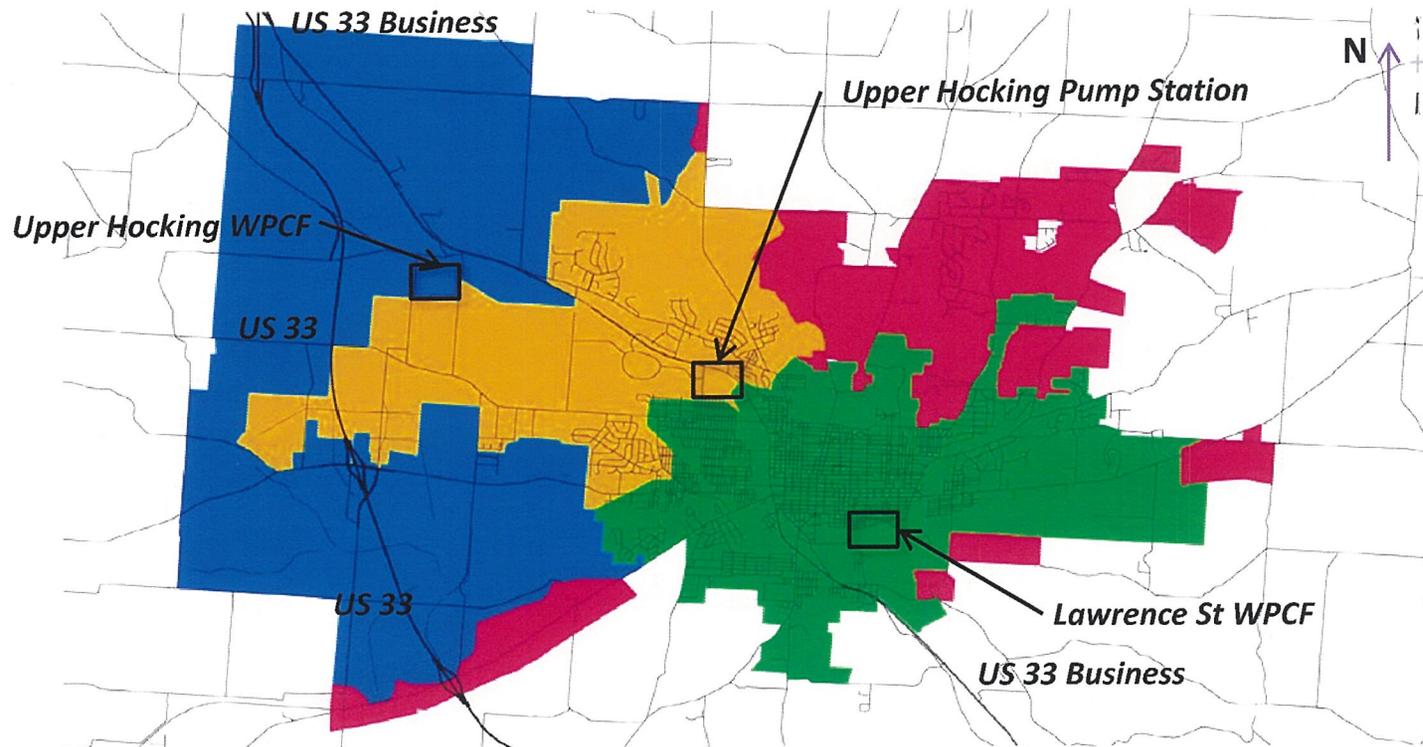
- **Project Background**
 - Collection System
 - Project History
- **Upper Hocking WPCF**
 - Design Flow Rates and Limits
 - Wet Stream Processes
 - VLRs
 - MBRs
 - Solids Handling Processes
 - Cannibal
 - Dewatering

City of Lancaster, OH Collection System

- **Combined Sewer Community**
- **Population Served ~ 37,000**
- **140 Miles of Sanitary Sewer**
- **17 Miles of Combined Sewer**
- **Lawrence Street WPCF**
 - Previous Ave Flow ~ 6.5 mgd
 - Current Ave Flow ~ 5.2 mgd
 - Peak Capacity – 18 mgd
- **Eliminate CSOs with construction of a “satellite” WPCF**



Collection System – Service Areas



Current Service Areas

-  Lawrence St. WPCF - Combined
-  Upper Hocking WPCF - Separate

Future Service Areas

-  Lawrence St. WPCF - Separate
-  Upper Hocking WPCF - Separate

Upper Hocking Water Pollution Control Facilities

Summary of New Facilities

- Upper Hocking WPCF
 - 2.0 mgd (ADF) Water Pollution Control Facility – to treat separately sewerage areas only.
- Upper Hocking Pump Station
 - Remote 8.0 mgd (peak) Pump Station and force mains – to divert flow from separately sewerage areas to the new WPCF

Schedule

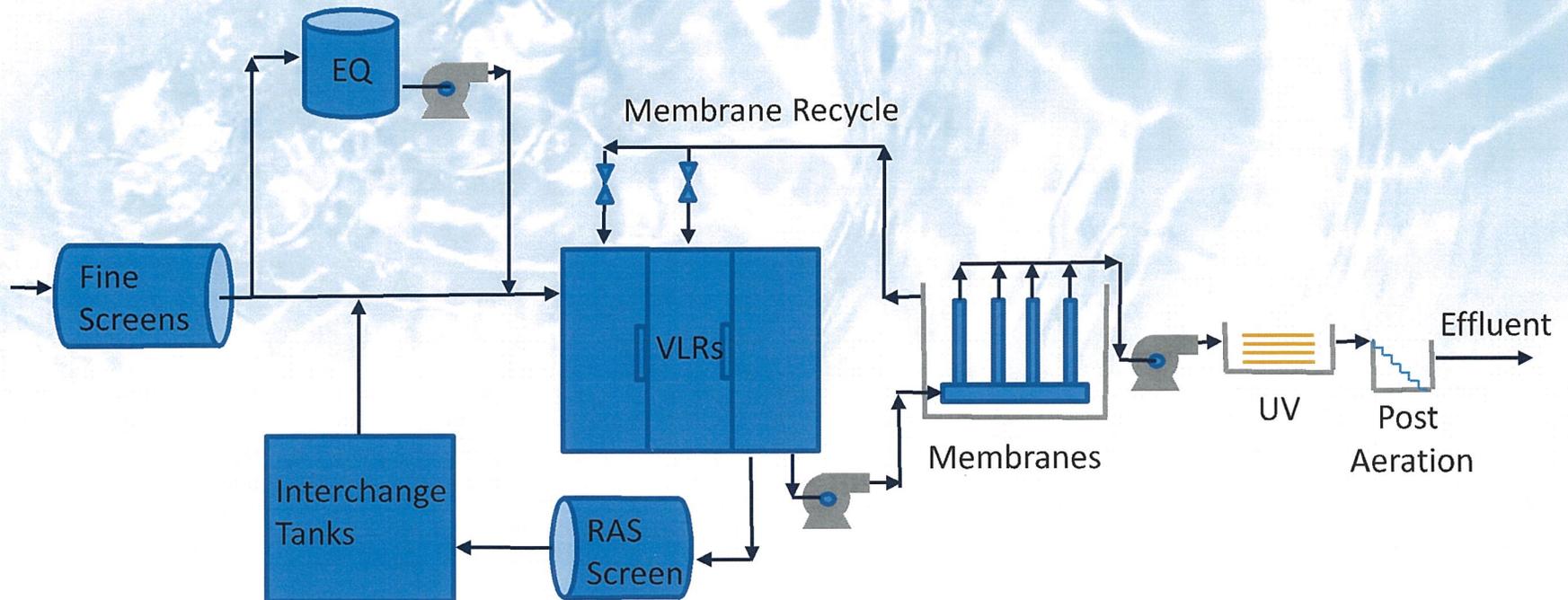
- Construction Began – January 2009
- Startup – July, 2011

Upper Hocking WPCF – Flow Rates

- **Peak Flow Through Preliminary Treatment – 8.0 mgd**
- **Design Flows Through Secondary Treatment**
 - Average Daily Flow Rate – 2.0 mgd
 - Minimum Flow Rate – 0.4 mgd
 - Peak Monthly Flow Rate – 3.5 mgd
 - Peak Daily Flow Rate – 6.0 mgd
 - Peak Hourly Flow Rate – 6.0 mgd
 - Maximum flow limited by membrane
- **Average Daily Flow Rate – 1.5 mgd**

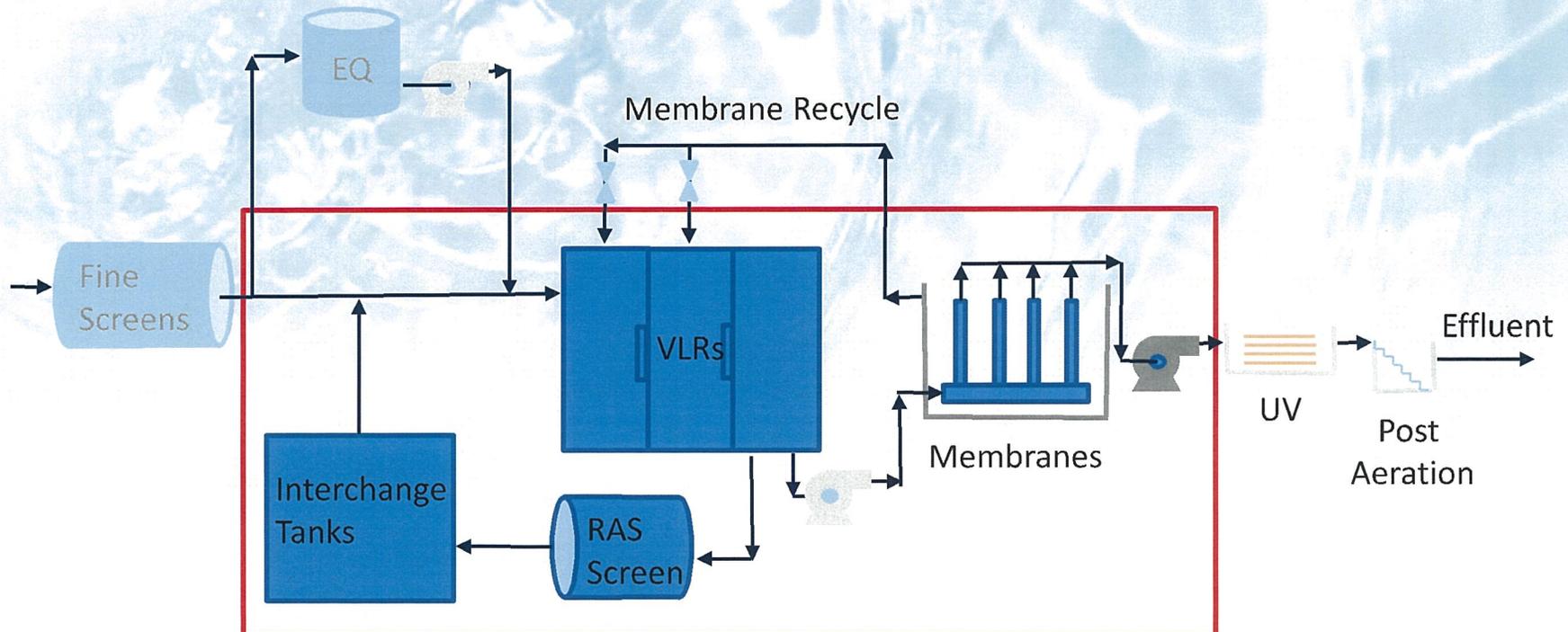
Plant Processes

- Influent Fine Screening (no grit removal)
- Equalization
- Aeration Process (Vertical Loop Reactors)
- Membrane Bioreactors
- UV Disinfection
- Post Aeration
- Cannibal® Sludge Reduction System



Plant Processes– Provided by Siemens

- Aeration Process (Vertical Loop Reactors)
- Cannibal® Sludge Reduction System
- Membrane Bioreactors
- Currently this is the only plant in the US to combine these processes



Preliminary Treatment – Fine Screening

- **Influent Fine Screens:**

- Fine screening critical for protection membrane life
- 2 units each rated for 8 mgd
- Internally-fed rotary drum screens
- 2 mm perforations

- **Screenings Washer**

- **Compactors:**

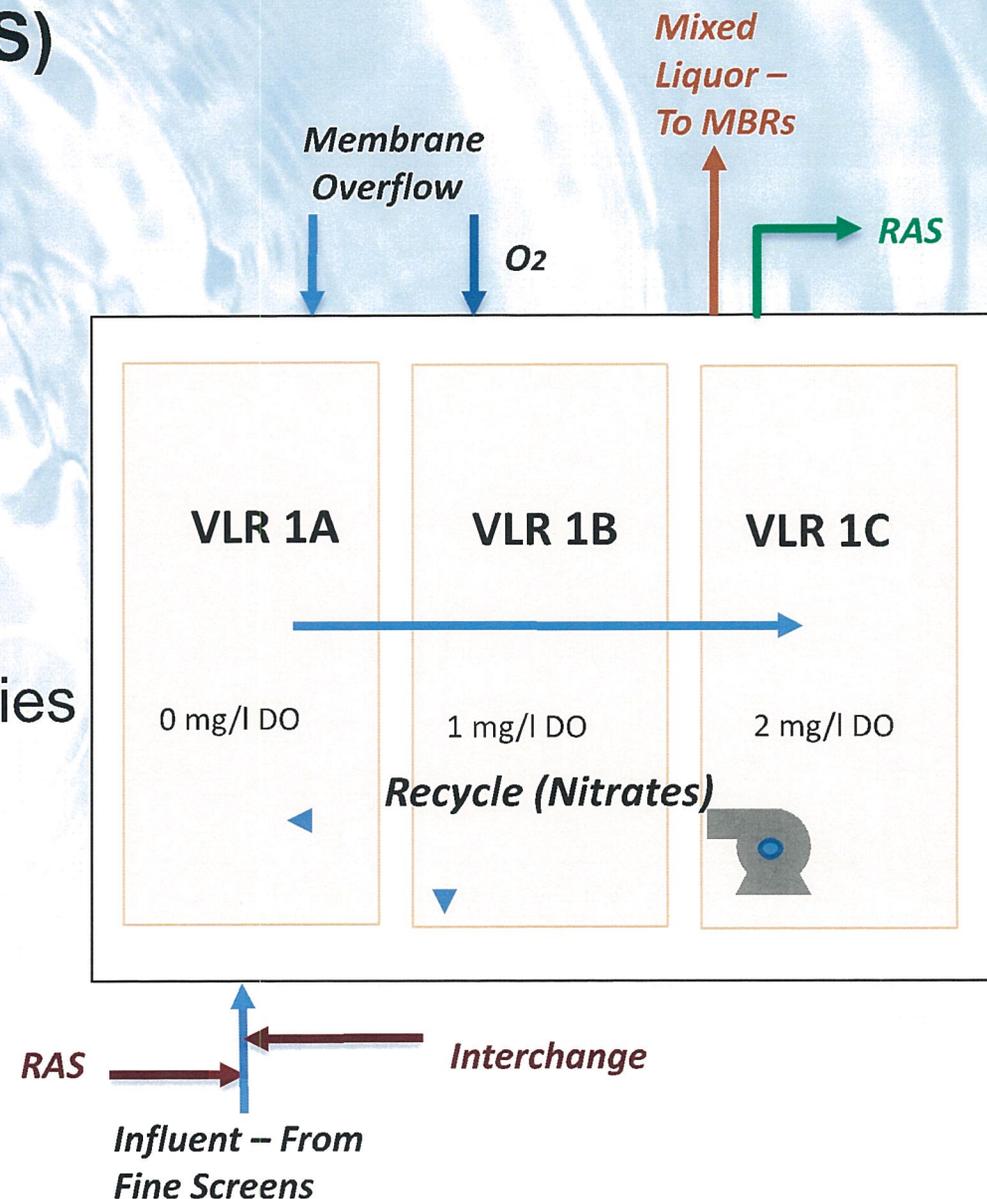
- 1 per screen
- Discharge to truck/container below



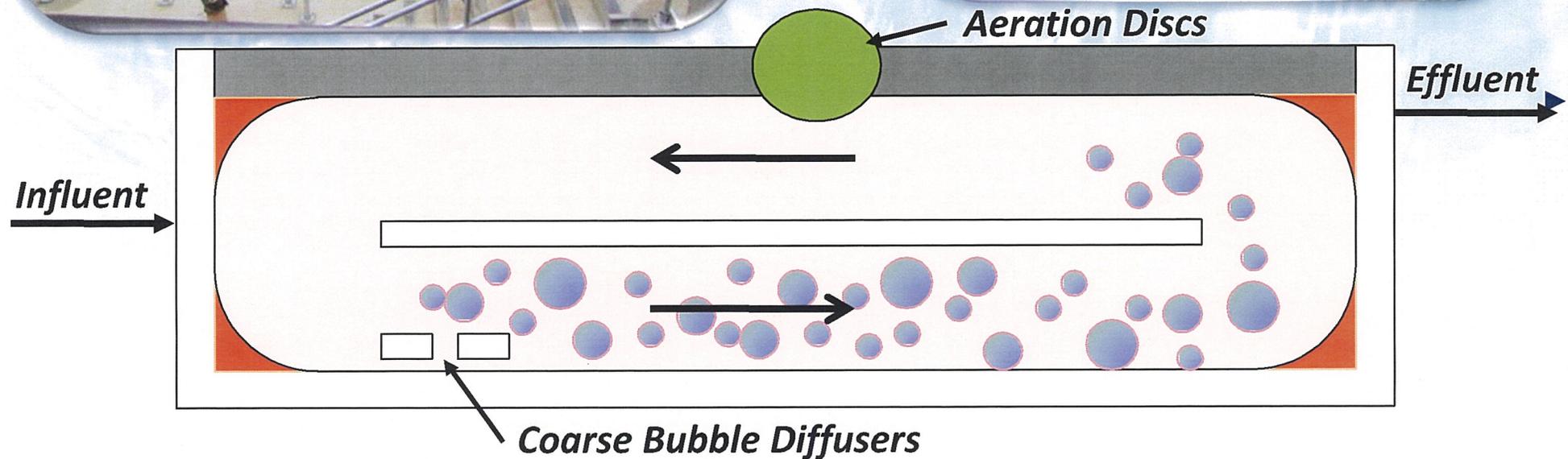
Process Aeration – Vertical Loop Reactors

Vertical Loop Reactors (VLRs)

- Three VLR basins
- Dimensions
 - Width – 30 ft, Depth – 20 ft,
 - Length – 66 feet
 - Volume – 285,000 gal each
- MLSS concentration – 7,000 to 10,000 mg/l
- Basins generally operate in series
- VLR 1A – anoxic zone
- VLR 1B and 1C – aerobic
 - Total nitrogen removal



Process Aeration - Vertical Loop Reactors (VLRs)



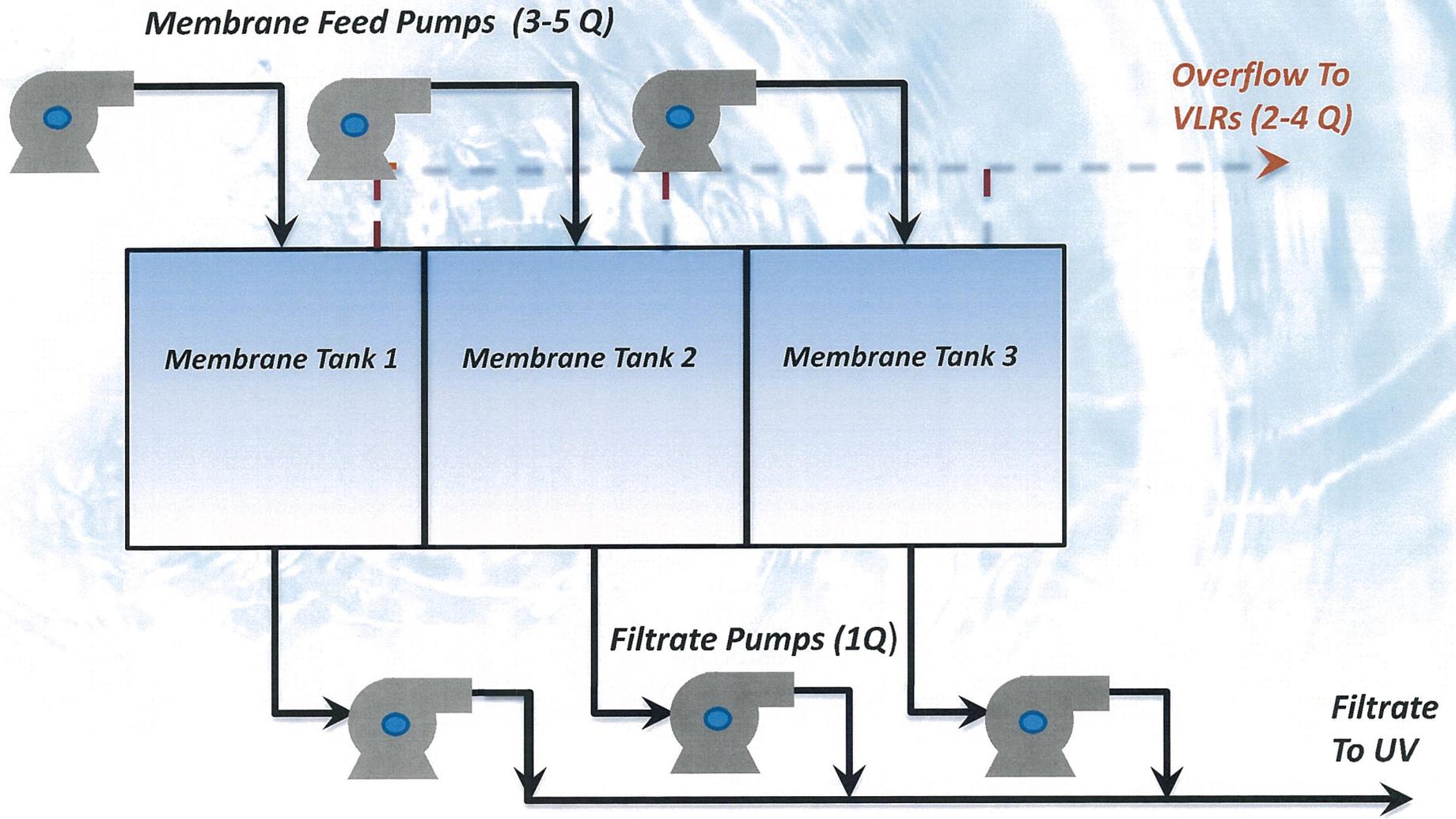
Membrane Bioreactors (MBRs)

- **Membrane Bioreactors Selected:**

- Superior effluent quality
- Discharges to Hocking River just upstream of the City of Lancaster
- With plant expansions, future discharge limits may be stricter because of low flow in stream
- High level of automation, minimum staff attention
- Takes less space than conventional clarifiers
- More reliable solids separation performance
- Eliminates need for filters
- Easily expandable
- Potential for effluent reuse at industrial park



Membrane Bioreactors (MBRs)



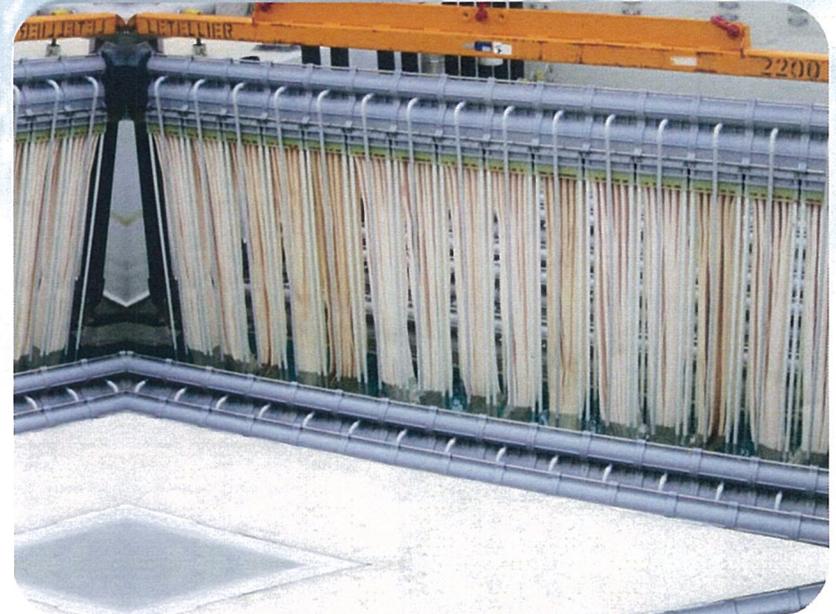
Membrane Bioreactors (MBRs)

- **Three tanks rated for 2 mgd (peak) each**
- **Composed of vertical membrane cartridges**
- **Siemens hollow fiber membranes**
 - Membrane pore size: 0.1 micron (0.0001 mm)
 - Membrane material: Polyvinylidene fluoride



Membrane Bioreactors (MBRs)

- **Membrane Bioreactors**
 - Tanks – 3 each
 - Dimensions:
 - 25 ft x 15.75 ft x 9.22 ft
 - Volume – 77,646 gallons each
 - Racks per tank – 17
 - Module per rack – 16
 - Module per tank - 272



Process – Membrane Bioreactors

Cleaning Processes

Relaxation

- Stop filtration (filtrate pumps)
- Removes caked solids from membranes

Sodium Hypochlorite Maintenance Clean

- 300 ppm sodium hypochlorite
- Removes biologicals from inside of membranes

Sodium Hypochlorite Clean-in-Place

- 1500 ppm sodium hypochlorite
- Removes biologicals from outside of membranes

Citric Acid Clean-in-Place

- 2 percent citric acid
- Removes mineral buildup from outside of membranes



Disinfection, Post-Aeration, P Removal

- **Ultraviolet Disinfection**

- Trojan 3000+
- Low pressure, high output
- *Currently is not being used. They are meeting permit without disinfection. Ohio EPA has approved this procedure.*



- **Post Aeration**

- Step aeration
- Dissolved oxygen requirement – 6 mg/l

- **Phosphorus Removal**

- Chemical addition
- 1 mg/l goal



Solids Handling Processes

- **Cannibal® (Siemens) Sludge Minimization Process**
 - Ultra fine screens for mixed liquor
 - Grit removal
 - Two sludge conditioning tanks (Interchange Tanks)
- **Sludge Storage Tank**
- **Centrifuge**

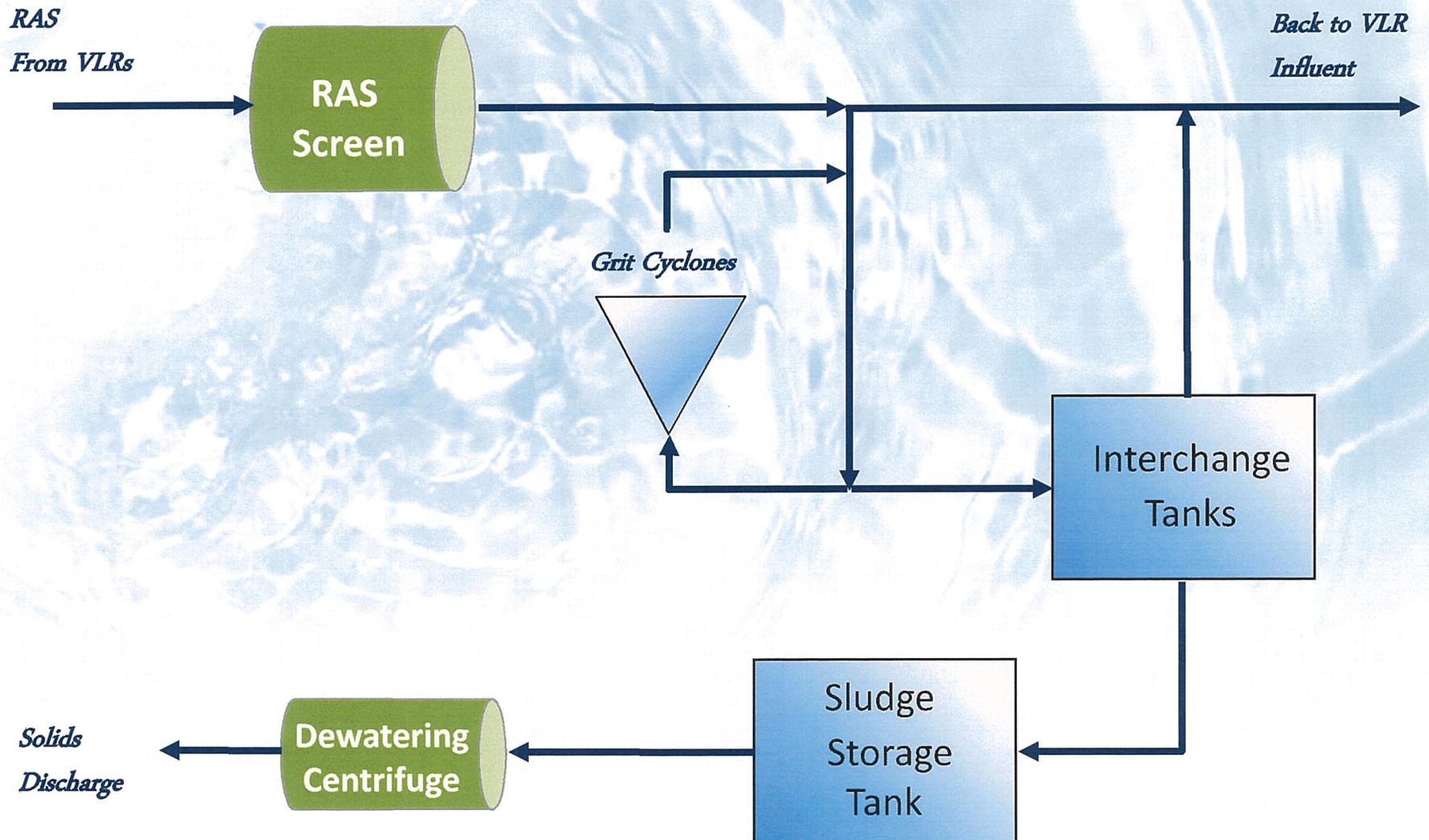


The Cannibal® Process

- **Mixed liquor is conditioned by ORP control to produce minimum net biological solids yield (minimize waste sludge)**
 - Designed to reduced biological yield to less than 0.28 lbs solids/lbs BOD₅ treated
- **Mixed liquor is screened and degrittied to remove non-readily degradable trash, grit, and inerts**



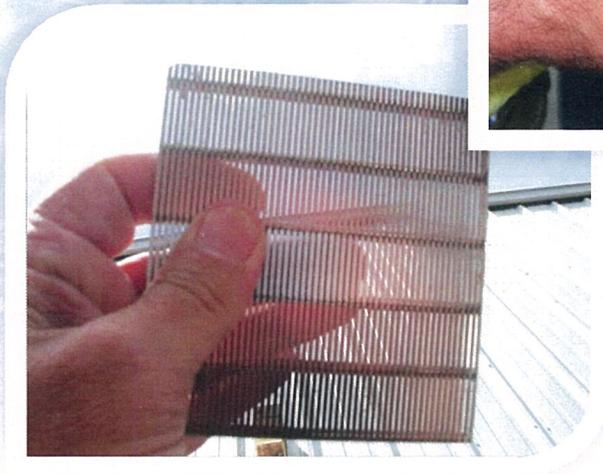
The Cannibal® Process



The Cannibal® Process – RAS Screening



- **RAS Rotary Drum Screen**
 - 0.25 mm wedgewire
 - Removes:
 - Inerts and trash
- **Washer Compactor**

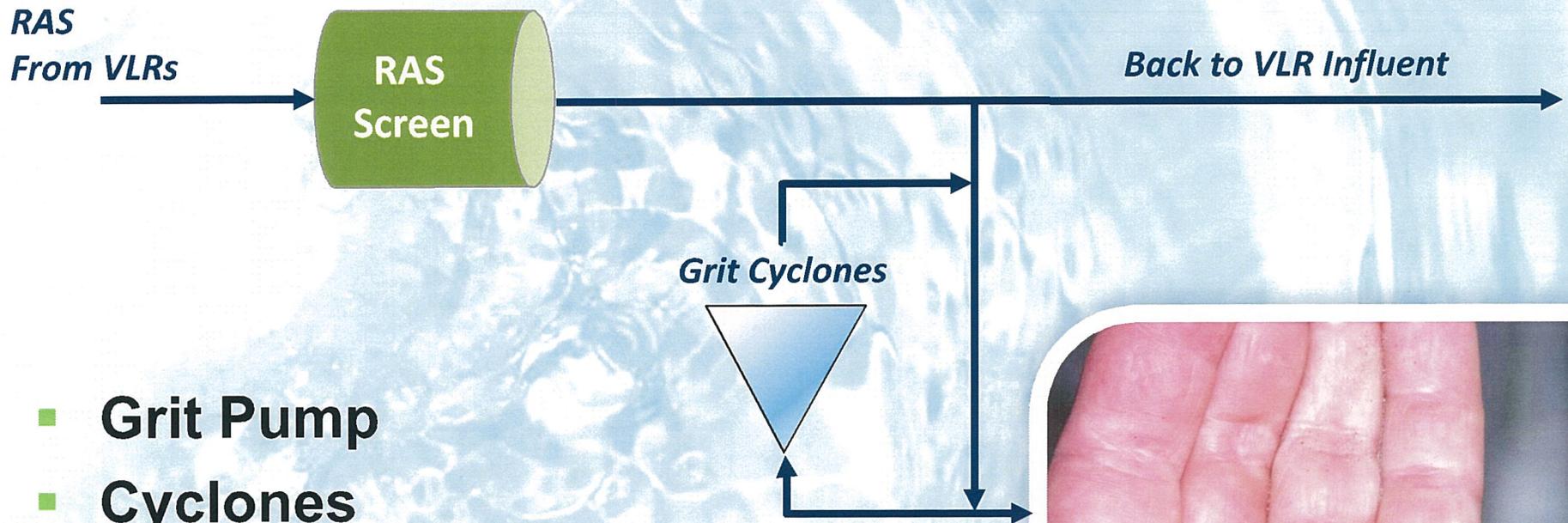


The Cannibal® Process – RAS Screening

- Screenings from approximately 44 hours of operation
- RAS screenings volume 4 to 5 times more than influent screenings



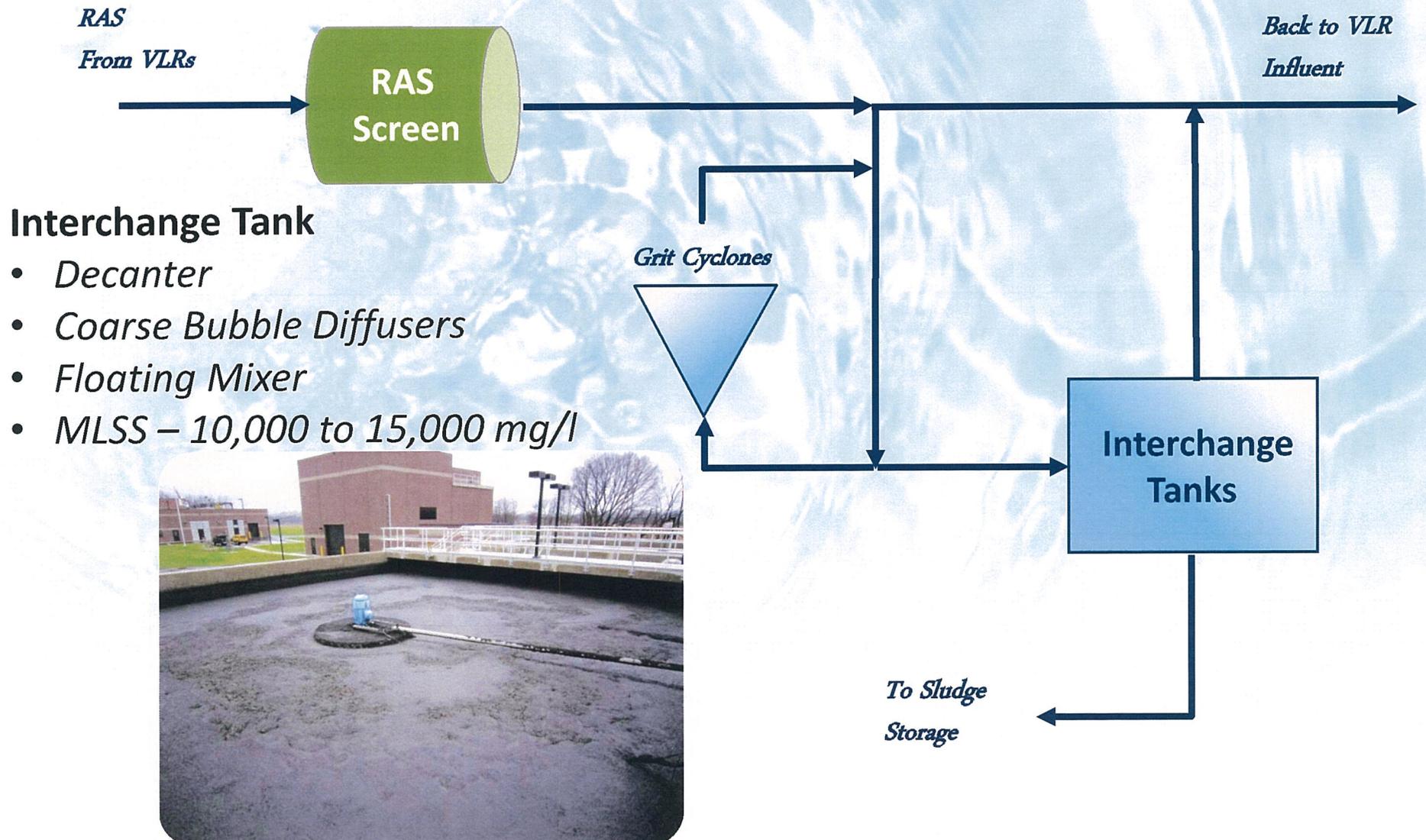
The Cannibal® Process – Grit Removal



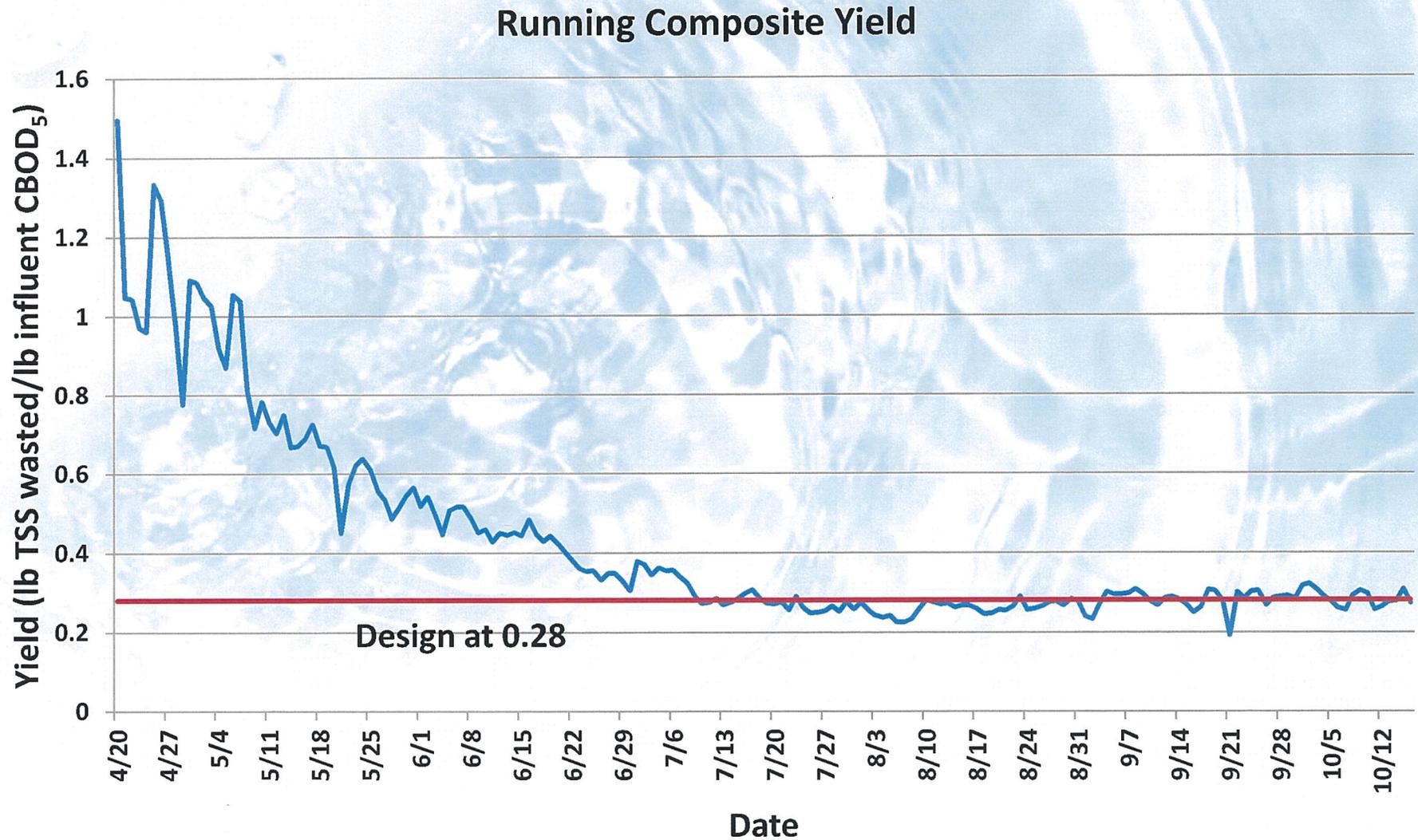
- **Grit Pump**
- **Cyclones**
 - Separate by specific gravity
 - Intermittent use
 - Removes fine grit/inerts



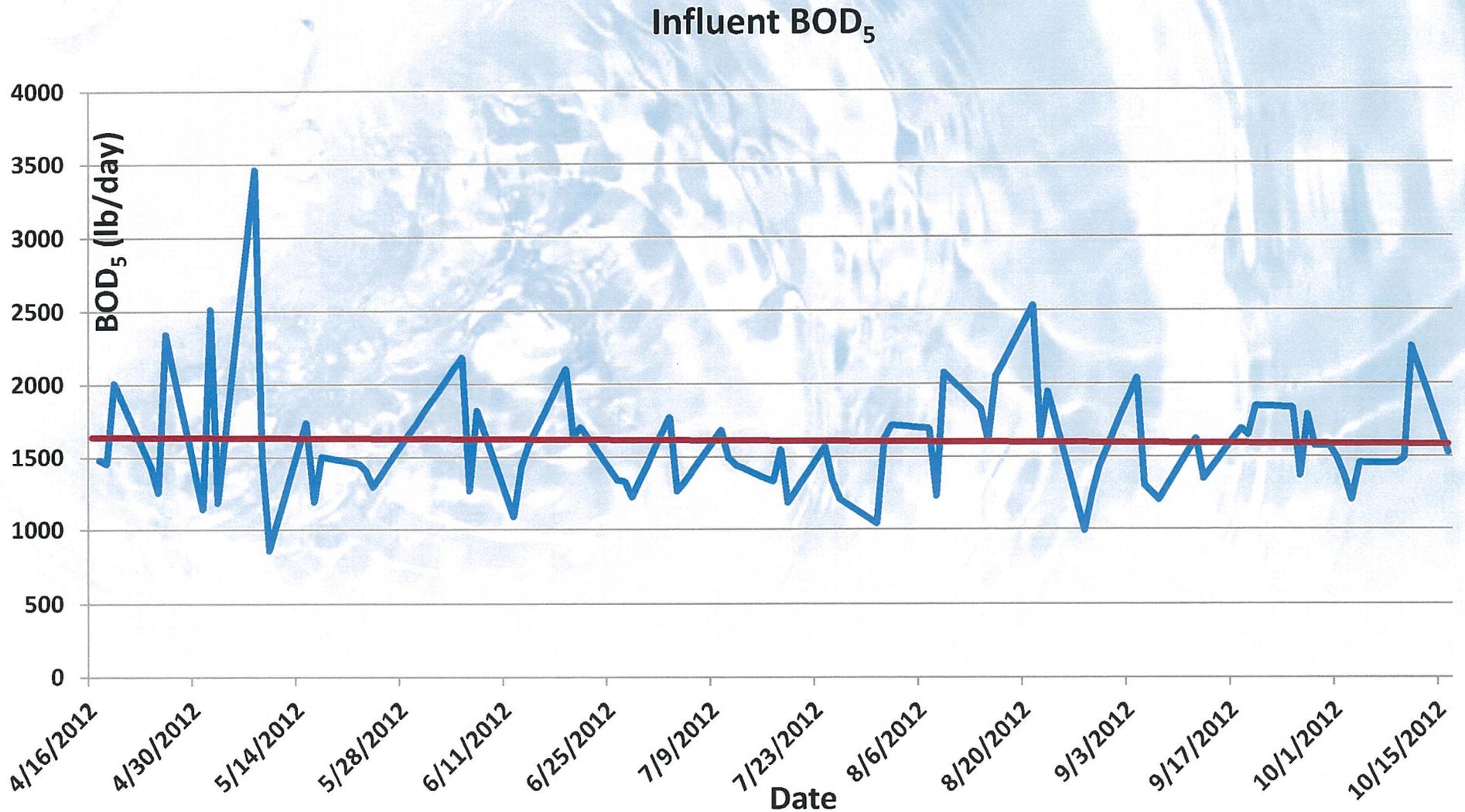
The Cannibal® Process – Interchange Tanks



The Cannibal® Process – Solids Yield

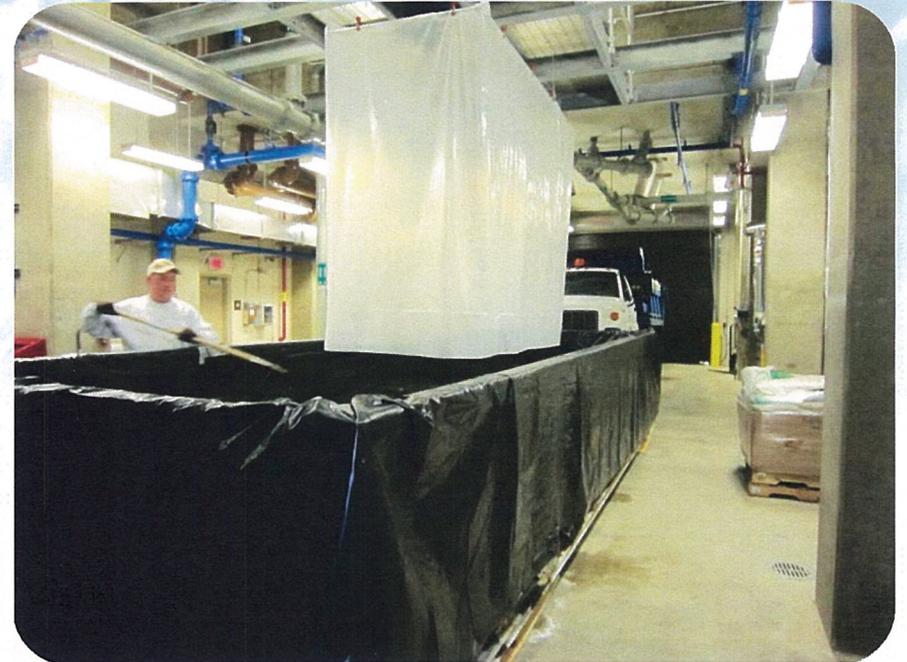


Influent BOD₅ Loading



Dewatering

- **Dewatering Centrifuge**
 - Andritz D4LL
 - Minimum Solids Capture: 95%
 - Feed Concentration: 1 – 3 %
 - Cake Solids Concentration: 20 %



Dewatering



← 20% +/- Biosolids
at Lawrence Street WPCF

20% +/- Biosolids →
at Upper Hocking WPCF



THANK YOU

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MALCOLM
PIRNIE

 **ARCADIS**

Project History

1995 – Began Sewer System Capacity Evaluation

Developed system model, addressed basement flooding

1997 – NPDES Permit

System Operational Plan – March 1998

System Characterization Report – Dec 1999

Long Term Control Plan – June 2000

2003 – NPDES Permit

Long Term Control Plan Addendum – March 2005

Addressed four major CSOs

2007 – NPDES Permit

Lake /Allen/Maple Sewer Separation – Feb 2009

Upper Hocking Water Pollution Control Facilities – Dec 2011

Phase II Long Term Control Plan – March 2014

To Date 21 of 33 CSOs eliminated

Upper Hocking WPCF – Effluent Limits

• NPDES Effluent Limits

	Monthly	Weekly
CBOD ₅	10 mg/l	15 mg/l
TSS	12 mg/l	18 mg/l
NH ₃ -N (Summer)	1.0 mg/l	1.5 mg/l
NH ₃ -N (Winter)	3.0 mg/l	4.5 mg/l
Fecal Coliform (Summer)	# 1,000/100 ml	# 2,000/100 ml
DO	6.0 mg/l minimum continuous	

• Additional Effluent Goals

	Monthly	Weekly
Total Phosphorus	1.0 mg/l	1.5 mg/l
Turbidity	0.2 NTU	0.2 NTU

City of Lancaster, OH

- Located in Central Ohio
- 30 Miles Southeast of Columbus
- Hocking River in Ohio River Basin



Process Evaluation and Cost Analysis

LIFE CYCLE COST EVALUATION						
	1	2	3a	3b	4	
SUMMARY OF ANNUAL COSTS	VLRs with Clarifiers	VLRs with Clarifiers and Cannibal System	VLRs with Membrane Bioreactor (MBR)	VLRs with Membrane Bioreactor (MBR)	VLRs with Membrane Bioreactor (MBR)	
Description	Annual Costs	Annual Costs	Annual Costs with Zenon Membranes	Annual Costs with US Filter Membranes	Annual Costs with US Filter Membranes	
Vertical Loop Reactors	\$32,390	\$38,900	\$24,300	\$24,300	\$24,300	
Power for disc aerators	\$30,300	\$25,700	\$19,500	\$19,500	\$19,500	
Power for process air blowers	\$2,090	\$13,200	\$4,800	\$4,800	\$4,800	
Membrane Bioreactors	\$0	\$0	\$27,630	\$48,990	\$48,990	
Power for permeate pumping			\$3,630	\$6,260	\$6,260	
Power for air scour blowers			\$13,700	\$29,700	\$29,700	
Sodium hypochlorite for membrane cleaning			\$2,300	\$4,050	\$4,050	
Citric acid for membrane cleaning			\$8,000	\$8,980	\$8,980	
Final Clarification	\$290	\$440	\$0	\$0	\$0	
Power for clarifier mechanisms	\$290	\$440				
Mixed Liquor Flow Splitting	\$280	\$280	\$0	\$0	\$0	
Power for pumping for flow splitting	\$280	\$280				
Return Sludge Pumping	\$3,800	\$3,800	\$10,100	\$16,500	\$16,500	
Power for return sludge recirculation pumps	\$3,800	\$3,800	\$10,100	\$16,500	\$16,500	
Tertiary Filtration	\$710	\$710	\$0	\$0	\$0	
Power for pumping through tertiary filters	\$710	\$710				
UV Disinfection	\$4,280	\$4,280	\$850	\$850	\$850	
Power for UV disinfection	\$710	\$710	\$140	\$140	\$140	
Lamp replacement	\$3,570	\$3,570	\$710	\$710	\$710	
Sludge Thickening	\$10,140	\$0	\$9,860	\$9,860	\$0	
Power for gravity belt thickener	\$150		\$150	\$150		
Polymer for gravity belt thickener	\$9,990		\$9,710	\$9,710		
Cannibal Process	\$0	\$33,220	\$0	\$0	\$33,220	
Power for aeration		\$2,560			\$2,560	
Power for mixing		\$510			\$510	
Power for screenings and compactions		\$1,470			\$1,470	
Power for cyclone pump and classifier		\$750			\$750	
Trash and inert disposal at \$50 per ton		\$27,930			\$27,930	
Sludge Storage	\$16,200	\$10,300	\$16,200	\$16,200	\$10,300	
Power for mixing	\$16,200	\$10,300	\$16,200	\$16,200	\$10,300	
Sludge Dewatering and Disposal	\$316,000	\$99,000	\$307,000	\$307,000	\$99,000	
Dewatering, lime addition, and disposal by private contractor	\$316,000	\$99,000	\$307,000	\$307,000	\$99,000	
TOTAL ANNUAL COSTS	\$384,000	\$190,930	\$395,940	\$423,300	\$233,160	
Present Worth Factor (r = 5.0%, n = 20 years)	12.462	12.462	12.462	12.462	12.462	
PRESENT WORTH OF O&M COSTS	\$4,787,000	\$2,379,000	\$4,934,000	\$5,280,000	\$2,906,000	
SUMMARY OF SINGLE EXPENDITURES						
Description	Year	Amount	Present Worth Factor			
Zenon Membrane Bioreactors						
MBR module replacement	10	\$716,000	0.6139	\$0	\$0	
US Filter Membrane Bioreactors						
MBR module replacement	7	\$1,142,000	0.7107	\$0	\$0	
MBR module replacement	14	\$1,142,000	0.5051	\$0	\$0	
PRESENT WORTH OF SINGLE EXPENDITURES				\$458,000	\$1,389,000	
TOTAL CAPITAL COSTS				\$31,100,000	\$33,200,000	

Project Background



UPPER HOCKING WATER POLLUTION CONTROL FACILITY



Process Evaluation Cost Analysis

	Capital Costs	O & M Costs	Present Worth of Single Expenditures	Total Costs
VLRs with Clarifier	\$31,100,000	\$4,787,000	\$0	\$35,890,000
VLRs with Clarifiers and Cannibal System	\$33,200,000	\$2,379,000	\$0	\$35,580,000
VLRs with Zenon Membranes	\$34,100,000	\$4,934,000	\$458,000	\$39,490,000
VLRs with Siemens Membranes	\$32,700,000	\$5,280,000	\$1,389,000	\$39,370,000
VLRs with Siemens Membranes and Cannibal	\$34,700,000	\$2,906,000	\$1,389,000	\$39,000,000

Upper Hocking WPCF – Water Quality

■ Average Influent Characteristics

	Flow (mgd)	CBOD ₅ (mg/l)	BOD ₅ (mg/l)	TSS (mg/l)	NH ₃ -N (mg/l)	TKN-N (mg/l)	Total P (mg/l)
Average	1.53	112	153	217	13.8	24.6	4.2
Design	2.00	180	240	180	18.0	28.0	5.0
% Design	77	48	49	92	67	58	64

■ Average Effluent Characteristics

	Flow (mgd)	CBOD ₅ (mg/l)	BOD ₅ (mg/l)	TSS (mg/l)	NH ₃ -N (mg/l)	Nitrate/ Nitrite (mg/l)	Total P (mg/l)
Average	1.53	<2	<2	<5	0.10	3.6	2.1

Siemens Supplied Processes

- Siemens System Includes:
 - Membrane Bioreactors
 - Vertical Loop Reactors
 - Cannibal ® Sludge Reduction System

60 seconds for every 12 minutes