



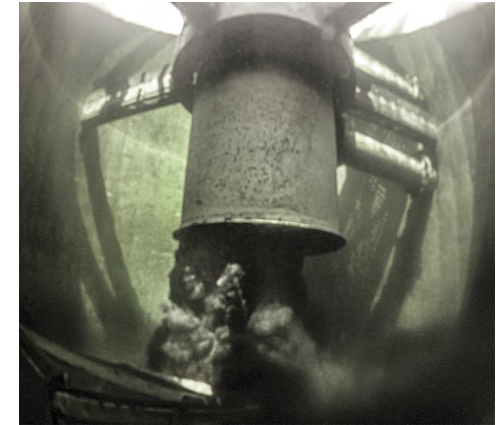
Magnetite Ballasted Technology to Meet Ultra-Low Phosphorus Limits in Wisconsin

CoMag[®] Pilot at the Fond du Lac WPCP

BioMag System

Activated
Sludge
Treatment

Ballasted
Biological
Floc



CoMag System

Coagulation
Flocculation
Treatment

Ballasted
Inorganic
Floc



Magnetite Background / History

- **Ballasted settling is not new**

- Bentonite
- Microsand
- Magnetite

**3rd Generation
Ballasted Flocculation Technologies**

- **Magnetite ballasted settling began in Cambridge, MA in 1999**

- CoMag

- **BioMag followed a few years later**



MAGNETITE

**Biological
&
Chemical
Flocs**

MAGNETITE AROUND US

COAL FLOAT



TONER



COMPUTERS



BIO-COMPASS



Magnetite is mined and readily available



Magnetite: Fe_3O_4

- Fully oxidized iron ore
- Doesn't rust or degrade
- Completely inert
- Non-abrasive (10 - 30 microns)

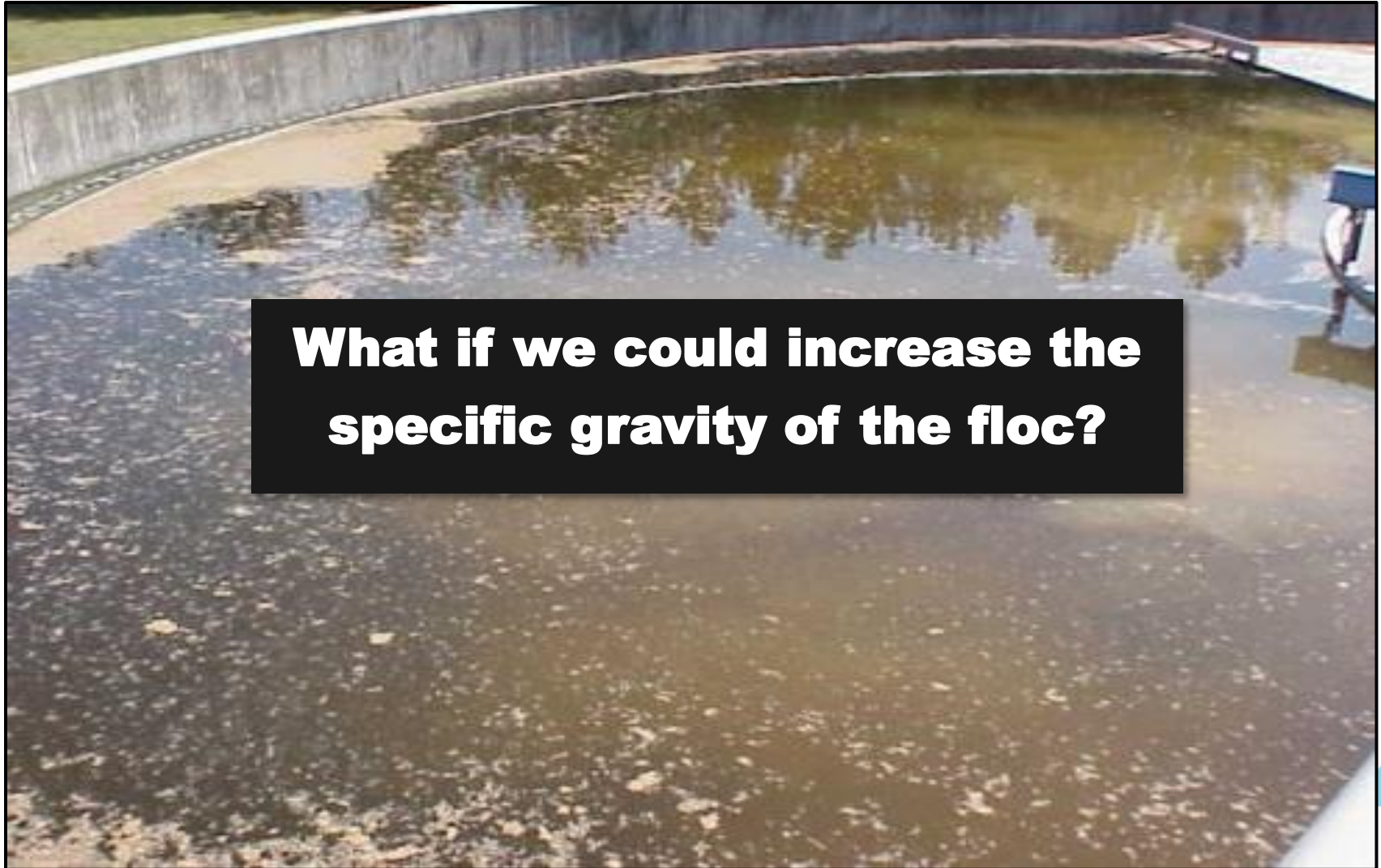
Four compelling properties

- Density and weight: Spec. gravity: 5.2
- Hydrophobic: affinity to embed in floc
- Magnetically retrievable
- Inexpensive ~30¢/lb

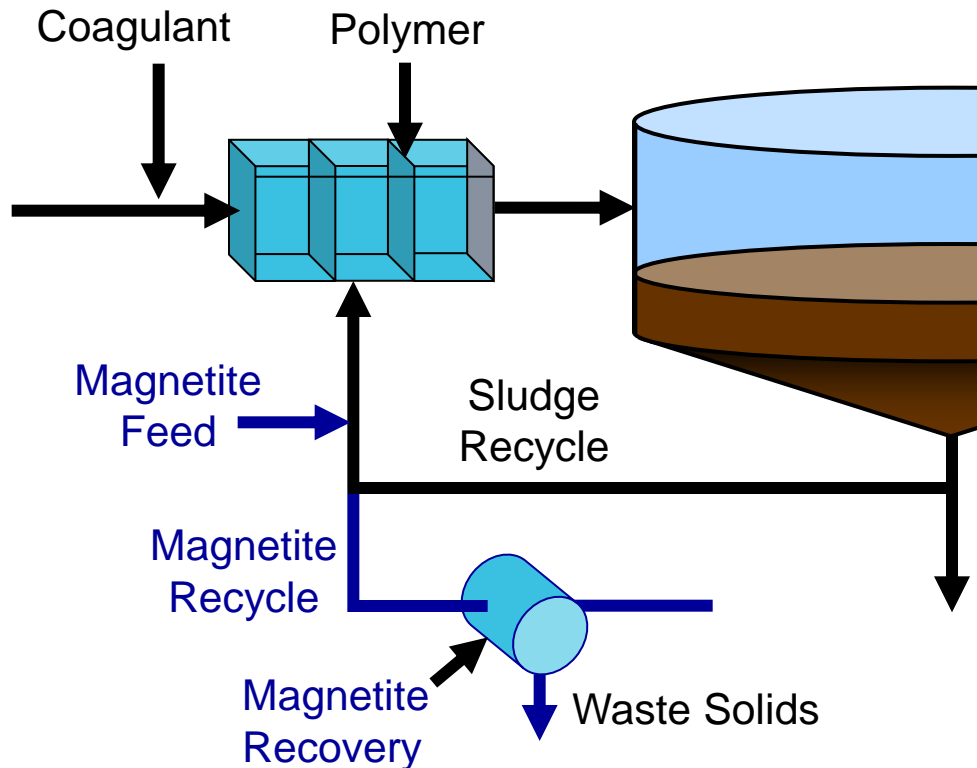


WHAT'S THE PROBLEM?... CLARIFIER BOTTLENECK

S.G. OF FLOCS IS BARELY > 1.0



CoMag[®] System Value Demonstration



- Clarifier footprint decreased by 80 - 90%
- Improved reliability
- Improved ability to handle peak flows
- Effluent quality similar to tertiary filtration

Pilot Project Background

- In 2010, the WDNR established standards for TP levels in different types of water bodies
- Each community faces a different set of constraints and time frames affecting the available options to address the new TP rules
- Some facilities may need major upgrades to meet TP limits as low as 0.03 mg/l as a six-month average



Surface Water Phosphorus Criteria

- **Rivers** **0.100 mg/l**
- **Streams** **0.075 mg/l**
- **Reservoirs** **0.02-0.04 mg/l**
- **Inland Lakes** **0.015-0.04 mg/l**
- **Great Lakes** **0.005-0.007 mg/l**

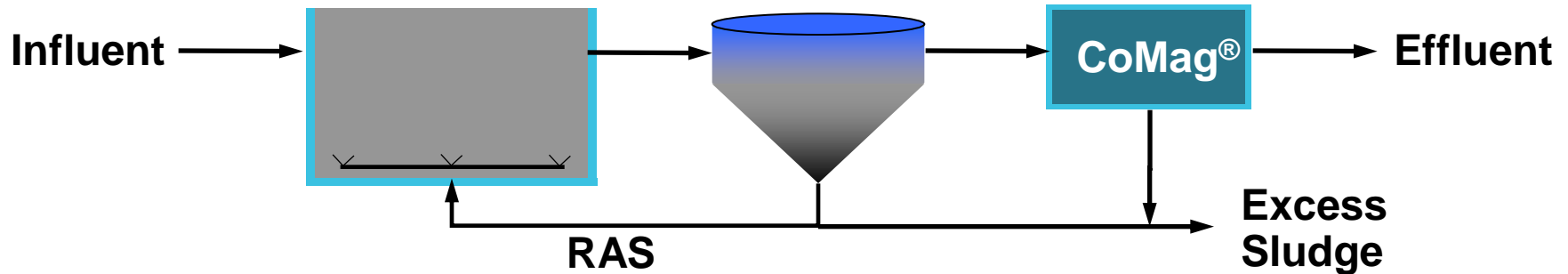


Fond du Lac

- **Discharges into Lake Winnebago**
- **Surface Water Criteria: 0.04 mg/l P**
- **Water Quality Based Effluent Limit: 0.04**
- **Desktop Evaluation of Treatment Alternatives: Ballasted Clarification, Reactive Filtration, Discfilters**
- **Pilot CoMag System**

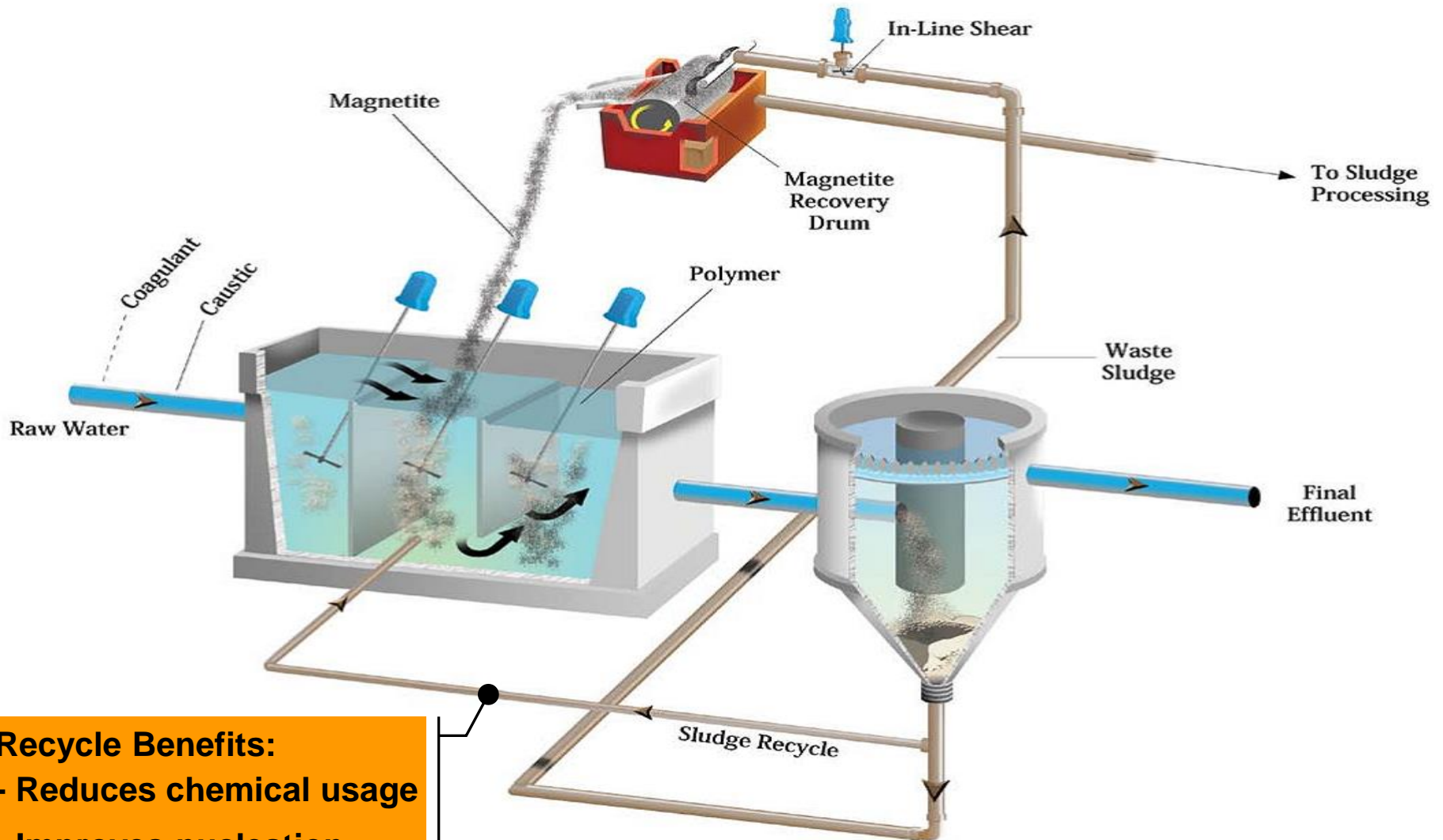


CoMag[®] Pilot Program at FDL



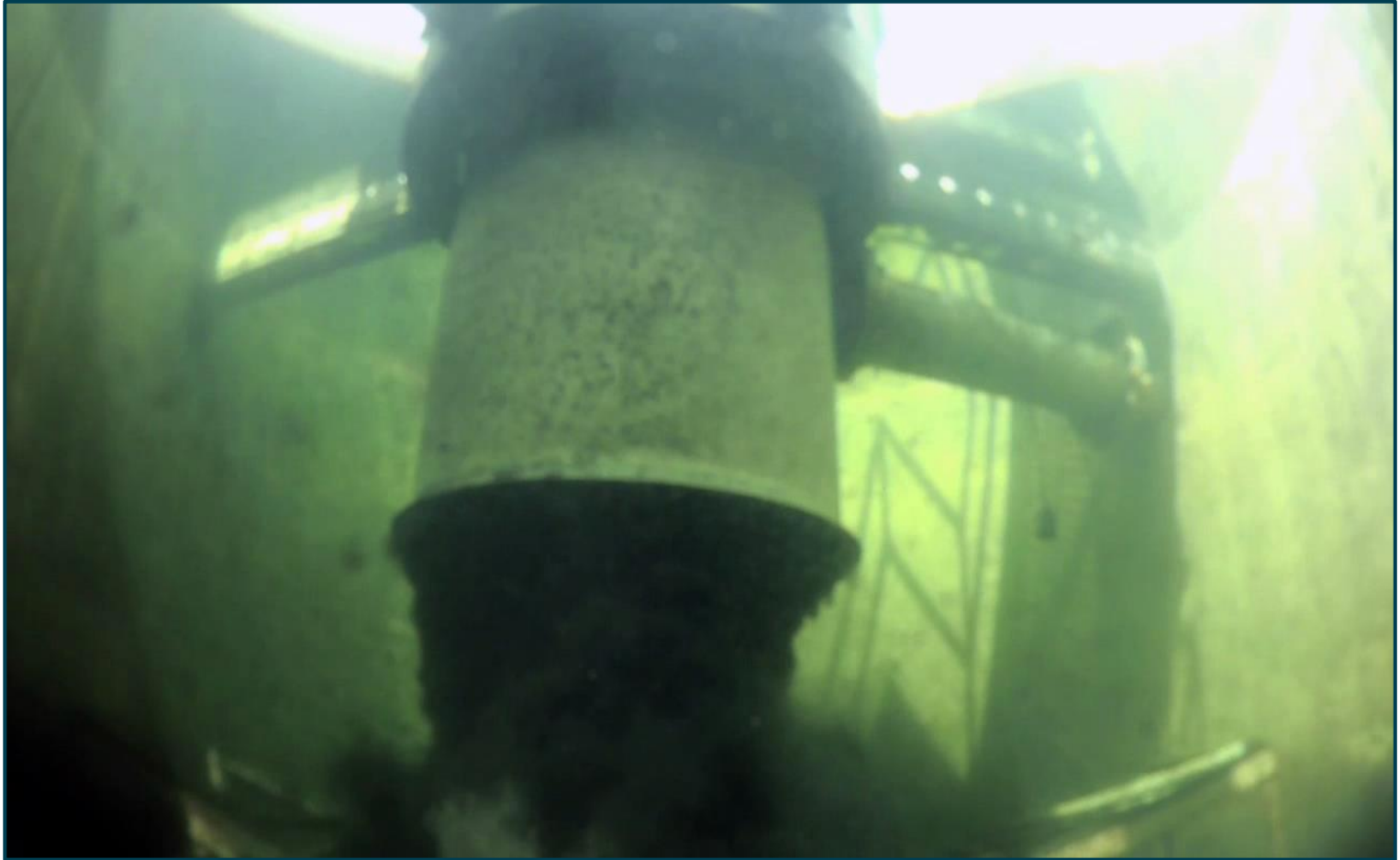
- Verify performance to achieve <0.04 mg/l TP as tertiary treatment
- Test three different coagulants: Alum, FeCl_3 and PACl
- Stress test for high solids @ 100 mg/l TSS
- Stress test for high flow @ 2X flow

CoMag[®] Process Flow Diagram



Recycle Benefits:
- Reduces chemical usage
- Improves nucleation

MAGNETITE BALLASTED SETTLING IN ACTION



COMAG - EQUIPMENT



← Reaction Tanks and Magnetite Recovery Drums

Clarifier →



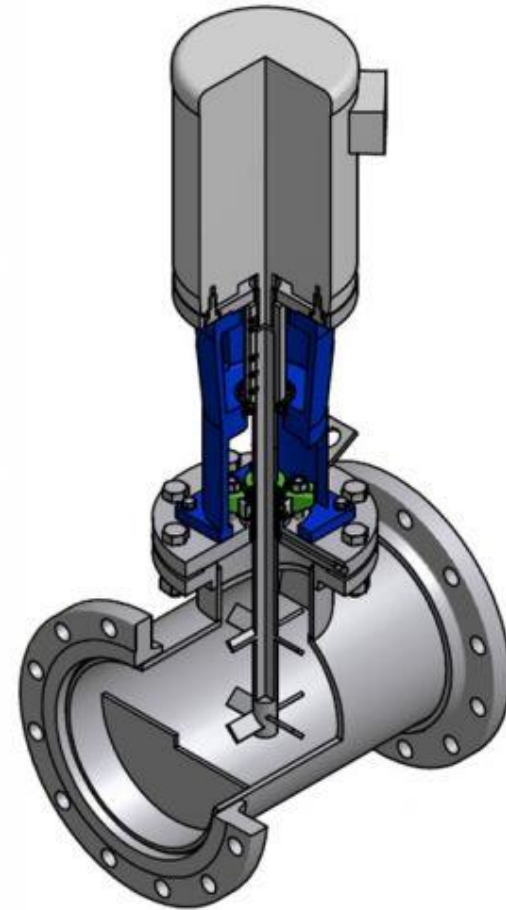
Charlton, MA

CoMag



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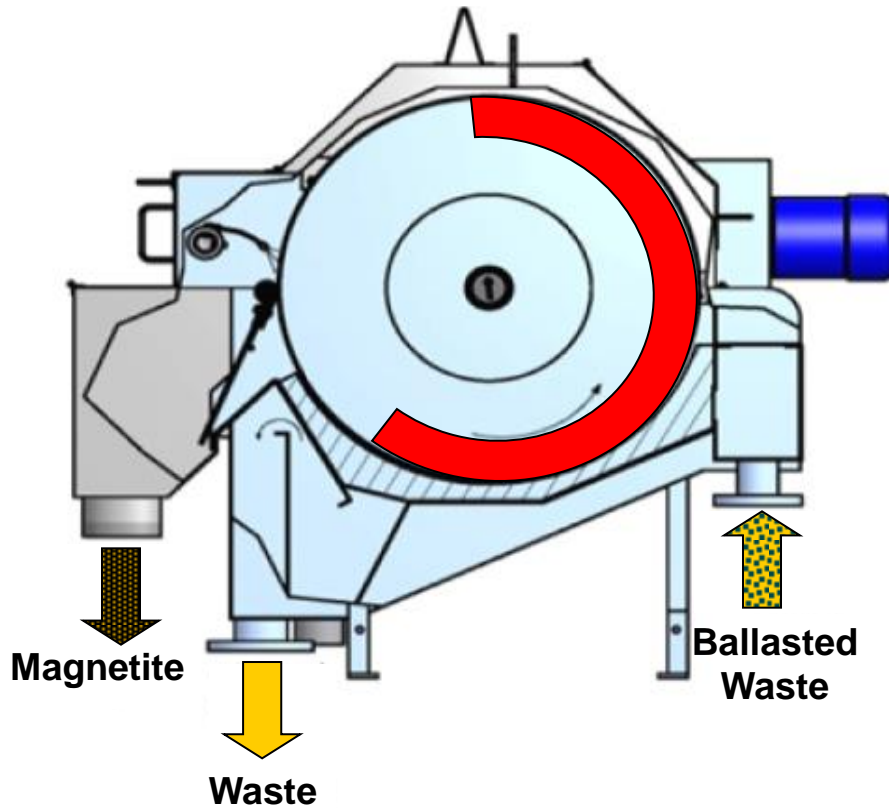
COMAG - SHEAR MILL



MAGNETIC RECOVERY DRUM



Magnetic Properties High Recovery Rates



Magnetite Recovery



TERTIARY TREATMENT FOR ULTRA-LOW TP



Effluent Turbidity



UV Transmittance

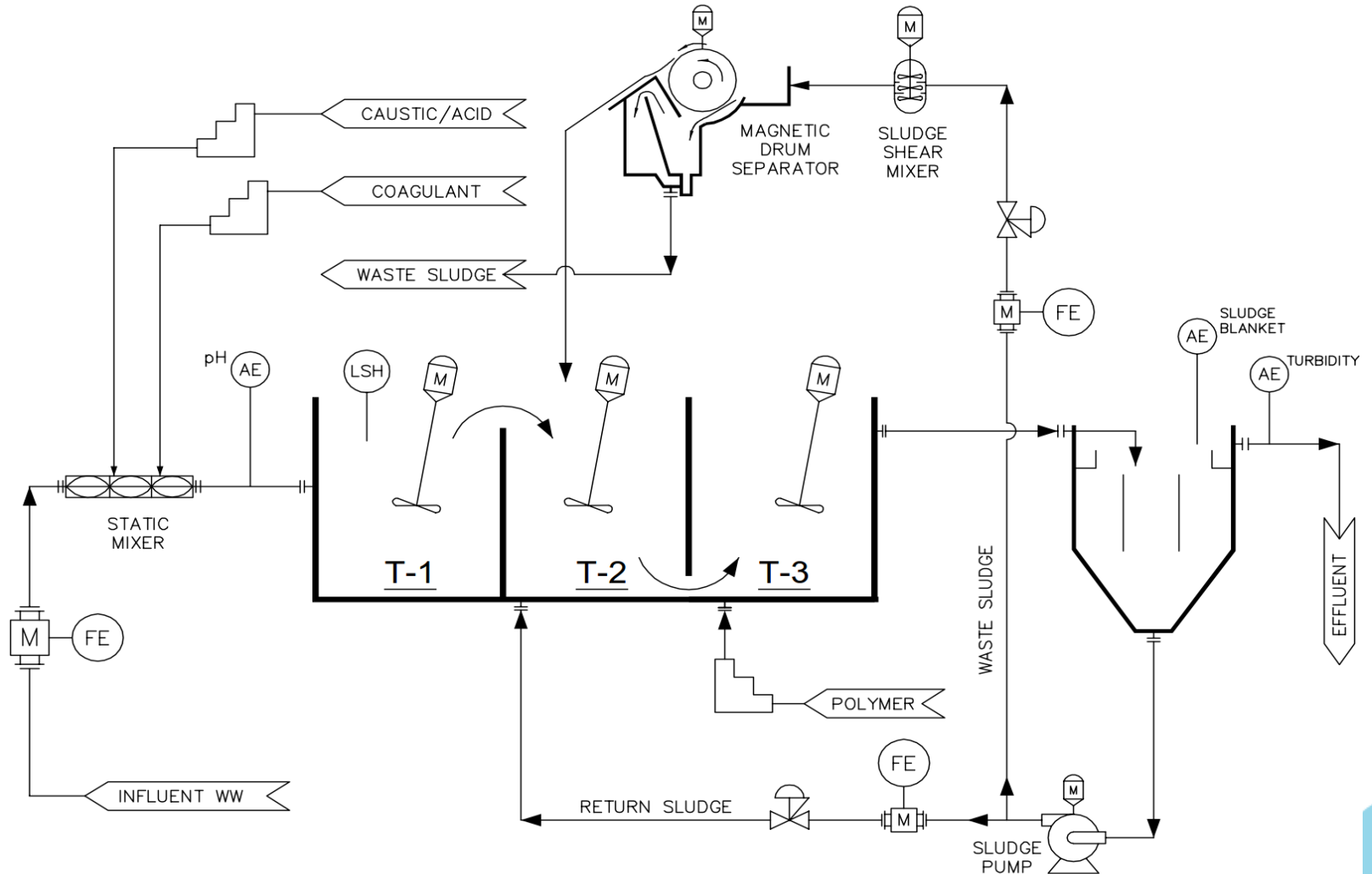
Quality of tertiary filtration

CoMag[®] Pilot Program

- Nominal capacity of 50 GPM, with operating range of 25 to 100 GPM
- Evoqua operator for 40 hours per week for duration of pilot program (typically 4 weeks)
- Pilot plant fully equipped
- CoMag[®] trailer is approximately 48' L x 8' W x 12' H
- Jar testing available for unique treatment / water sources



Process Flow Diagram



CoMag[®] Pilot Program at FDL from September 16 to October 15, 2013



CoMag[®] Pilot Program at FDL from September 16 to October 15, 2013



CoMag[®] Pilot Program at FDL

Average Influent & Effluent Data

		Alum	Ferric Chloride	PACl
TP (mg/l)	Inf	1.0	1.0	0.9
	Eff	0.039	0.025	0.036
TSS (mg/l)	Inf	29	19	25
	Eff	1.6	1.9	3.2
Turbidity (NTU)	Inf	NM	NM	NM
	Eff	0.24	0.29	0.17
UV Transmittance (%)	Inf	68	65	69
	Eff	76	75	79

Notes:

- Average data include stress tests
- NM = not measured



CoMag[®] Pilot Program at FDL Consumables

		Consumables
Alum	Alum	12 mg/l as Al
	Polymer	0.70 mg/l dry weight
	Magnetite	7-10 lbs per MGD
Ferric Chloride	FeCl ₃	24 mg/l as Fe
	Polymer	0.80 mg/l dry weight
	Magnetite	7-10 lbs per MGD
PACl	PACl	20 mg/l as Al
	Polymer	0.70 mg/l dry weight
	Magnetite	7-10 lbs per MGD

Notes:

•The alkalinity of the wastewater was high enough, and no caustic addition for pH adjustment was required for any of the three coagulants tested



CoMag[®] Pilot Program at FDL Stress Tests

			Alum	Ferric Chloride	PACl
Solids Stress Test	Flow (gpm)		50	50	50
	TSS (mg/l)	Inf	114	95	111
		Eff	1.3	1.5	1.5
	TP (mg/l)	Inf	2.2	2.5	2.5
		Eff	0.044	0.028	0.047
	Hydraulic Stress Test	Flow (gpm)		100	100
TSS (mg/l)		Inf	24	13	13
		Eff	2.6	1.6	1.5
TP (mg/l)		Inf	0.65	1.05	0.71
		Eff	0.029	0.020	0.033

CoMag[®] Pilot Program at FDL

Additional Data

		Alum	Ferric Chloride	PACl
Lowest TP achieved (mg/l)		0.020	0.010	0.020
BOD removal		91%	74%	77%
Fecal Coliform Reduction		NM	99.7%	99.7%
Aluminium (µg/l)	Inf	NM	NM	1,379
	Eff	NM	NM	148
Iron (µg/l)	Inf	NM	NM	0.05
	Eff	NM	NM	< 0.03

Notes:

•**NM = not measured**

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CoMag[®] Pilot Program at FDL

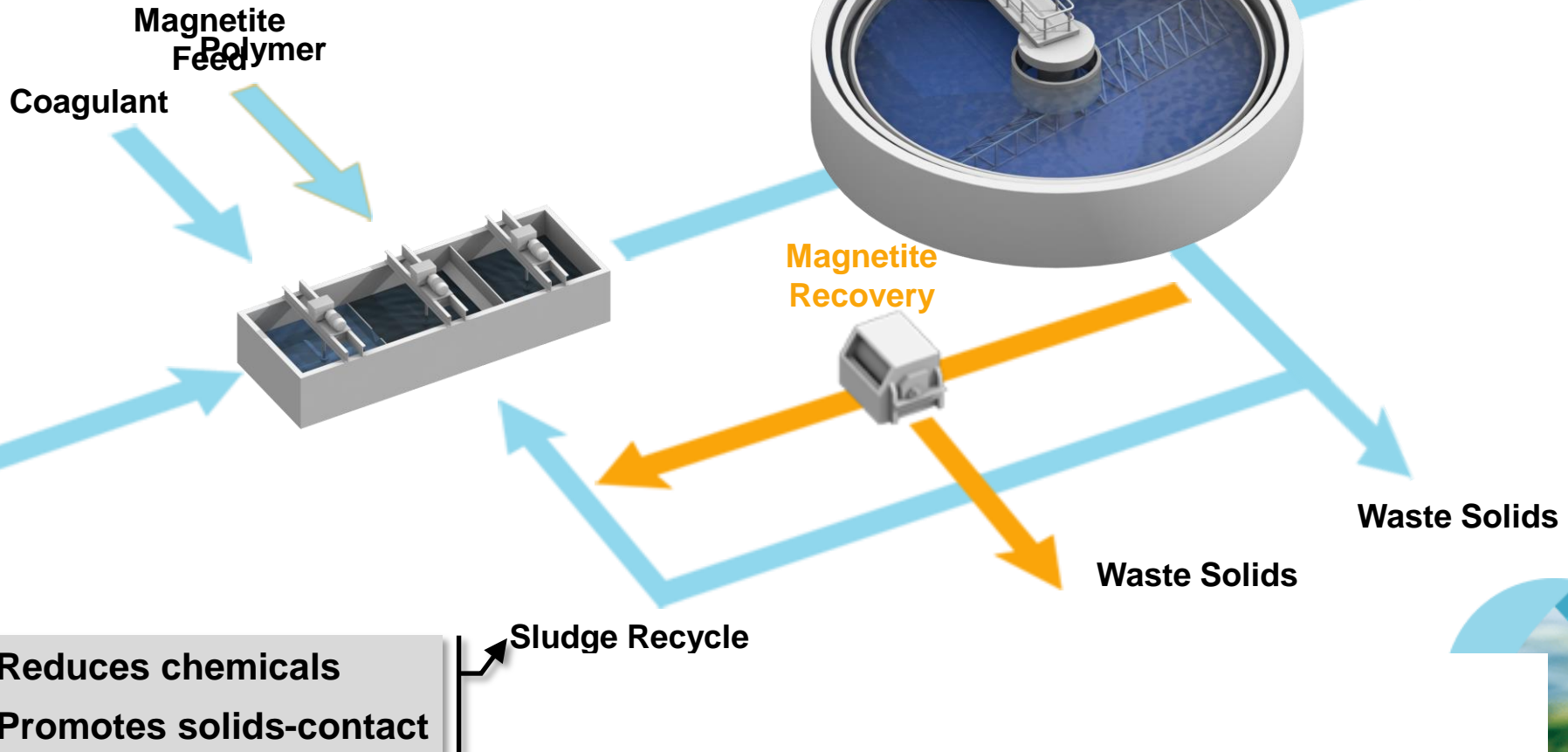
Conclusions

- **Demonstrated ability to consistently meet ultra-low phosphorus limit of 0.04 mg/l TP with three coagulants**
 - Performance easily dialed up or down
- **Resilience against hydraulic and solids peak loads**
- **Higher effluent quality for disinfection:**
 - Improved UV transmittance by 15%
 - Achieved 2 to 3 log removal of Fecal Coliforms
- **Low magnetite consumption:**
 - 7-10 lbs per MGD at ~\$0.3/lb
- **Ability to remove heavy metals**



COMAG VALUE PROPOSITION

- ❖ Clarifiers 80-90% smaller
- ❖ Increase capacity up to 10X
- ❖ Quality of tertiary filtration



- ❖ Reduces chemicals
- ❖ Promotes solids-contact

CoMag[®] Ultra-Low TP Full Scale Performance

Location	Average TP
Sturbridge, MA	0.039 mg/l
Maynard, MA	0.026 mg/l
Charlton, MA	0.025 mg/l
Billerica, MA	0.036 mg/l
Concord, MA	0.045 mg/l



DISC FILTERS - COMAG COMPARISON

Disc Filters

- Need secondary effluent with low TP
- Susceptible to fouling
- Limited response to peak flows



Iron Fouling



More Robust



CoMag Effluent Performance Tertiary Treatment

Parameter	Typical Performance
Aluminum	90% Removal
Arsenic	50% - 90% Removal
BOD	<2 mg/l
Copper	50% - 90% Removal
Fecal Coliform	98% Removal
Phosphorus (Total)	<0.05 mg/l
Total Suspended Solids	<5 mg/l
Turbidity	< 2 NTU



BioMag / CoMag Strong Foundation

- ❖ Developed in the US in the late 90s
- ❖ 21 Municipal Projects sold up to date
- ❖ 42 Pilots conducted



CoMag[®] Applications for Solids Removal

- Tertiary Treatment - Ultra Low TP
- Primary Treatment - CEPT
- Storm Flow
- Fixed Film Ballasted Clarification
- CSO Treatment
- Drinking Water
- Industrial: Mining, P&P, F&B, RO Pretreatment, Produced and Frac Water

Able to remove:

- Particulate (suspended) solids
- Colloidal suspensions, including emulsions
- Heavy metals
- Pathogens
- Phosphorus
- Color



BALLASTED HIGH RATE PRIMARY (PILOTS)

- **Midwest CSO; 16.0 MGD Application**
- **Chemical Dosage: 4-7 mg/l Al; 1-1.5 mg/l Polymer**
- **TSS Removal: 139 mg/l in - 27 mg/l out (80%r)**
- **BOD Removal: 138 mg/l in - 48 mg/l out (65%r)**
- **UV Transmittance Improvement: 68% increase**



- **Design Flows: 23 MGD ADF; 40 MGD MMo; 80 MGD PHr**
- **RBC Secondary Process; No Primaries**
- **Upgrade Required: Future NH₃-N Requires Stable Nitrification**
- **Economics Requires Minimum Expansion of Secondary Process**
- **Very Tight Site Constraints (Space / Footprint Limitation)**



OBJECTIVE

- **Add Chemically Enhanced Primary Clarification**
- **Extend Capacity of RBC Process (reduce load)**
- **Produce CEPC Effluent <100 mg/l BOD; >1.0 mg/l OP; >70% TSSr**
- **Minimize Chemical Addition**



CONCLUSIONS SUMMARY

- **Optimum Alum Dose to Meet Objectives-55 ppmv (3.2 mg/l as Al)**
- **Polymer Dose-1.0 mg/l**
- **TSS Reduction at 55 ppmv or higher: 80%-90% (242 mg/l to 43 mg/l)**
- **Increasing Flow Had Little to No Impact on Performance**
- **Able to Achieve CBOD < 100 mg/l at 55 ppmv Alum (194 mg/l to 71 mg/l; 63%r)**
- **Achieved Soluble CBOD Reductions of 20%-60%**



Overall TSS Results

	TSS			Volatile TSS		
	Influent	Effluent	Reduction	Influent	Effluent	Reduction
	mg/L	mg/L	%	mg/L	mg/L	%
Average	224	71	71%	198	54	74%
Minimum	167	25	14%	156	19	9%
Maximum	420	309	87%	376	171	89%
Median	214	44	81%	190	35	83%
Count	17	15	15	17	15	15

Overall BOD Results

	CBOD			Soluble CBOD		
	Influent	Effluent	Reduction	Influent	Effluent	Reduction
	mg/L	mg/L	%	mg/L	mg/L	%
Average	194	88	55%	61	48	20%
Minimum	91	26	21%	18	9	-16%
Maximum	260	167	78%	130	83	61%
Median	202	89	56%	65	57	21%
Count	17	17	17	17	17	17

THANK YOU FOR YOUR ATTENTION

John Irwin

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Represented by HP Thompson