OTCO ANNUAL WASTEWATER WORKSHOP

MARIETTA WWTP BIOLOGICAL SELECTOR ENHANCES SYSTEM RESILIENCY

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THE MARIETTA OHIO WWTP

Located on the north side of the Ohio River in the City of Marietta Ohio.

HISTORICAL BACKGROUND

- The Marietta Wastewater Treatment Plant (WWTP) is an activated sludge plant rated at 4.00 MGD.
- Biological treatment was added to the original primary plant in 1987.
- The historic downtown is passively combined so the plant experiences wet weather I/I.
- The plant was modified in 2001 and 2002, and more recently the renovation program, in four phases between 2011 to 2022.

EFFECTIVE TREATMENT OVERVIEW

Excellent liquid solids separation

- Good clarity
- Speed of water release from settling floc

Meets NPDES Permit Requirements

- Concentration and loading limits (monthly and weekly)
- Sludge treatment
- Other conditions required
- Including Part IC Compliance Schedule

WHAT IS SLUDGE BULKING (AND FOAMING)

Caused by filamentous bacteria

- Not floc forming.
- Long and extended growths from flocs.
- Prohibits efficient liquid-solids separation.

Demonstrated by following tests

- 30 Minute settling test and SVI
- Core sampler (sludge judge)
- Microscopic analysis (Phase Contrast)

THIRTY MINUTE SETTLING TEST

For the 30-minute settleometer test, a good objective is:

- > 800 ml in 5 minutes
- > 400 ml in 30 minutes

Then, settling should be good enough to not lose solids under most conditions.

SLUDGE VOLUME INDEX EQUATION

SVI is defined as 'the volume (in mL) occupied by 1 gram of activated sludge after settling the aerated liquid for 30 minutes.

Visualize the most mass in the least volume as being favorable.

$$SVI = \frac{\text{Settled MLSS} \times 1{,}000}{\text{MLSS}}$$

$$SVI = \frac{\text{ml/L} \times \text{mg/g} = \text{m/G}}{\text{mg/L}}$$

SLUDGE VOLUME INDEX (AURORA WESTERLY WWTP)

5 Minutes

30 Minutes

Settled 700 ml in 30 minutes (300 ml volume)

$$SVI = \frac{300 \text{ ml} \times 1{,}000 \text{ mg/g}}{2{,}000 \text{ mg/l}} = 150 \text{ ml/g}$$

TYPICAL CONDITIONS CONTRIBUTING TO FILAMENTOUS BACTERIA

- Septicity
- Low Dissolved Oxygen
- High volatile organic acids (> 100 mg/L): ***MARIETTA WWTP***
- Long HDT in collection system: ***MARIETTA WWTP***
- Food soluble $CBOD_5$ waste: ***MARIETTA WWTP***
- Low F/M due to reactor configuration: ***MARIETTA WWTP***

ARE ALL FILAMENTS BAD?

- Some filaments promote good floc structure (e.g. Type 0041).
- Filaments are bad in high quantities based on scale of 0-5.
- Less than 0-1 is favorable, 2- 3 is marginal, and 4-5 are problematic.
- 0 and 5 scores are unusual. During 2001-2003, Marietta WWTP was ~ 4

TIMELINE OF SLUDGE BULKING PROBLEM

- Severe between 2001 and 2003
- Short term control between 2004 and 2012….somewhat effective
- Long term permanent control (after selector put on-line) in 2012…very effective
- Success continues in 2024 despite changes in loadings.

FILAMENTOUS SLUDGE BULKING BEGINS

After the addition of a sludge dewatering press in 2001, the problem started. Added filtrate seems to have been a trigger.

- Bulking was steady and acute to where the plant was in NPDES violation for consecutive months in 2002 and 2003 for multiple parameters including for $CBOD_5$, TSS, and Fecal Coliform.

- The Ohio EPA requested a plan of action from the city.

BROUGHTON DAIRY (DEAN FOODS)

- The dairy was the city's largest employer and produced > 100,000 GPD.
- The waste was high in $CBOD_5$ but had low nitrogen or phosphorus. It was nutritionally unbalanced for activated sludge.
- The waste flow had a long detention time to the WWTP through a 30-inch trunk sewer, which generated volatile organic acids.
- The city maintained a good working relationship with the dairy.

MASTER FACILITIES PLAN (2003-2005)

- The city retained R. D. Zande & Associates (now Stantec) to prepare a Master Facilities Plan. Dale Kocarek was the investigator.

- Objective was to develop a future planning document that considered compliance, space requirements, technology, replacing aging infrastructure, and growth.

- We understood that compliance was essential to achieve quickly.

- At the onset, we proposed a phased plan due to financial reasons.

MASTER FACILITIES PLAN CONTINUED

- Dairy waste encouraged *S. Natans*, Type 1701 and Type 021N.

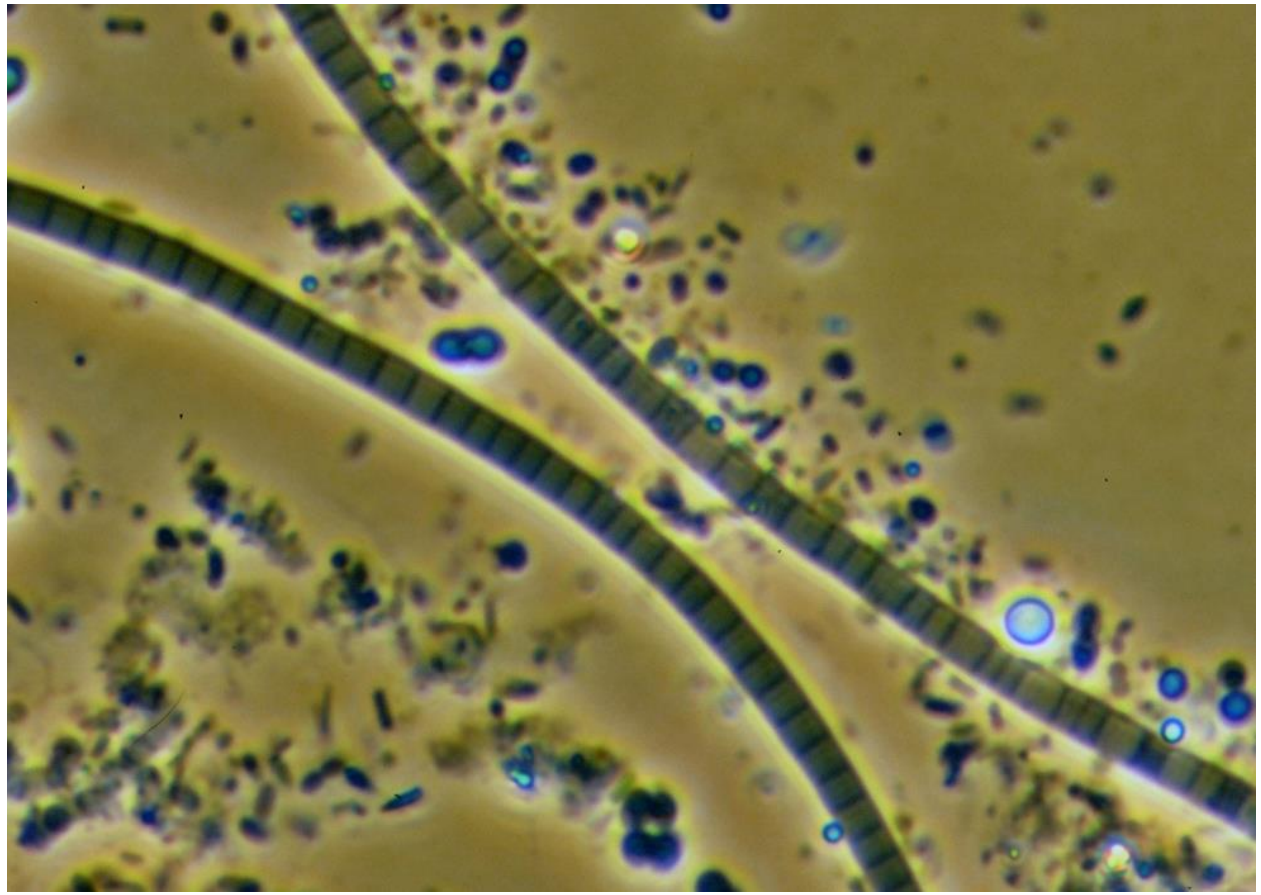
- This condition was worse at night when the ratio dropped out of the ideal range of 100:10.1 for carbon: nitrogen; and phosphorus. This also helped generate *Nostocoida limicola* I and 2.

- Also, the activated sludge bioreactor promoted low F/M bulking due to the reactor configuration.

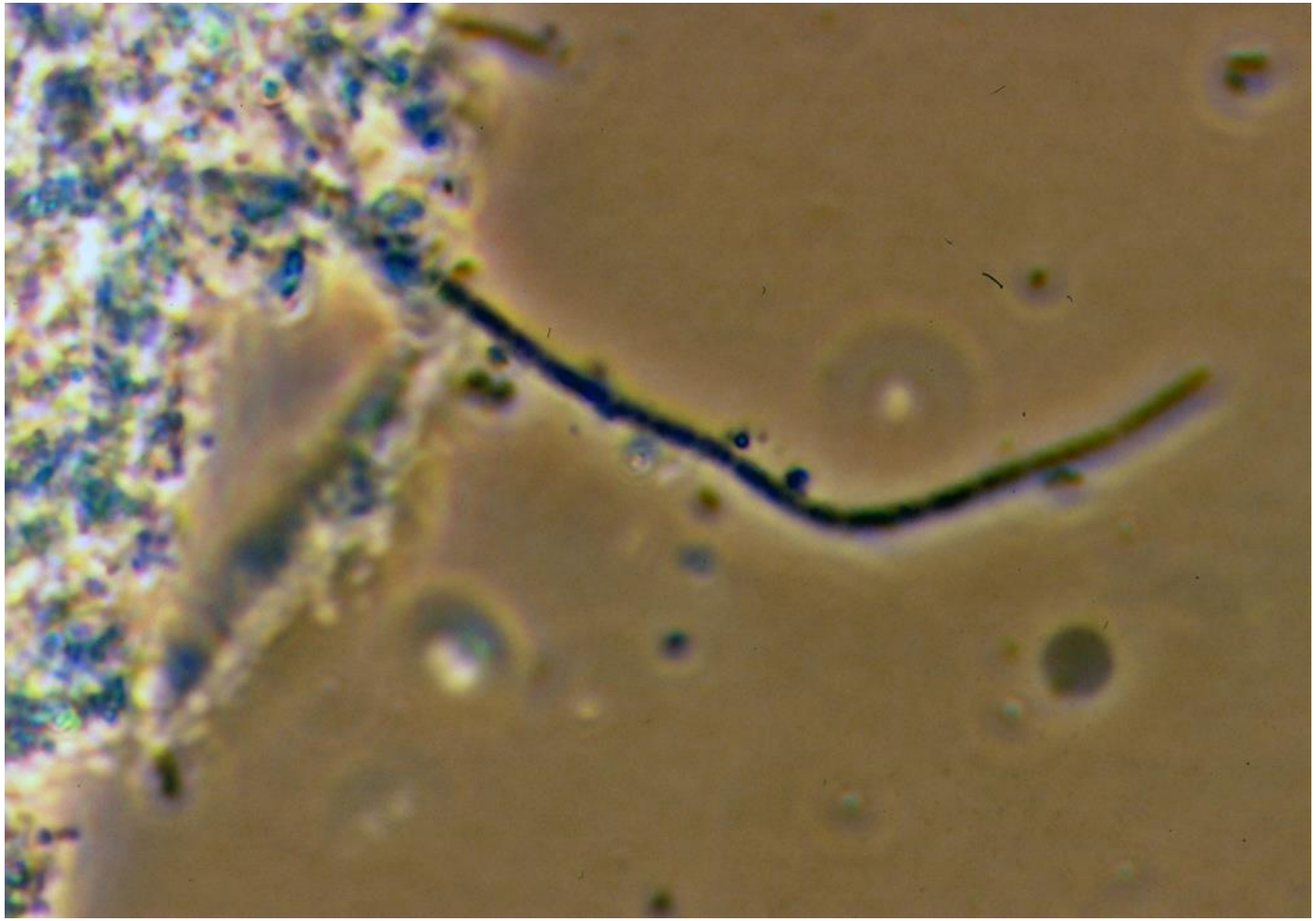
- Much of the credit for the short-term compliance plan is due to efforts of Mr. Elliott.

TYPE O21 N

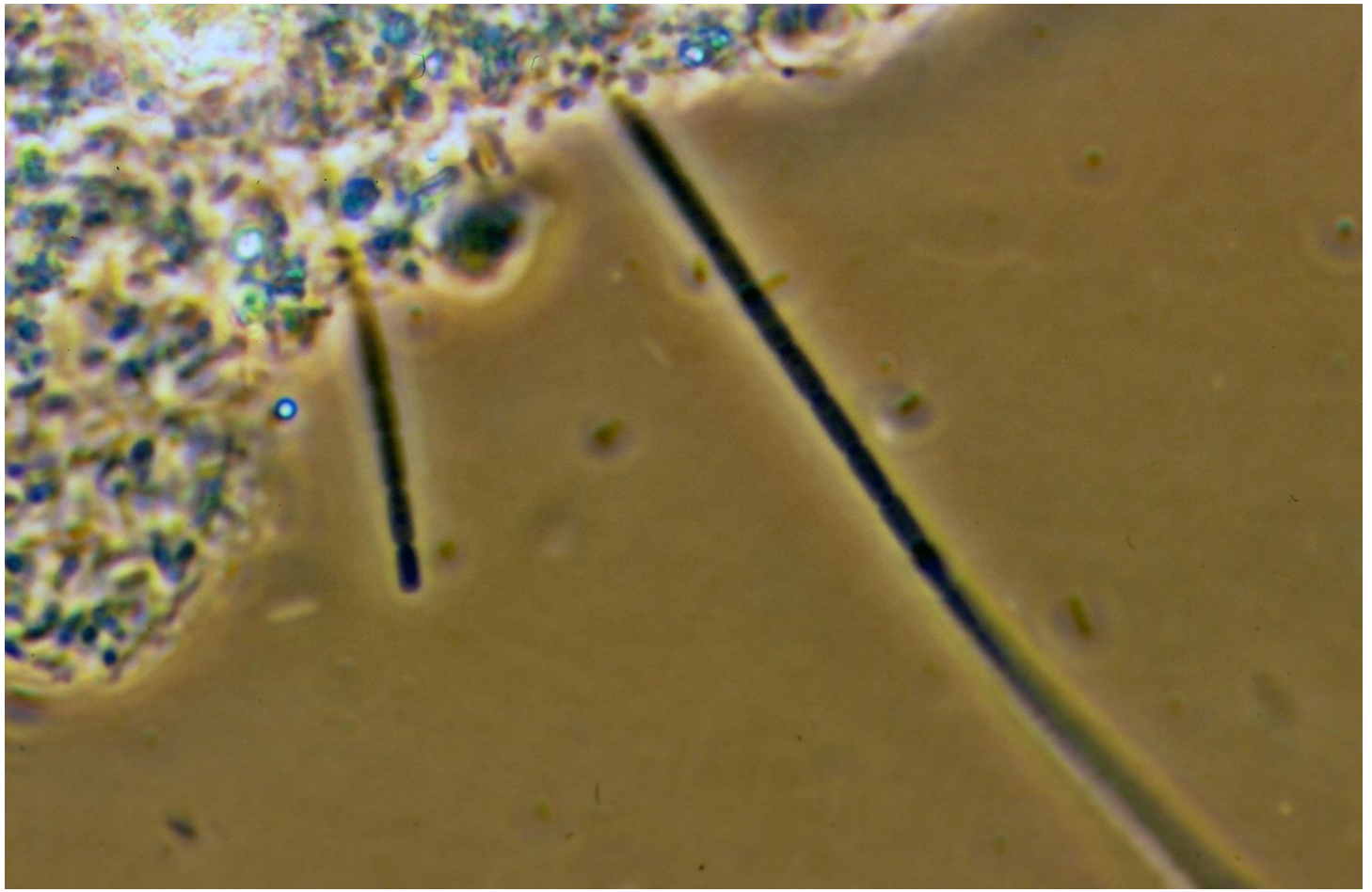
All filament photographs (5 slides) compliments of Michael Richards, Ph.D.



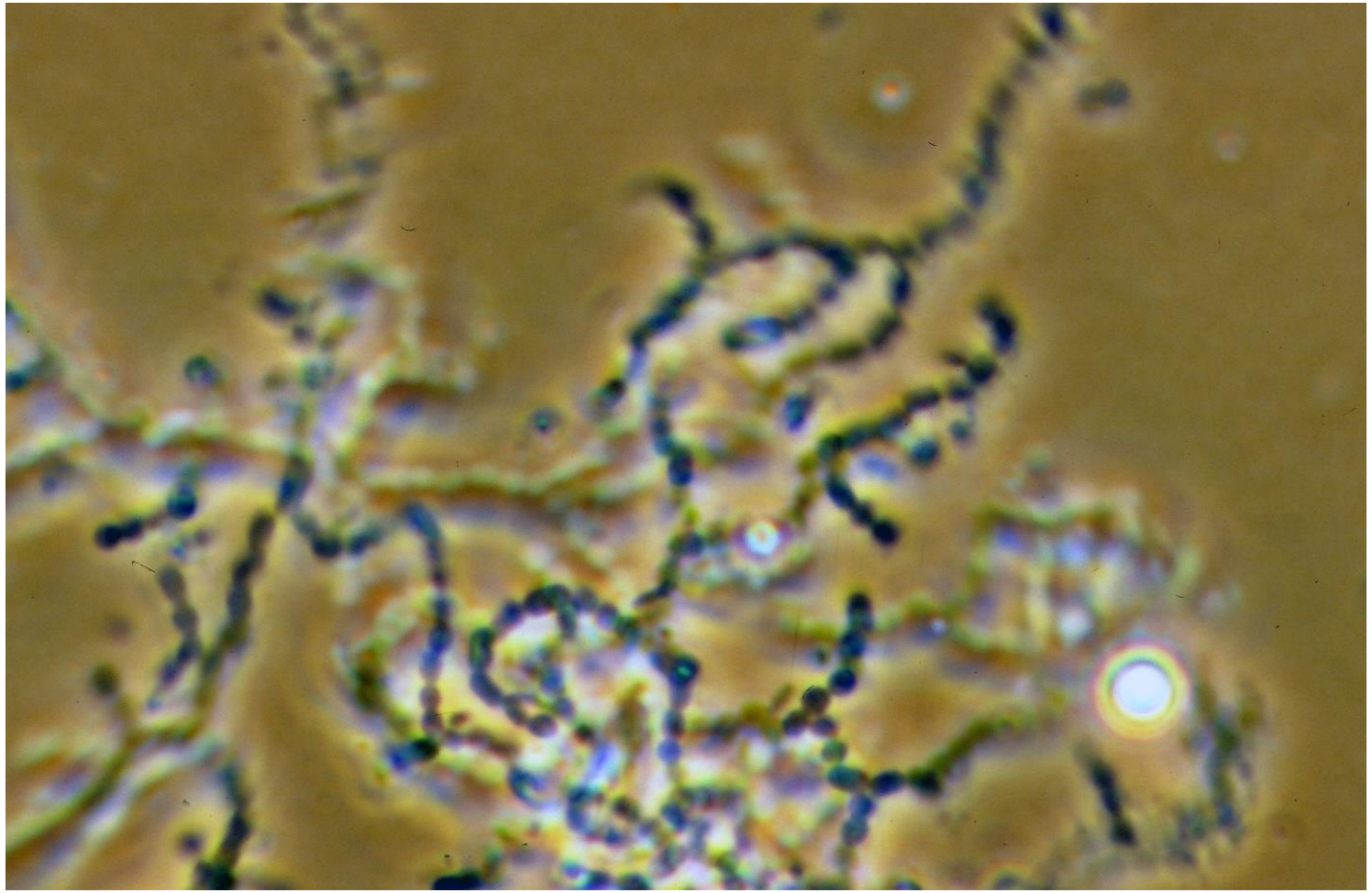
TYPE 1701



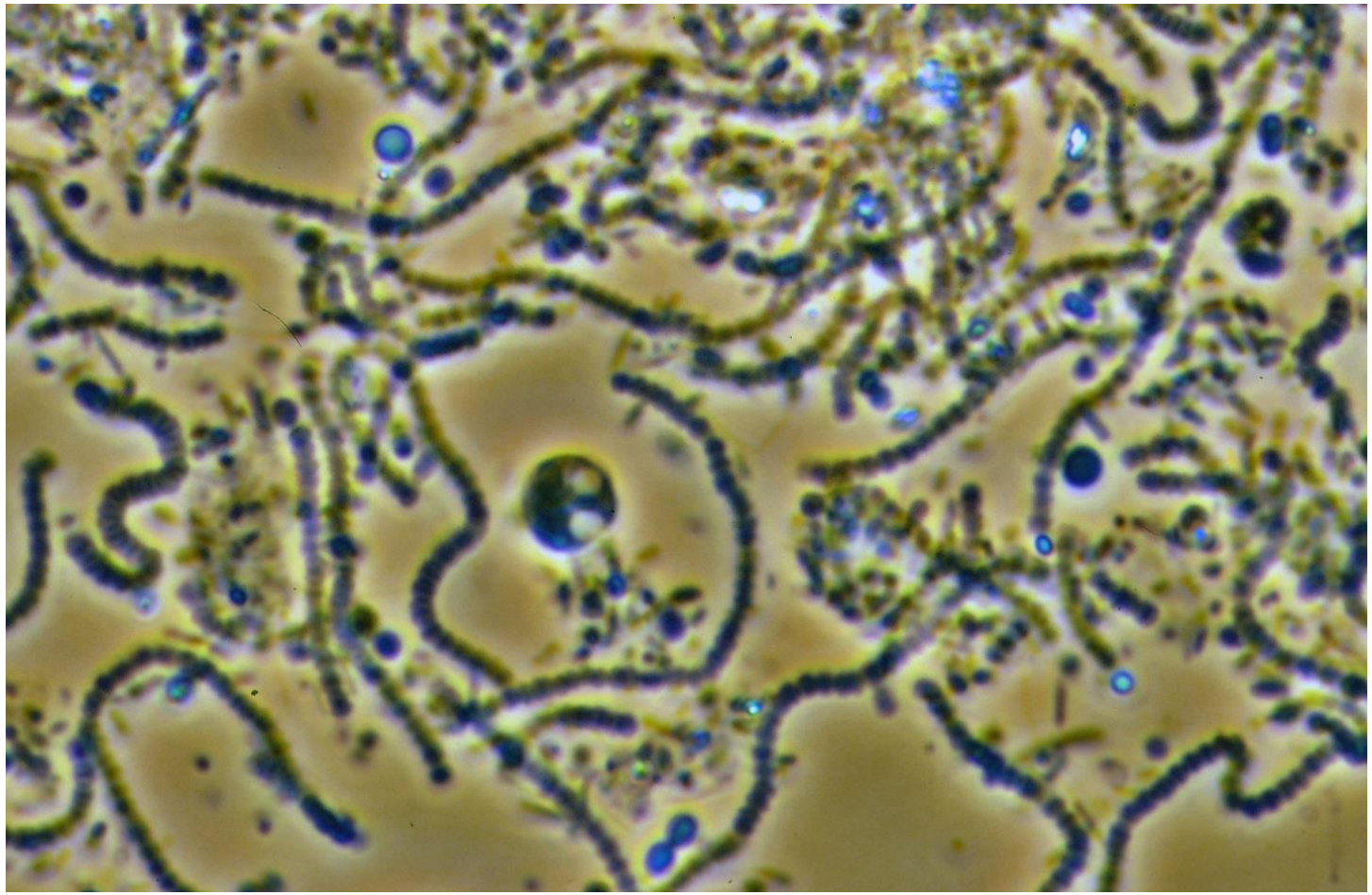
S. NATANS



TYPE 1863



N. LIMICOLA II



MARIETTA WWTP FILAMENT SUMMARY

FILAMENT	CONDITIONS	F/M (INVERSE DAYS)	POSSIBLE REMEDY
S.Natans	Low D.O Sulfides Organic acids	> 0.6	Decrease F/M ratio < 0.2 Cells in series operation Adequate aeration Monitor CBOD/N/P ratio: 100/10/1
Type 1701	Low D.O Organic acids	0.3-0.6	Decrease F/M ratio < 0.2 Cells in series operation Adequate aeration Monitor CBOD/N/P ratio: 100/10/1
Type 021N	Sulfides Organic acids Nutrient deficiencies	0.2-0.5	Decrease F/M ratio < 0.2 Cells in series operation Adequate aeration Monitor CBOD/N/P ratio: 100/10/1
Thiothrix sp.	Sulfides Organic acids Nutrient deficiencies	0.2-0.5	Decrease F/M ratio < 0.2 Cells in series operation Adequate aeration Monitor CBOD/N/P ratio: 100/10/1
N. Limicola	Food wastes	0.2-0.5	Add supplemental nitrogen and phosphorus

WHAT IS BIOLOGICAL SELECTION?

- An environment to encourage growth of floc formers versus filaments.
- Floc formers are short and agglomerate into masses, while filaments are long and compete favorably in substrate limited or nutrient imbalanced environments.
- Based on the work of Dr. Glen Daigger and published in JWPC journal articles in the 1980s.
- Effective liquid-solid separation leads to better treatment under peak flow conditions.

DR. DAIGGER'S INVESTIGATIONS

- Glenn Daigger, Ph.D., P.E., BCEE is a process engineer, professor, and researcher in 1980s to present.

- He developed design protocols for selector design including multi cell orientations, F/M guidelines, and hydraulic detention times generally under anoxic conditions.

- Those guidelines were used in the selector design at the Marietta WWTP.

SHORT TERM COMPLIANCE PLAN

- Implement a tanks in series operation and turn off air in first tank to create anoxic/anaerobic cell.

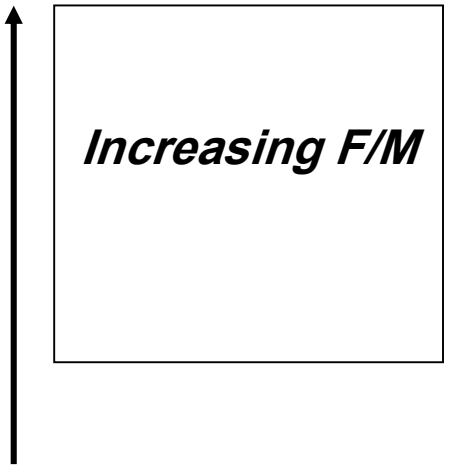
- Reduce F/M from 0.2 inverse days <0.1 inverse days to *shift* from “bad” filaments such as S. Natans and Type 1701 to filaments such as Type 0041 which are less problematic.

- Include “timed” supernation from the anaerobic digesters to add N and P.

- Marietta also used sodium hypochlorite and polymer.

FILAMENTOUS ORGANISMS OBSERVED BASED ON F/M

- S. Natans
- Type 1701
- Type 021N
- Type 0041
- Thiothrix species
- Nostocoida Limicola I and II



Effluent violations were reduced from more than 20 per month to less than 6 per year.

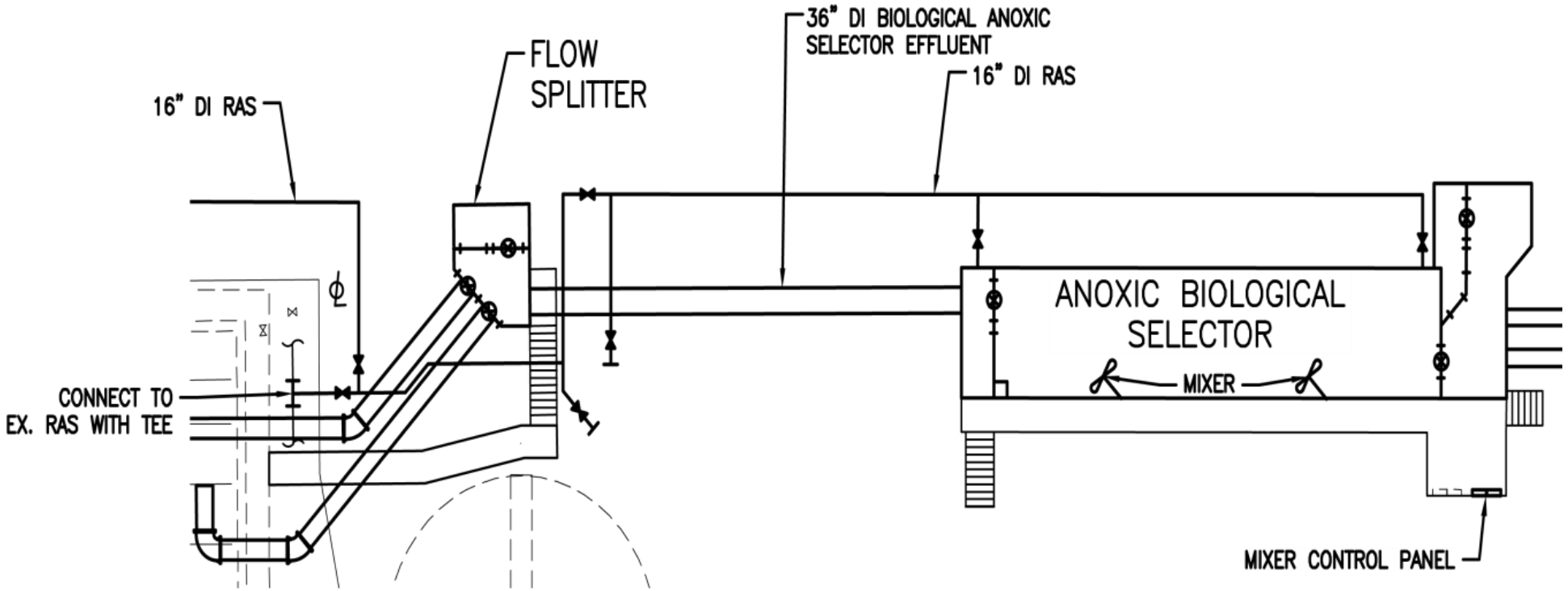
LONG TERM SOLUTION

- The long-term solution was to implement a biological selector with a more effective influent gate system to control flow into the aeration tank.

- Create a “food to micro-organism” (F/M) ratio of 3 to 8 Inverse Days in the selector tank to encourage the growth of floc formers and select against filaments.

- The system was physically wedged between the primary clarifiers and aeration tanks near the road and access driveway.

MARIETTA ANOXIC BIOLOGICAL SELECTOR TANK



PHOTOGRAPHS DURING CONSTRUCTION (NEXT 2 SLIDES)

Selector 12/8/23

DESIGN REQUIREMENTS

- Tank volume is 60,000 gallons between primary settling and activated sludge. RAS is fed into the front end of the selector.

- The tank has two compartments separated by a baffle wall to establish a high F/M in cell one and minimize short circuiting in system as a whole.

- One 5 HP Submersible mixer per cell: two in total.

- Can be bypassed for maintenance if needed. (Never has been taken off-line).

DESIGN REQUIREMENTS (CONTINUED)

- Low hydraulic drop requirements must be maintained (reality of retrofits).
- F/M of 3 to 8 Inverse Days with at least two compartments.
- Maintain a hydraulic detention time (HDT) 15 to 30 minutes under normal flow conditions.
- During high flow conditions, the 15 to 30-minute detention time may not be possible.

CHANGES OVER THE LAST TEN YEARS

- The dairy leaves town, and septage waste receiving begins.

- Based on a microscopic evaluation on December 8, 2023, the number of filaments observed was approximately 0 on a scale of 0-5.

- Conversion from anaerobic digestion to aerobic digestion in 2015 reduced volatile organic wastes.

- Other system changes included stopping land application, changing from the belt filter press to a centrifuge and installation of septage receiving (DEFA WPCLF incentive).

NEW SOURCES OF REVENUE/SEPTIC RECEIVING STATION

- 2,350,569 gallons of septic treated in 2023 and a charge of $0.09/gallon for a total revenue of $211,551.21 in 2023. The simple Rate of Return is less than 5 years.

- In 2023, the plant was operating around 60% of capacity, septic allowed an increase in organic loading beneficial to the plant operations.

- A subdivision north of Marietta will be connecting around 500 homes to Marietta. The system will be an Orenco system which is a discharging septic tank.

CONCLUSION

- The biological selector was highly successful and brought the WWTP into OEPA compliance and is in use today.

- During this period, the average SVI dropped from > 150 ml/g on all days to 60-90 ml/g.

- By eliminating this problem, the city was able to treat more wet weather flow, maintain compliance with its NPDES permit, and take in more revenue and enhanced system resiliency.

POSITIVE OUTCOMES

- The selector helped keep a food industry in town for many years and then pave the way for another source of revenue. It was a gesture of good will.

- Relationships with the industry were always positive, even in the most challenging times due to the efforts of Mr. Elliott.

- The low SVI helped the WWTP process more wet weather flow through from 2.0 MGD to 15.0 MGD, nearly doubling the flow treated.

OBSERVATIONS

- Each facility is unique, and it is hard to tell in advance which ones will have liquid-solid separation problems.

- Selectors can be challenging to justify due to cost unless designed into a plant upgrade.

- Selectors must be hydraulically upgradient of the biological reactor. This can be difficult in a retrofit when the hydraulic gradeline is relatively flat.

- The stability created by the selector is allowing the city to take in more revenue from wastes.

ACKNOWLEDGEMENTS

The discussions and improvements at the Marietta WWTP covered nearly two decades, and there were a number of people that Steve and I wish to acknowledge:

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- Joseph Tucker, P.E., Former City Engineer
- Staff of the City of Marietta WWTP

THANK YOU AND QUESTIONS

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