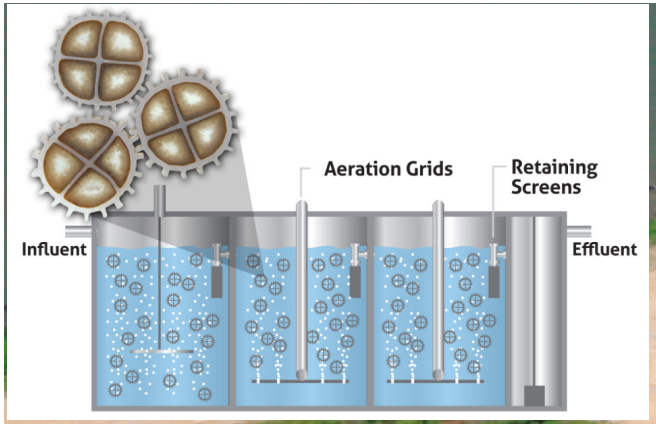
Performance of Modern Biofilm Treatment Technology



Presented by:
Rich Grant, PE
Fleis & VandenBrink Engineering, Inc.
November 5, 2014

Who Are We?

- 9 local offices in MI & IN
- Employee-owned firm with 40 shareholders
- 120 person staff with over 40 professional licensed
- 80% of our work is Municipally based
- Our 250 municipal clients

Locations


Traverse City
Midland
Muskegon
Grand Blanc
Grand Rapids
Farmington Hills
Kalamazoo
Fort Wayne
Indianapolis

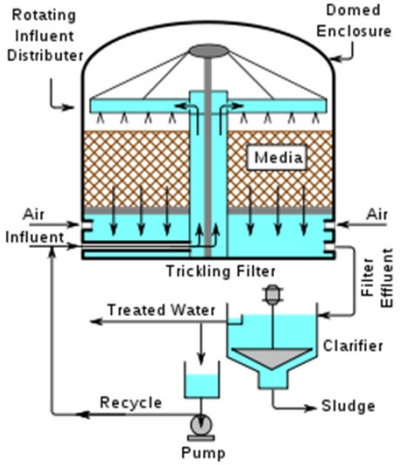
OUTLINE

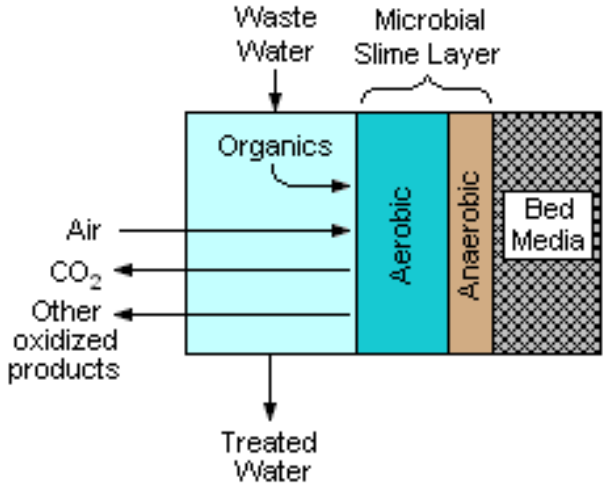
- Biofilm Technology Overview
- Back to Basics – Why is Cold Weather Nitrification Difficult?
- Moving Bed Biofilms – Design & Operational Benefits
- Case Studies
- Design Considerations
- Operational Features

Biofilm Technologies

TRICKLING FILTERS

- A fixed-film technology that is over 100 years old (1890s)
- Biological ‘slime’ layer growth on various inert media
- Aeration provided by water splashing across media
- Upgrade existing TFs capacity with engineered plastic media - higher specific surface area/ per volume
- Can provide biological ‘roughening’ but additional biological treatment process likely required in modern WWTF

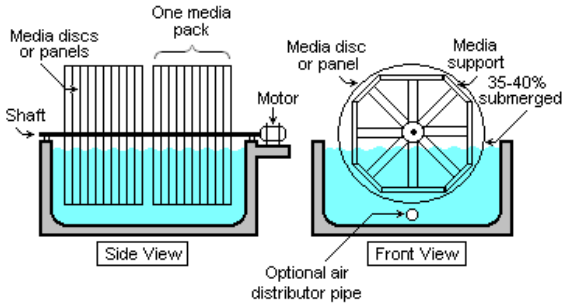


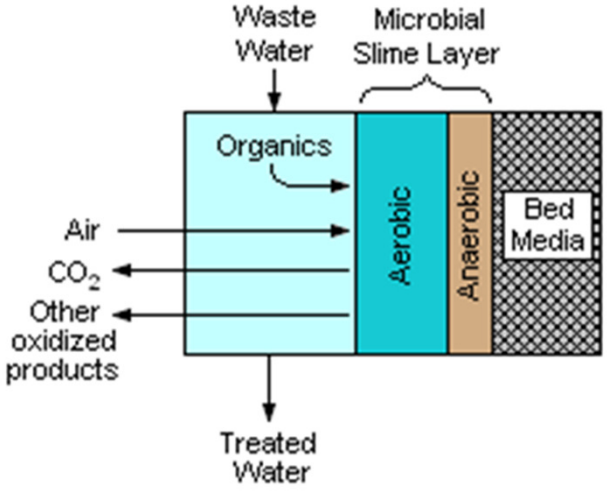


Biofilm Technologies

ROTATING BIOLOGICAL CONTACTORS (RBCs)

- First installations in 1960s
- Typically 40% media submergence
- Aeration provided by rotating media
- Density of media ‘packs’ varied to accommodate carbonaceous and nitrification zones
- Prone to mechanical issues with center shaft breaking…air operated units had less issues
- Still many RBCs systems in operation
- Some owners/operators love’em as simple to operate & control

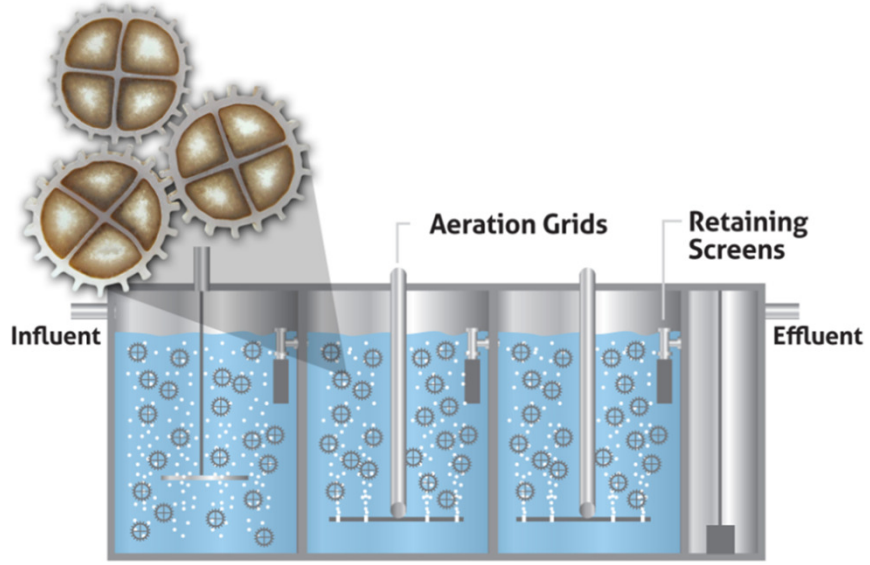


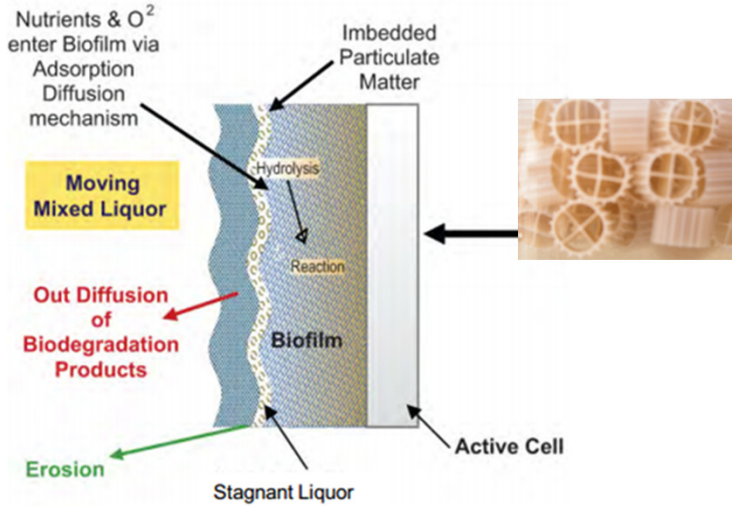


Biofilm Technologies

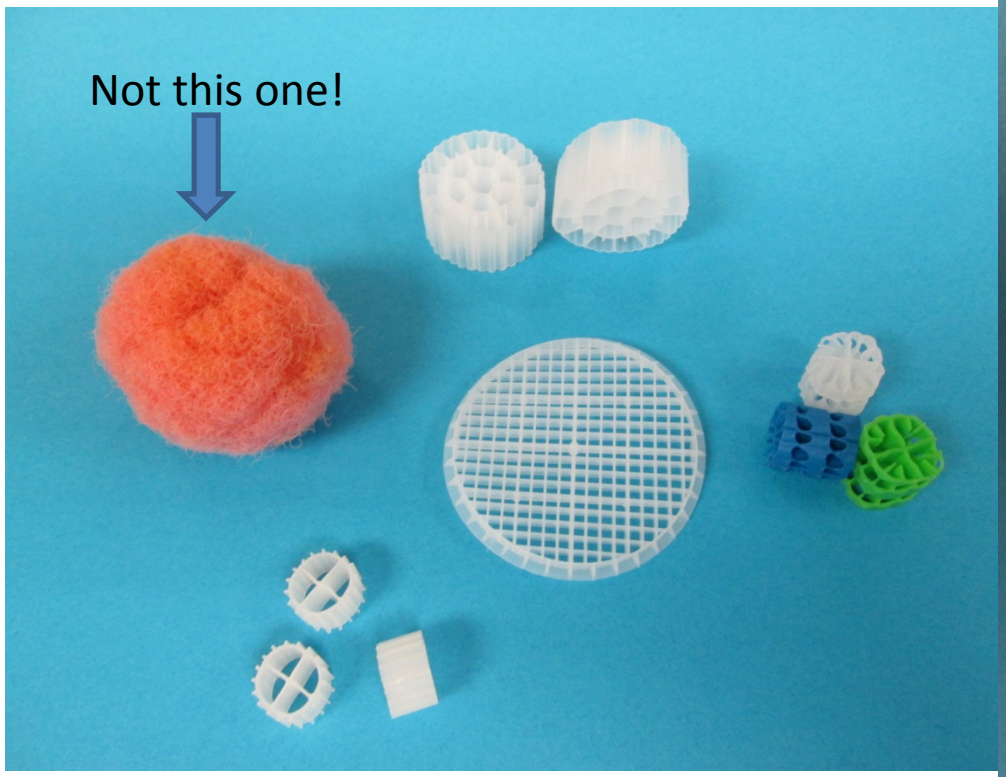
MOVING BED BIOLOGICAL REACTOR (MBBR)

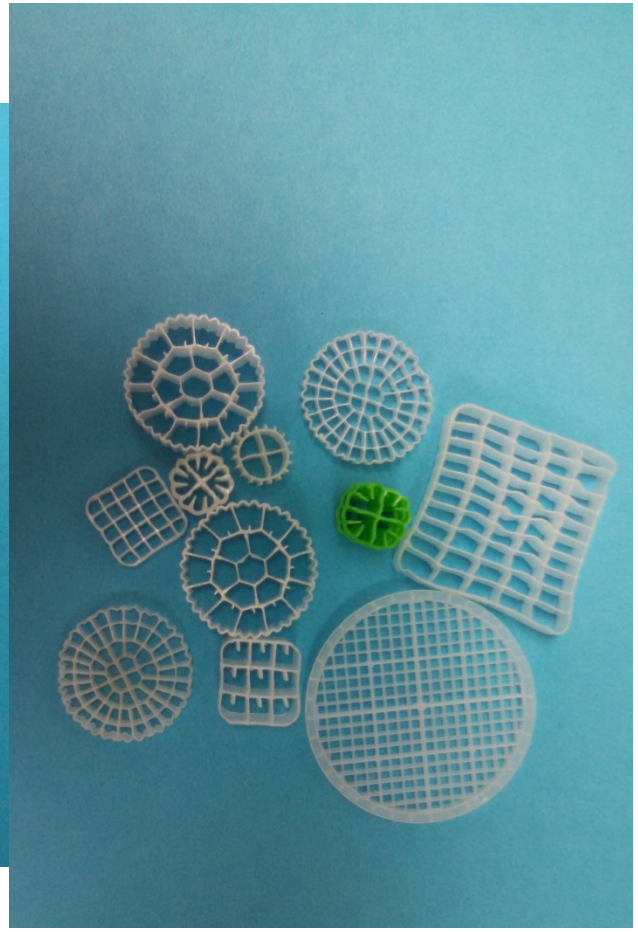
- First installations in northern Europe, early 1990s
- Gained prominence after 1994 Lillehammer, Norway Winter Olympics
- Proved to provide robust, high quality treatment in cold weather climates
- Coarse bubble diffusion used for mixing and aeration
- Media can be up to 65-70% of tank volume so very large population of 'bugs'
- Biomass retained in reactors so treatment maintained even as bug reproduction slows down
- Smaller footprint required than traditional suspended biomass systems





Examples of MBBR Media





Back to Basics – Why is Cold Weather Nitrification Difficult?

$$NH_4 + 3/2O_2 \rightarrow NO_2^- + 2H^+ + H_2O$$

$$NO_2^- + 1/2O \rightarrow NO_3^-$$

- Nitrification bacteria *Nitrosomonas* and *Nitrobacter* are temperature dependent
- Conventional wisdom was nitrification was lost at less than 10°C wastewater temperatures due to:
  - Nitrifiers outcompeted due to reproduction rate drop
  - Followed by washout from reactor(s)

NEW Conventional Wisdom:

- With segregated reactors for carbonaceous and nitrifying bacteria, type of biofilm self-regulates based on available food source (i.e., make a home for the nitrifiers at the end of the aerobic treatment)
- Nitrification can continue (albeit at a slower rate) well below 40°F
- Northport WWTF – full nitrification occurring at a wastewater temperature of 38°F/ 3.3°C

Moving Bed Biofilms – Design & Operational Benefits

Design Benefits:

- Shorter hydraulic retention times (typ. 6 to 12 hrs)
- Cost effective expandability
- Coarse air used for mixing provides medium to fine air OTE
- Can handle significant flow and organic loading variability (plants with ex. I/I issues, SIUs/food processors with high organic loading requirements)
- High quality effluent allows for year-round discharge
- Customizable process design for:
  - BOD reduction or roughening
  - Nitrification
  - Post-nitrification
  - Total nitrogen removal

Moving Bed Biofilms – Design & Operational Benefits

Operation Benefits:

- Flow-through treatment, no RAS needed
- Self-regulating biomass
- Minimal process control (D.O.) and adjustments
- Ability for bugs to acclimate/self-optimize to large flow and loading variability
- High I/I flows not disruptive to biological process
- Consistent performance season to season

Northport Leelanau Township Utility Authority – Case Study

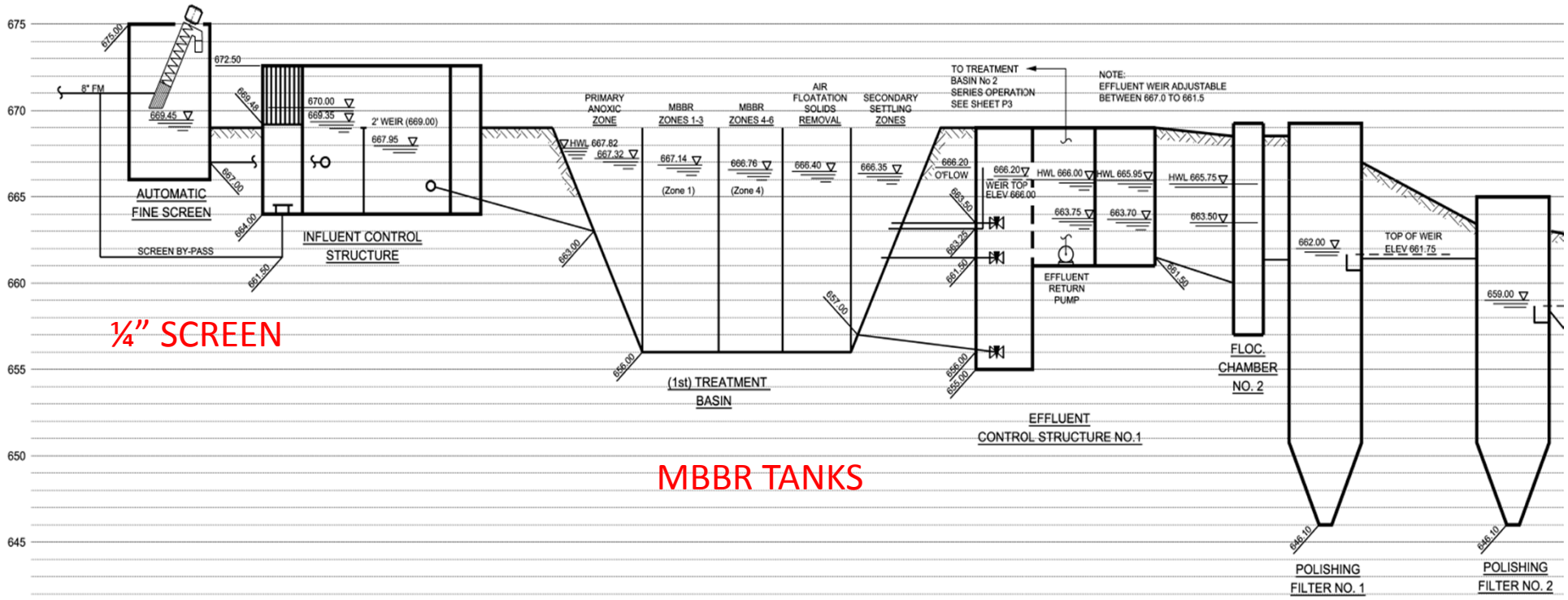
Project Background

- Project Issues
  - Small lots with old/failing drainfields (or no system)
  - Locally high groundwater table
  - Poor draining soils
  - Steep slopes
  - Health Dept. not approving on-site wastewater disposal
- Service District
  - Village of Northport
  - Leelanau Township (portion)
  - REUs- 450 Residential & 215 Institutional & Commercial

Design Basis

- Wastewater Treatment Facility Design
- 132,000 gpd 20-yr Avg. Day Design Flow
  - 2Q to 4Q Recyle Rate for Denite
- Design Influent Wastewater Strength Design:
  - 275 mg/L BOD-5 & TSS
  - 34 mg/L NH-3, 46 mg/L TKN
  - 8 mg/L Total Phosphorus

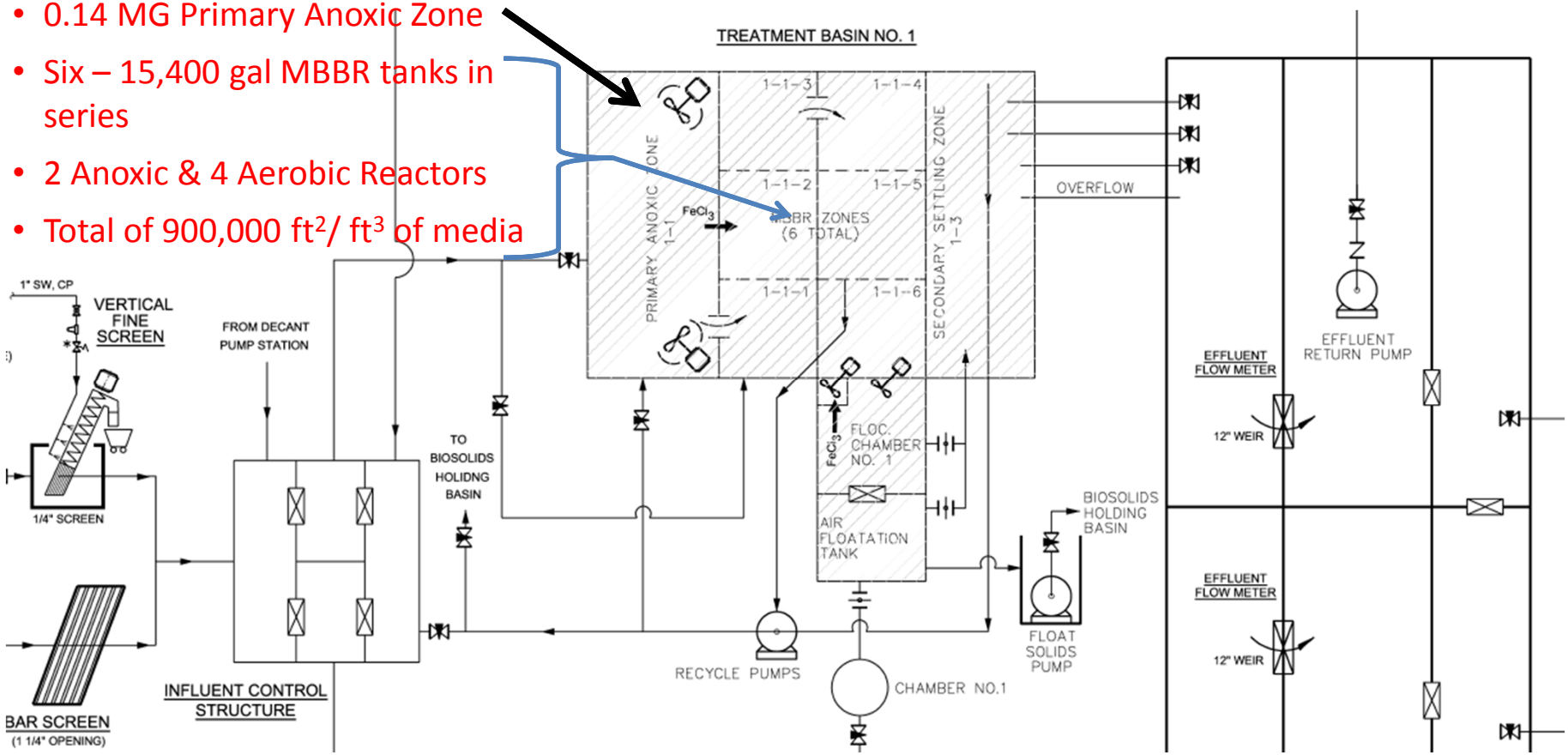
Hydraulic Profile



Northport WWTF

Process Flow Diagram

- 0.14 MG Primary Anoxic Zone
- Six – 15,400 gal MBBR tanks in series
- 2 Anoxic & 4 Aerobic Reactors
- Total of 900,000 ft^2/ ft^3 of media



Northport WWTF

Primary Anoxic Zone & MBBR Tanks
Northport/Leelanau Township

Treatment Requirements

Groundwater Discharge Permit (Venting to Surface Water)

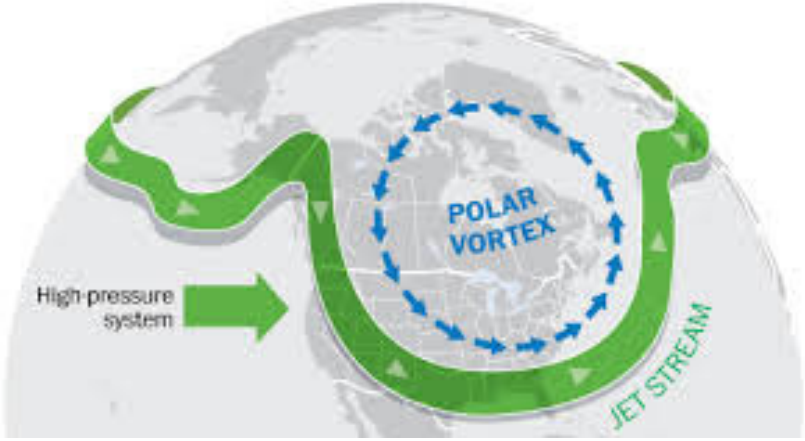
<u>Effluent Limits</u>

▪ Total Phosphorus	0.3 mg/L Monthly Avg.
	0.5 mg/L Daily Max.
▪ BOD-5	30 mg/L Monthly Avg.
	45 mg/L Daily Max.
▪ pH	6.5 – 9.0 s.u.
▪ TIN	Report (8 mg/L Treatment Goal)
▪ D.O., Cl, Na	Report

Updated
Treatment Performance

<u>Winter 2014: Effluent Results</u>

- Influent Flow: 36,600 gpd
- Ammonia-N: 0.9 mg/L average
- Nitrate-N: 8.4 mg/L average
- Nitrite-N: 0.1 mg/L average
- TIN: 9.3 mg/L average
- BOD-5: 3.5 mg/L average



Updated
Treatment Performance

<u>Summer 2014: Effluent Results</u>

- Influent Flow: 79,000 gpd
- Ammonia-N: 4.3 mg/L average
- Nitrate-N: 0.8 mg/L average
- Nitrite-N: 1.0 mg/L average
- TIN: 6.1 mg/L average
- BOD-5: 3.7 mg/L average

Village of Bloomingdale – Case Study

Project Background

- Project Issues
  - Groundwater discharge no longer viable option
  - Old facultative lagoons – under sized and not able to new meet stringent NPDES discharge limits
  - Local fruit processor looking to grow considerably
  - Sanitary collection system infiltration/inflow issues
- Service Customers
  - Village of Bloomingdale
  - Fruit processor – seasonal flow and loading
  - Large local high school

Design Basis

- Wastewater Treatment Facility Design
- 85,000 gpd 20-yr Avg. Day Design Flow – Winter
- 121,000 gpd 20-yr Avg. Day Design Flow – Summer
- Design Influent Wastewater Strength Design:
  - Winter - 224 mg/L BOD-5
  - Summer - 575 mg/L BOD-5
  - Winter - 22 mg/L NH-3, 41 mg/L TKN
  - Summer 12 mg/L NH-3, 22 mg/L TKN
  - Winter - 8 mg/L Phos
  - Summer - 5 mg/L Phos

Bloomingdale WWTF

Bloomingdale WWTF

- Integrated MBBR system with reuse of Ex. lagoons
- 10 MG Effluent Lagoon allows for significant flexibility with seasonal discharge operations
- Operator friendly
- NPDES seasonal discharge

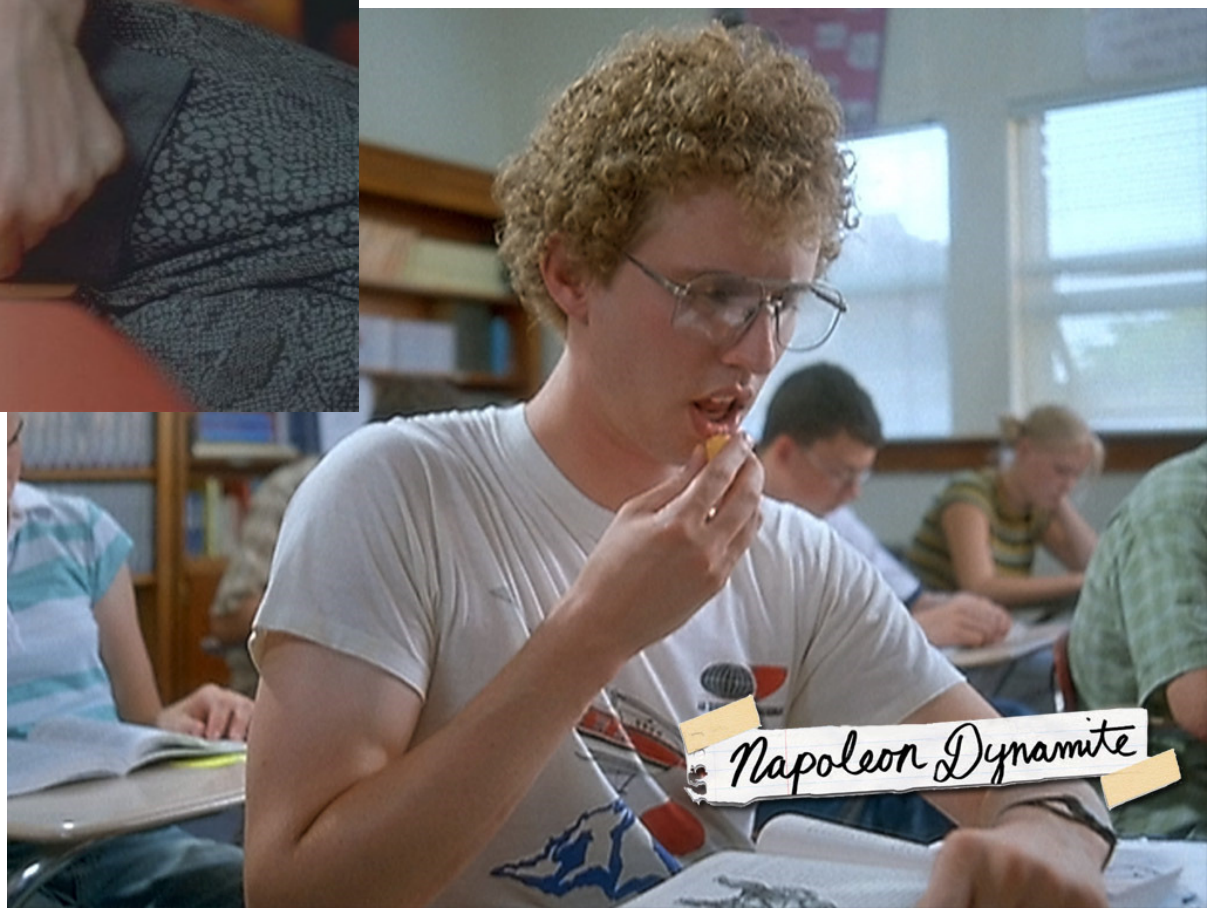
Berry Processor - Bloomingdale

- Identified Industry needs

  Discussed future BOD treatment needs vs. production
- GREAT Marriage (win-win) of
  - Tanks with available treatment volume … minimum HRT
  - A home for Lots of MBBR plastic media … enough for berries
  - Biofilm's ability to 'sorb' extra BOD 'food' for later consumption

A more topical way to think of this concept…

Save some BOD for later...



Too Much Food is Bad for Your Bugs?!

By Rich Grant, PE and Elaine Venema, PE (Fleis & VandenBrink)

Michigan's food processors have grown and prospered. BUT they need a place to discharge their waste. Here's how to make a WIN : WIN solution in your town.

Jobs in your town from a 'clean industry' are almost always a good thing, right?

Whether it's a job for a new homeowner, for your kid, for the mayor's kid … jobs are a goal of your town that we can and should support with the wastewater treatment plant (WWTP).

Tasty Treats!!

Process water from beer, blueberries and other fruits, cheese, sausage and meat products, pickles, milk, and egg processing can all be tasty treats for a municipal wastewater plant; however too much of a "good" thing can also spell disaster. (Is the Mayor listening?)

In helping food processor industries, we find that "a little extra food" can cause some big headaches at the WWTP. Your worker-bugs get sick when they're overfed today and then starved tomorrow! Industries just don't 'get' that point.

Upgraded Bloomingdale WWTP is Simple & Robust

Talking regularly and planning together with your food processor industry is every bit as important as having the right contract/agreement and the right industrial discharge permit.

The Discussion This Week:

Keep in contact with your food industry customers, give them a weekly/monthly call to ask "how's it going?"

- Are the typical seasonal changes (loadings) expected again this year?
- When do I need to prepare the plant for your peaking?
- How's Business? Are there any planned expansions?
- Have you had any equipment headaches?
- Have you had any *oops* moments?

The Right IPP Permit

- Limits discharge strength and volume
- Requires equipment and procedures to prevent slug loading
- May require flow/strength equalization
- Outlines sampling and monitoring procedures

The Right "Contract"

- Purchase of enough service capacity
- Allocation of treatment capacity

Case Study 1 – Blueberries

The Village of Bloomingdale wastewater treatment plant needed to switch from a groundwater discharge to a surface water discharge to meet MDEQ requirements. During the project planning phase it was determined that a local blueberry processor had gradually been increasing its wastewater flows and had big plans to expand its operations. Great News! The old facultative lagoons did not have enough treatment capacity to meet the more stringent surface water discharge limits or handle additional flow/loading from the blueberry processor.

We created inexpensive capacity to handle seasonal loadings by constructing a three-stage Moving Bed Biofilm Reactor (MBBR) upstream of the existing lagoons. The attached growth process (like plastic rotini pastas) is great at handling variable,

Summer 2014 MWEA Matters

Bloomingdale WWTF:

- Fruit Processor Customer with High Organic Seasonal Loadings

Challenging Industries

Food Processors/Agricultural:

- Nutritional Supplements/Dairy
- **Fruit Processing/Canning**
- Pickling Operations
- Tannery/Rendering
- Flour/Grain Mills
- Egg/Poultry
- Breweries

Treatment Performance

NPDES Discharge Permit

Effluent Limits

- Total Phosphorus 1.0 mg/L Monthly Avg
- CBOD-5 13 mg/L Monthly Avg (May – Sept)
  25 mg/L Monthly Avg (Oct – May)
- TSS 30 mg/L Monthly Avg
- Ammonia 5.5 mg/L Daily (May – Sept)
- Min. % Removal CBOD-5 & TSS: 85% Monthly Avg

Treatment Performance Review

4 month sampling period from August through October 2014

- 2 days a week,
- (30) 24-hr composite samples total

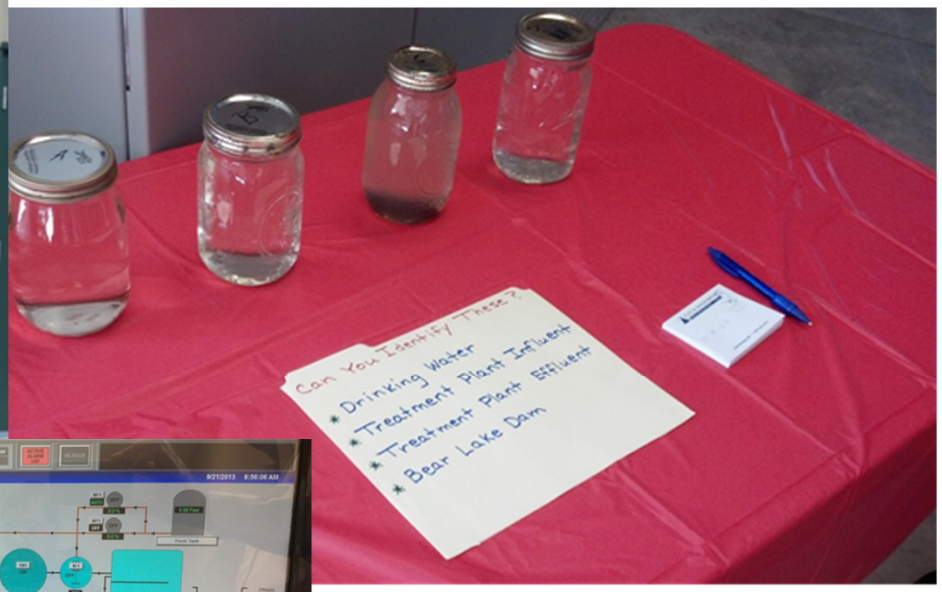
		Raw Influent						
	Flow gpd	C-BOD mg/l	C-BOD (Sol.) mg/l	COD mg/l	NH4-N mg/l	N Total mg/l	P Total mg/l	TSS mg/l
AVG	112,985	404	327	749	10	21	3.2	168
MAX	157,960	817	651	1,720	17	33	5.5	404

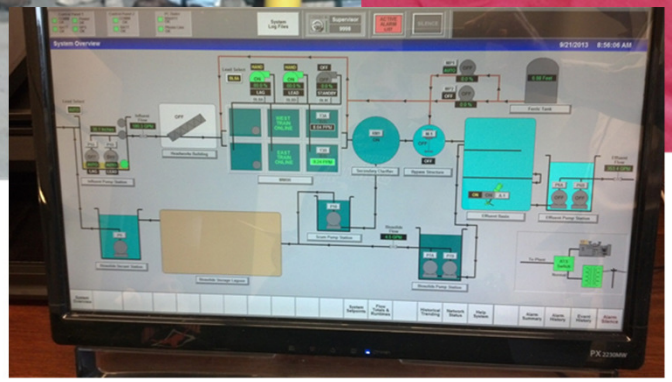
CMFF Effluent							
C-BOD mg/l	C-BOD (Sol.) mg/l	COD mg/l	NH4-N mg/l	NH4-NO3 mg/l	N Total mg/l	P Total mg/l	TSS mg/l
63	3.9	375	0.3	3.1	19	3.9	307
206	15	1,230	3.6	19	41	7.3	720

	Secondary Clarifier Effluent					
	C-BOD mg/l	COD mg/l	NH4-N mg/l	N Total mg/l	P Total mg/l	TSS mg/l
	7.5	54	0.4	2.2	0.8	15
	36	180	5.1	8.2	3	45
% Rem	98%	93%	97%	89%	75%	91%

Note: Sec. Clarifier effluent is discharge to 10 MG effluent lagoon

Bloomingdale WWTF Open-House Fall 2013





Tom Rock, Village President

"This plant is key to our future, both with local employment and our need to clean the water. The MBBR is working great. Without this plant, the world class blueberry processing company MBG would not have expanded in our town. It's a real win-win."

City of Plainwell – Case Study

Project Background

- Project Issues
  - Owner wanted to replace RBCs
  - MBBR constructed off-line until bugs were ready, 2-4 weeks start-up to get biofilm established
  - Integration of new biofilm process with existing treatment processes

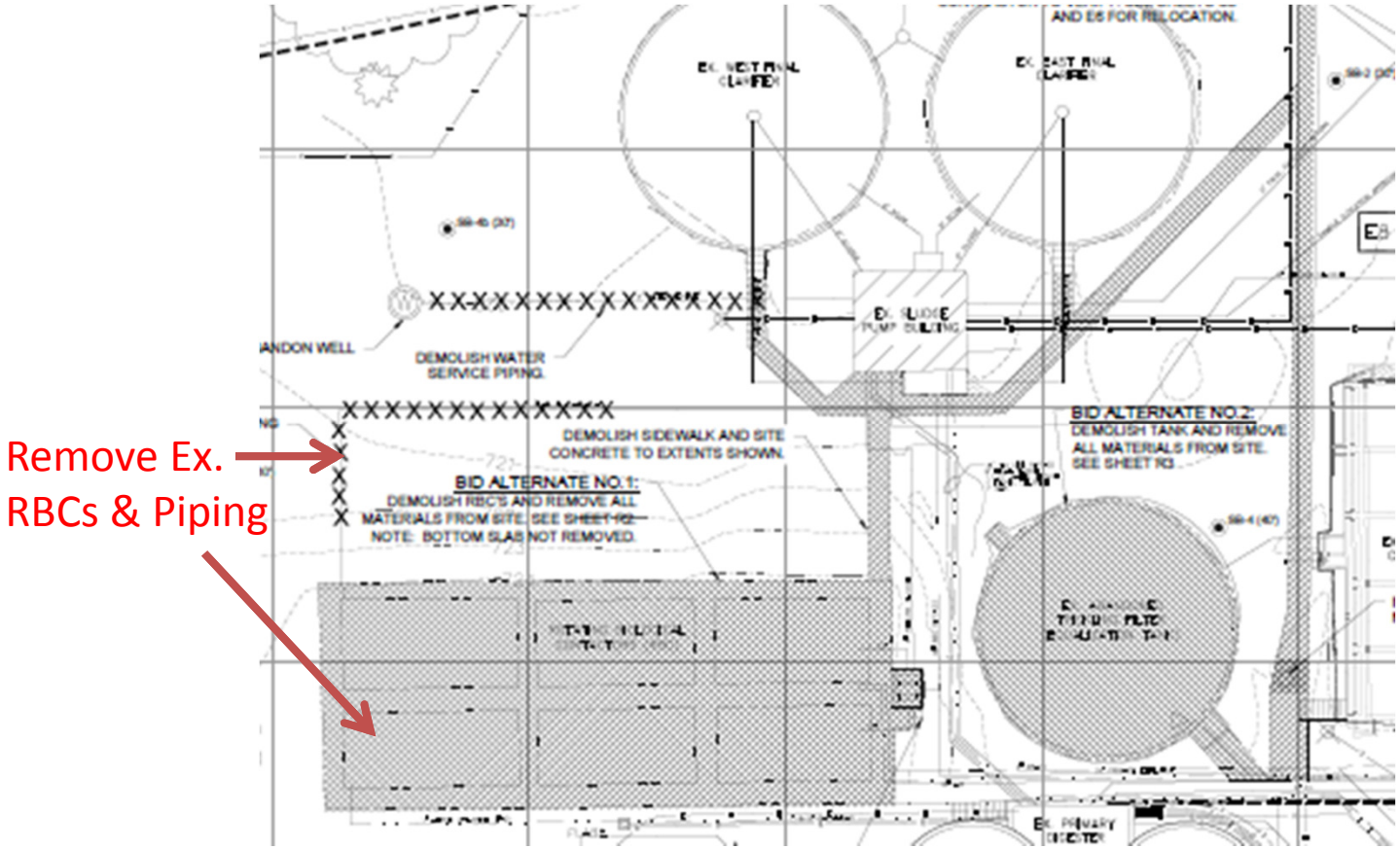
- Service District
  - City of Plainwell
  - Village of Martin
  - Gun Plain Township, portion of Otsego Township

Plainwell WWTP Improvements

- New automatic screening and headworks building expansion
- New odor control biofilter
- New Moving Bed Bio-Reactor (MBBR) treatment system; removed existing RBCs
- New blowers and blower building

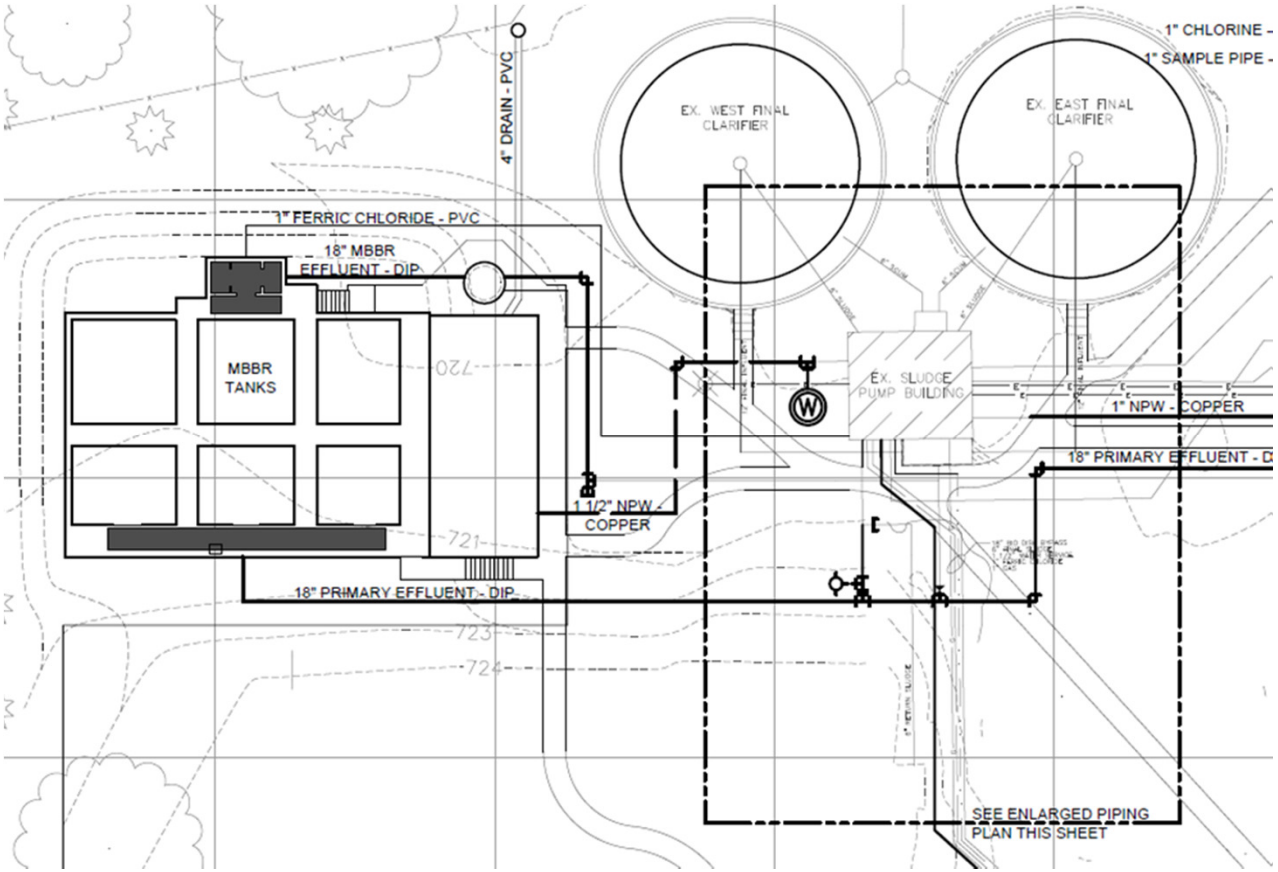
Demo Site Plan

Integrating new MBBR system with ex. WWTF

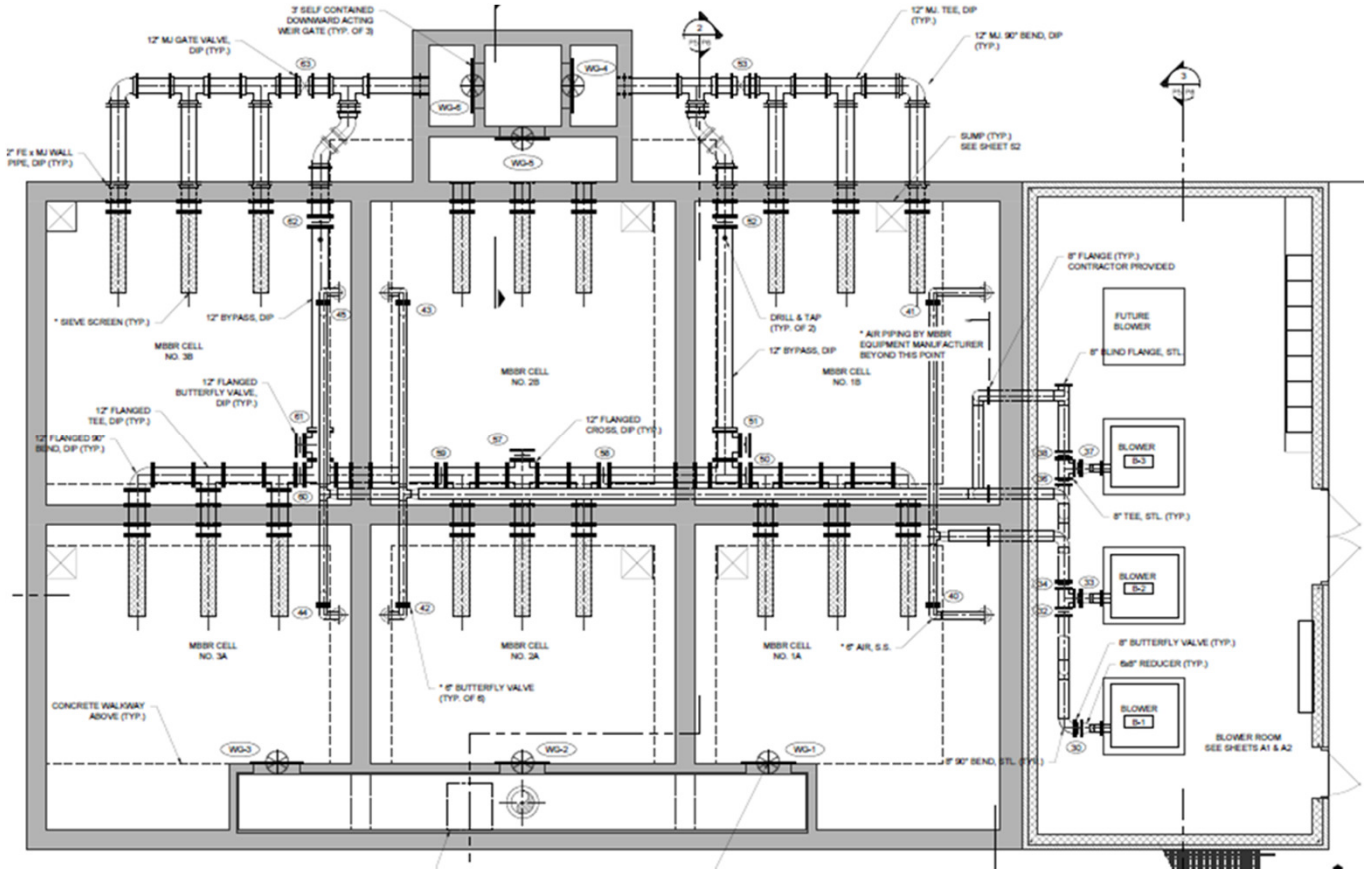


MBBR Tanks Under Construction

MBBR Site Plan



MBBR Tank Plan



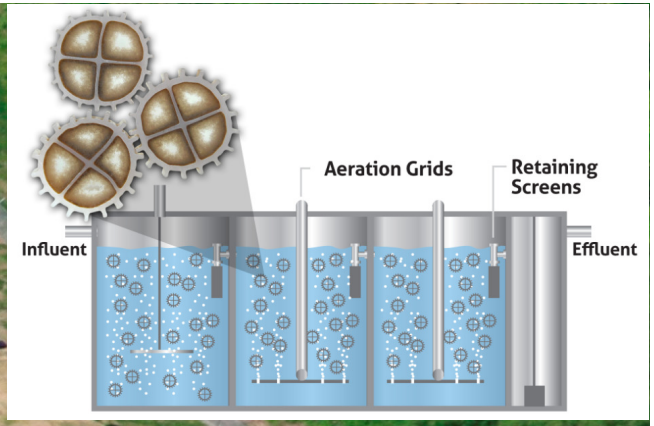
Moving Bed Biofilms – Design Considerations

Design Considerations:

- Ability to by-pass any one reactor for operation & maintenance flexibility
- Expandability – consider oversizing tanks by 25-50% to allow future expansion with just media addition
- Need headworks screening (min ¼”)
- Oversize or double up media retention sieves
- Need approx. 8” to 12” of available head to fit MBBR system into ex. facility
- Provide D.O. monitoring/PID control. Need to maintain a min. mixing energy to keep media moving
- Blower design to allow for air/energy flexibility
- Consider polymer system to assist with solids settling

Performance of Modern Biofilm Treatment Technology

QUESTIONS?



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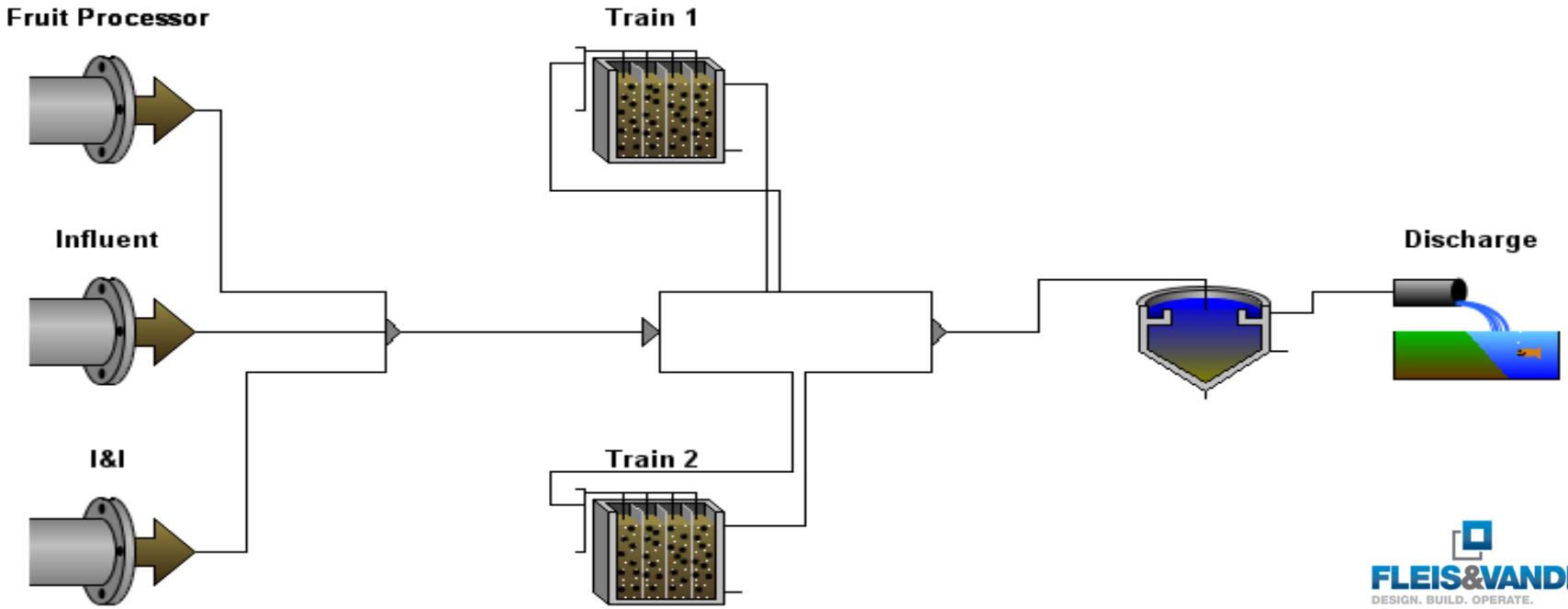
November 5, 2014

Treat at POTW

Capacity Analysis:

- Evaluate flows & loads
- Engineering calculations – MAHLs, AORs, organic loading, hydraulics
- Identify processes with insufficient capacity – Headworks? Secondary Trt?



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