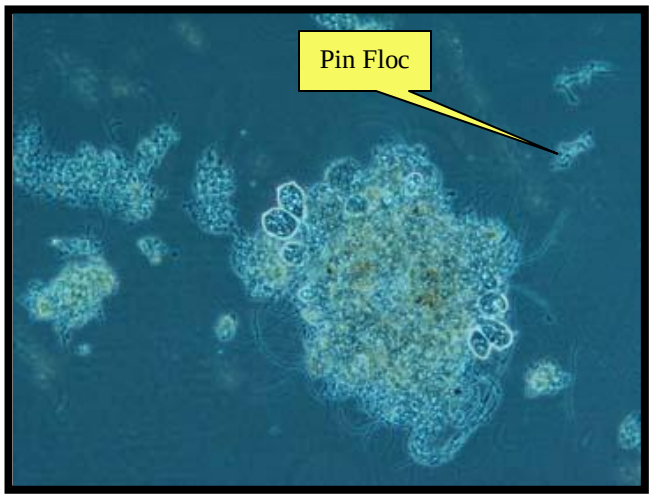
Activated Sludge Microbiology Evaluation
And Filamentous Identification
March 5, 2009

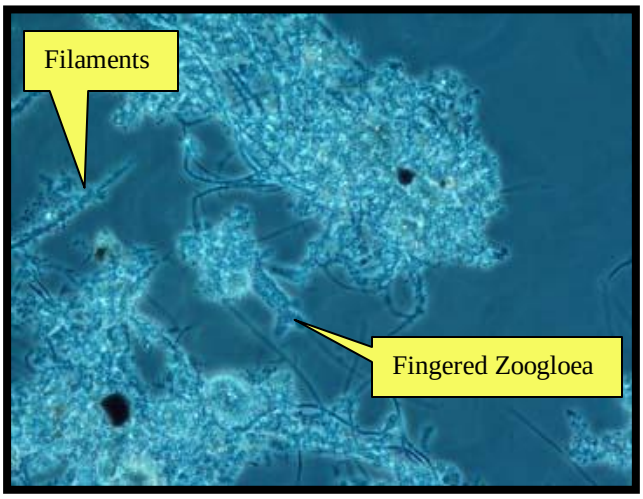
General Summary

The sample was submitted in response to settling problems in the aeration basin of a municipal client. The sample was collected on March 2, 2009 and shipped over night to the EBS laboratory. Analysis was performed on March 3, 2009. This report is based on the laboratory examination of the sample and discussions with the plant's consulting engineer. In addition to the settling problems, discussions with plant personnel revealed that system performance for some of the key parameters (specifically TSS and color) has recently deteriorated.

Floc Structure, Settling and Water Clarity

Floc was variable in size, ranging from small, dense pin floc to large, bulky, diffuse, open floc. The sample settled well leaving behind a fairly clear supernatant. The MLSS for the sample was 1790 mg/l. At this MLSS value the SVI calculated to 149, which indicates a fair settling rate. Filament abundance was a 4 (very common) on the 0 – 6 scale with all floc containing filaments within the floc and extending out into the bulk solution. There was some interfloc bridging by the bacteria, but it wasn't excessive. Therefore the sludge settling remains reasonable. This sample had a fairly clear supernatant after 30 minutes of settling. The supernatant TSS was 25 mg/l due primarily to the pin floc left behind. The low amount of solids and, therefore, floc, inhibit the sample from grabbing on to all of the smaller solids, like pin floc, as it settles. The summary of the microscopic examination information is shown in Table 1. Table 2 contains the analytical testing data. The photos below provide examples of the various characteristics observed. In addition to the floc and filaments noted, another significant observation was made. The system contained a relatively large amount of Zoogloea. This specific type of bacteria produce a collection of extracellular polymer strands composed of polysaccharides. This makes them "sticky" so that they form floc. They can be good for settling in normal amounts, but can hinder settling if they become excessive. While this sample had elevated amounts of Zoogloea, it did not appear to inhibit the settling of the sample.





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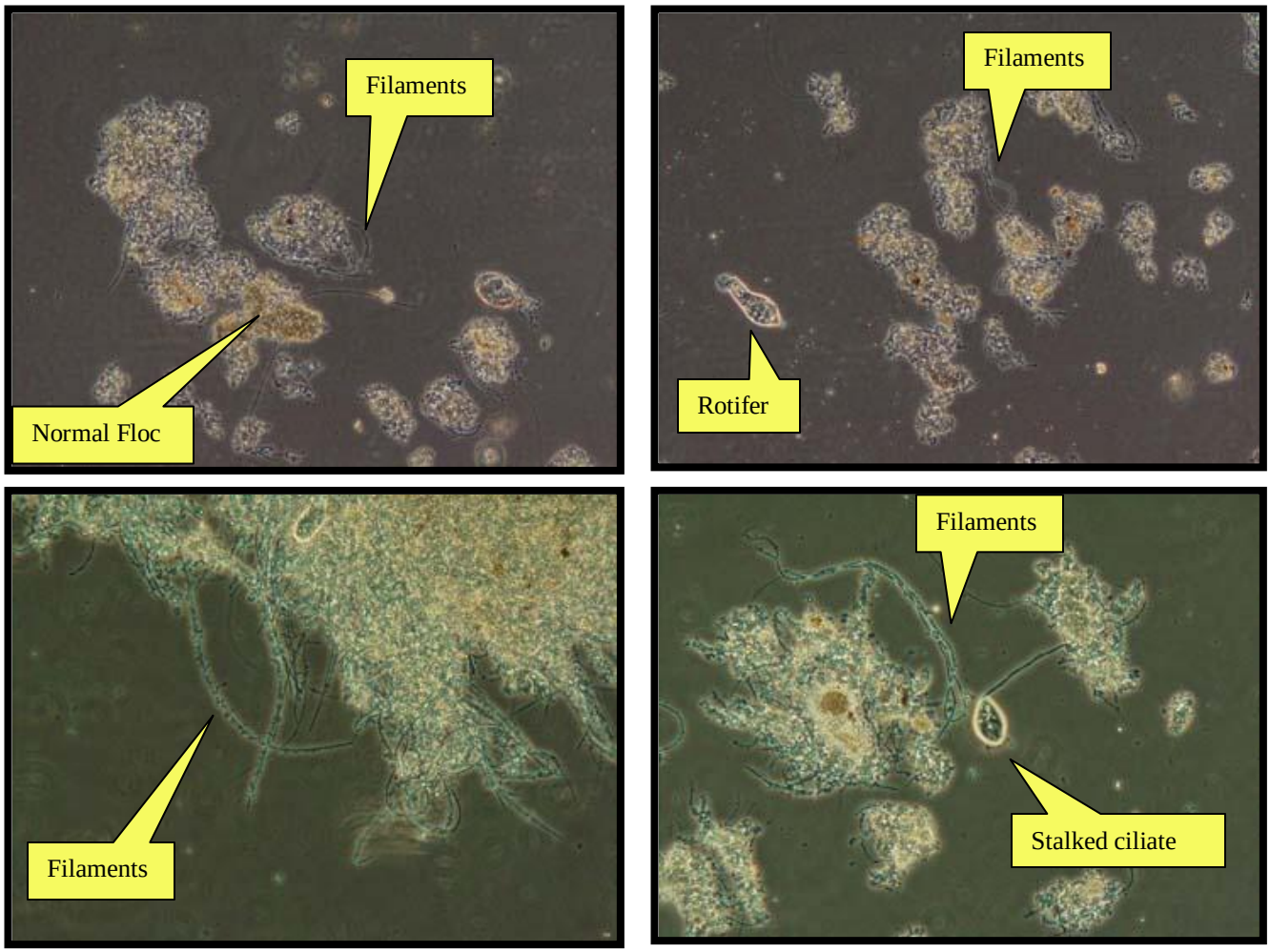

Table 1
Summary of Microscopic Observations

Microbiology				
	Primary Effluent	**Aeration Basin**		**Secondary Effluent**
Floc Structure	Irregular and diffuse with some compact areas. Signs of filamentous bridging.	Irregular and diffuse with some compact areas. Some filamentous bridging.		Irregular and diffuse with some compact areas. Signs of filamentous bridging.
Dispersed Bacteria (0 - 3)	3	2		2
Pin Floc (0 - 3)	2	1		1
Filament Rating (1 - 6)	2	4		4
India Ink Stain (1 - 3)	2	2.5		2
Zoogloea Abundance (0 - 3)	2	2.5		2

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Table 2
Analytical Testing Data

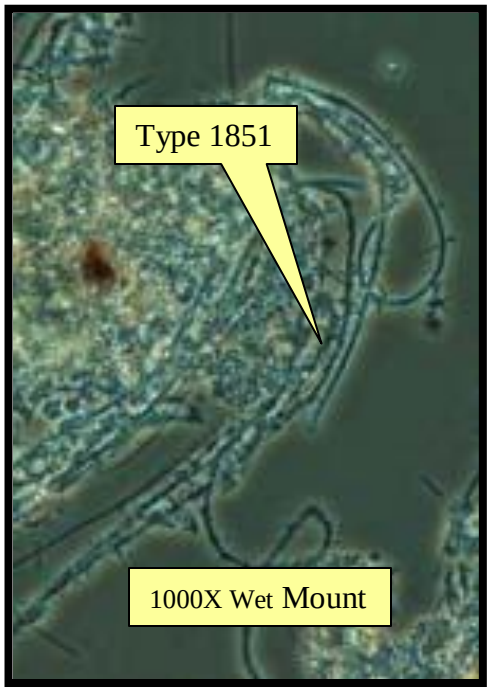
	Primary Effluent	Aeration Basin	RAS	Secondary Effluent
pH	6.65	6.68	6.67	6.74
NH3 as N (mg/L)	14.02	12.46		10.02
oPO4 as P (mg/L)	1.346	2.976		1.158
MLSS/TSS (mg/L)	94	1790	6580	24
MLVSS/VSS (mg/L)	74	1380	5140	22
Supernatant TSS (mg/L)		25		
30 min settling (mLs)		267		
SVI (mLs/g)		149		
sCOD (mg/L)	76	76	160	58
tCOD (mg/L)	178			80
Kool Kount (CFU/mL)	4.0E+06	1.0E+05		1.0E+05
Chloride (mg/L)		175		

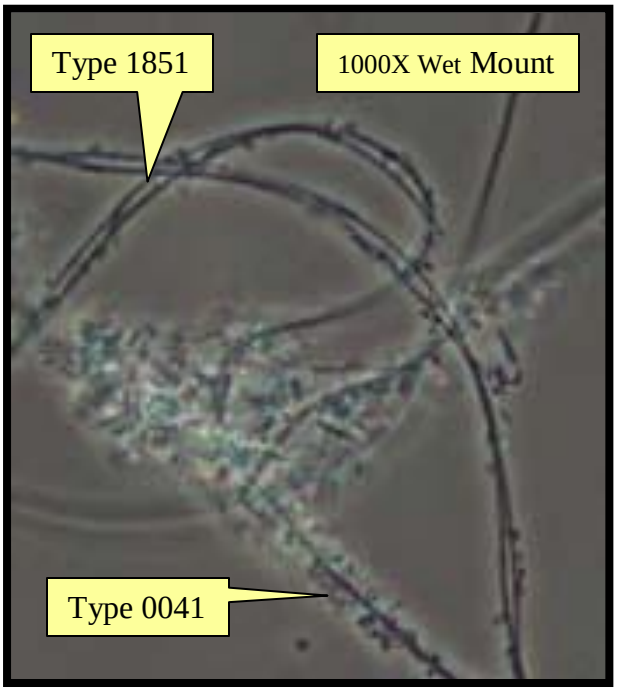
Filament Type and Abundance

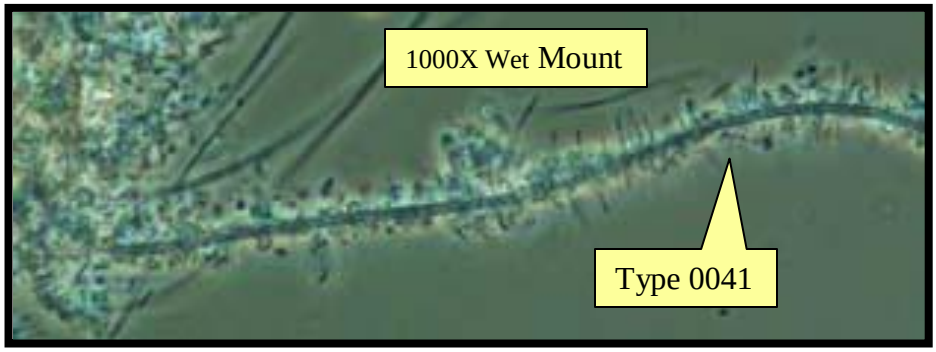
Filament abundance was very common. The predominant filament types were Type 1851, Type 0041, and Type 0961, with incidental amounts of Type 021N and Nocardioforms. Four of these species are listed as low f/m (high MCRT) filaments in the Manual on the Causes and Control of Activated Sludge Bulking, Foaming, and Other Solids Separation Problems, 3rd edition, by David Jenkins, Michael Richard, and Glen Daigger. This relationship is also noted in Wastewater Biology: The Microlife, 2nd edition, published by the Water Environment Federation. Three of them have also been associated with a system that has a complete mix in the aeration basin instead of a plug flow. Table 3 below is a summary of the causes associated with each of the filamentous bacteria species identified in your sample. Evidence of chlorination was observed as "empty" cells and "kinks" or breaks in the filaments were present.

Table 3
Filamentous Bacteria Causes

Filament ID		Causes							
Filament Rank	Identification	low F/M	Soluble, readily metabolized substrates	Complete Mix	Nutrient Deficiency	Low Molecular Weight Organic Acids	H2S	Old Sludge	Foaming
1	Type 1851	X	X (often simple sugars or organic acids)	X					
2	Type 0041	X			X				
3	Type 0961	X				X			
4	Type 021N		X	X	X (N)	X	X	X	
5	Nocardiaforms	X		X				X	X



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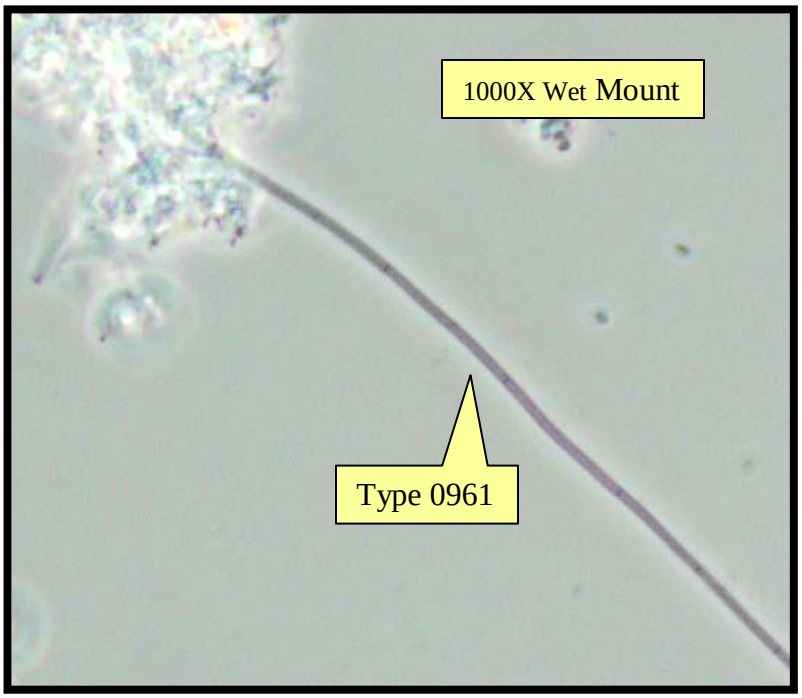
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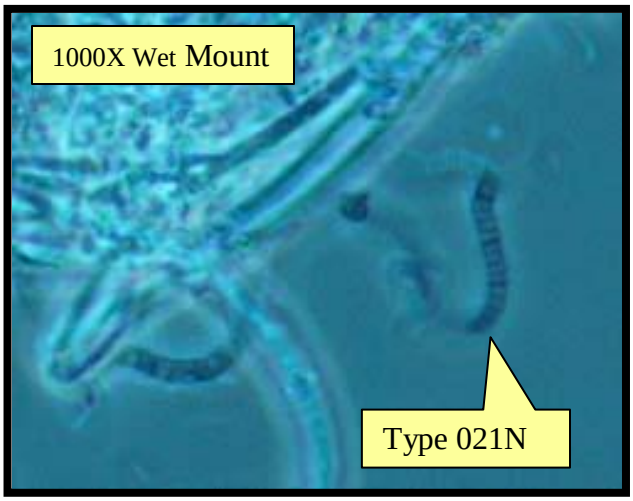
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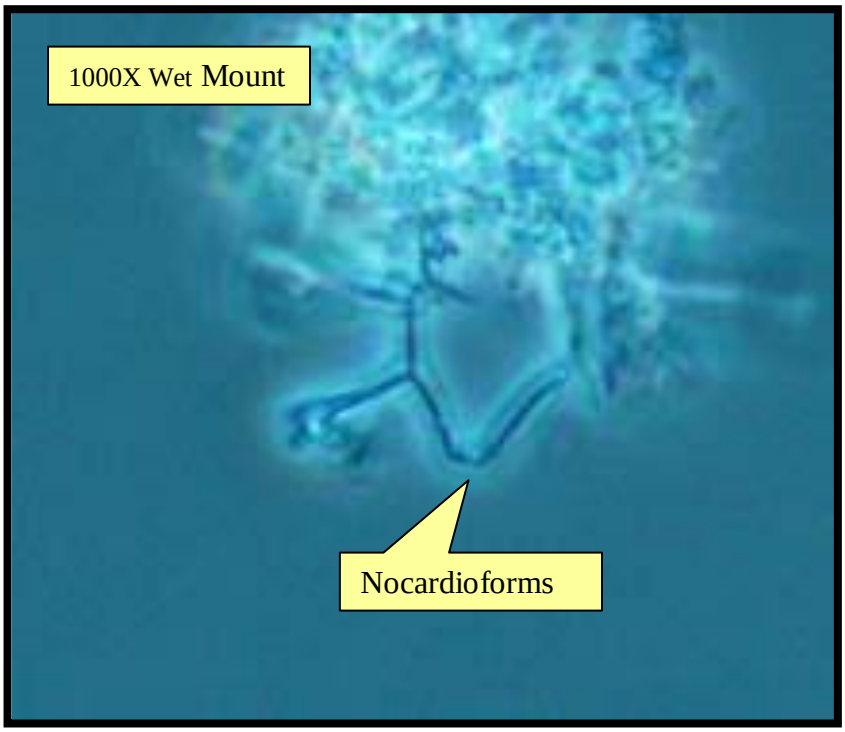
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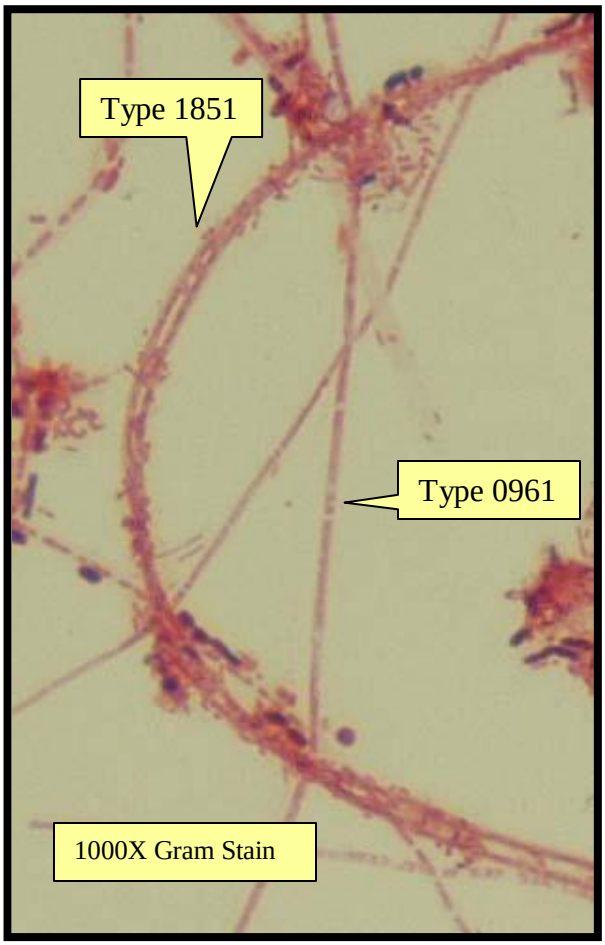
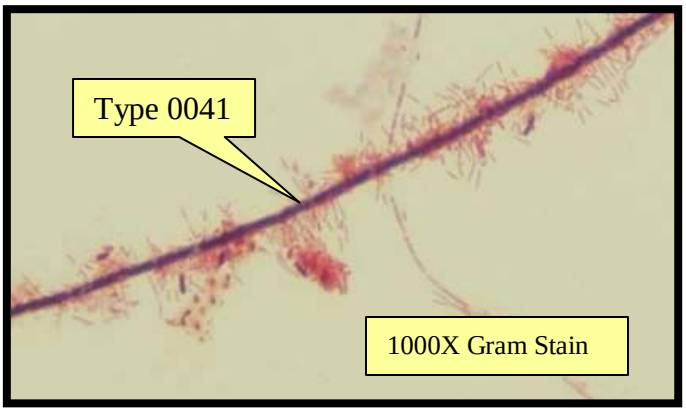
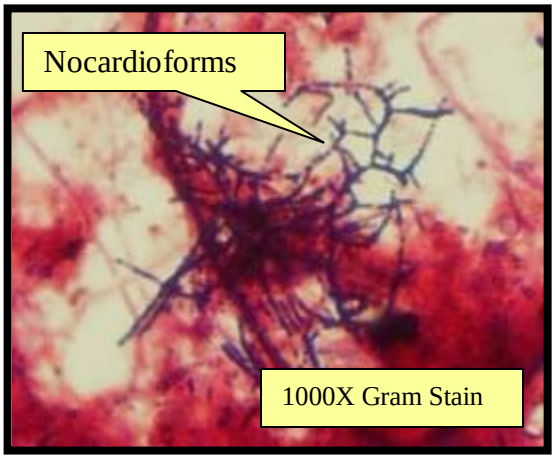
Nocardioforms

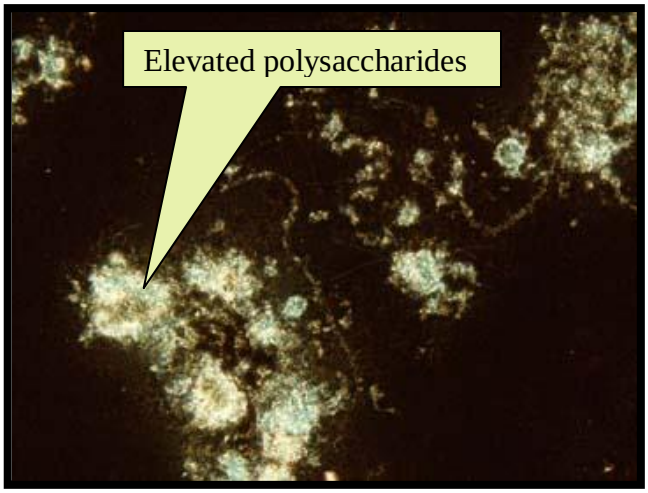


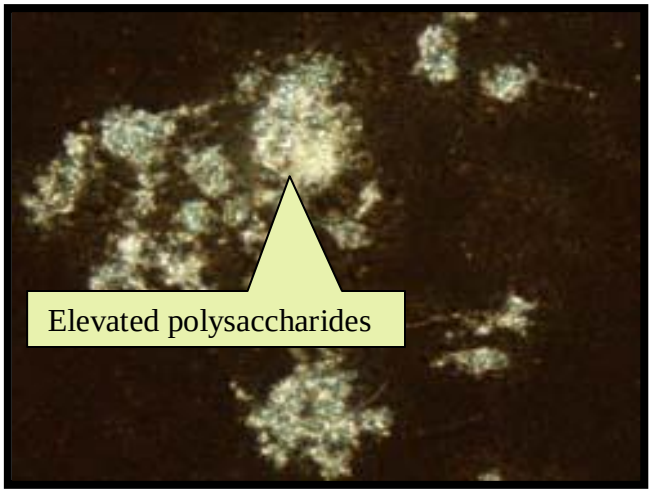




India Ink Stain and Polysaccharide Abundance

The India Ink Stain is a useful tool for estimating the amount of exocellular polysaccharides in the biomass. This is useful in diagnosing various problems, including nutrient deficiency. The India Ink Stain for this sample was elevated with poor floc penetration of the ink. The white areas are the areas where the Zoogloeal colonies are present in high numbers.





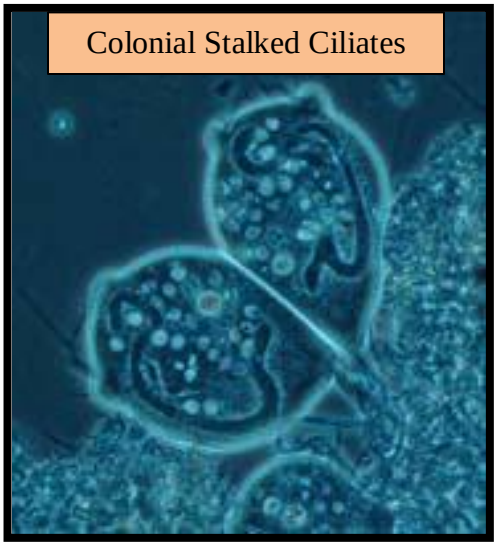
Higher Life Forms

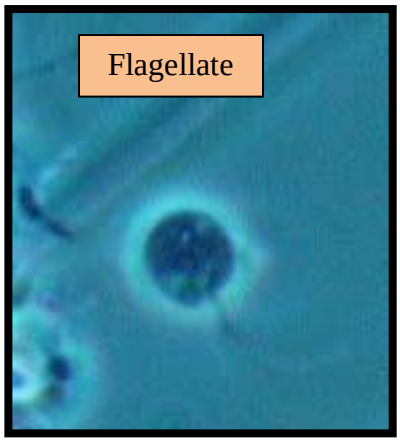
The higher life forms observed in this sample were not very numerous, but were fairly diverse in types. We saw mostly small flagellates with an occasional free-swimmer, stalked ciliate, or rotifer. A summary of the higher life forms observed is in Table 4 below along with a few pictures taken from your samples.

Table 4

Higher Life Forms

Higher Life Form Distribution				
	Primary Effluent	**Aeration Basin**		**Secondary Effluent**
Flagellates	32	17		28
Free Swimming Ciliates	1	0		0
Stalked Ciliates	0	3		2
Rotifers	0	1		0
Nematodes	0	0		0
Higher Life Form Totals	33	21		30
Maturity Index	1.0	1.4		1.1
Micro Evaluation	32 flagellates; dispersed bacteria (3); pin floc; filaments (3); zoogloea; spirilla; 1 free swimming ciliate; flagellated bacteria	irregular, diffuse floc; 17 flagellates; 3 stalked ciliates; 1 rotifer; zoogloea; filaments (3.5-4)		filaments (3.5); dispersed bacteria (3); 28 flagellates; 2 stalked ciliates





Conclusions and Recommendations

Settling problems can be related to numerous causes. It is always dangerous to attempt to make definitive causal comments from many miles away based on a single sample, particularly since I have no previous exposure to this system. That being said, my findings and general recommendations are listed below.

1. Since the plant has five independent aeration cells in operation, closing off one cell to increase the amount of food going to the other four would increase the F;M ratio by ~20%. The fifth can be used for elevated loading periods or for emergencies. This does reduce the time under aeration from approximately 5.3 hours to 4.3 hours, but with normal BOD loadings, this should not be a problem. Going to three basins may be problematic from a retention time standpoint, unless RAS rates could be reduced.
2. Developing a good COD:BOD relationship can be very helpful in approximating real time f:m ratios. Since bacteria only degrade the BOD portion of the COD, an approximation of the BOD: COD ratio is necessary. Usually, plants will use a simple ratio, such as 3:1 or 4:1. There are two problems with this. First, any textbook estimation may not be applicable to a given system. Second, any simple ratio assumes that COD is zero when BOD is zero, which is not the case. We recommend developing a real correlation for influent COD: BOD creating an equation with linear regression. This can be accomplished with about 20 – 30 representative samples. We would be happy to discuss this approach in more detail.
3. Continue adding the chlorine to the RAS. Definite effects of the chlorination were observed in the filaments. A typical amount of bleach to add yields 2-10 lbs of available chlorine for every 1000 lbs of MLSS. One gallon of bleach provides approximately 1 lb of chlorine. Based on a total basin volume of 6.65 million gallons and an MLSS of 1790 ppm, the pounds of solids are 99,276 lbs or 99.3 thousand pounds. Therefore, you should be adding between 200 and 1000 gallons of bleach per day. If you close one basin, add 160-800 gallons per day.

4. Chlorination effectiveness is also a function of contact times per day. Without incorporating the clarifier volumes or recycle rates we can only approximate the contact times. However, at 20 MGD of influent flow and 6.65 MG aeration basin volume, the contacts per day work out to about 3, which is generally accepted as the minimum requirement. Increasing recycle rates increases contacts per day. Also, taking one basin out of service reduces system volume and increases chlorine contacts.
5. There was a fair amount of pin floc present. It was mentioned that it had been changed recently to a fine bubble diffused air system and that he was concerned that they might have over aeration. Some of this might be attributed to the change in aeration. If the basin is aerated more fully than it was previously, the bubbles could be shearing some of the floc and causing the pin floc. However, there are many plants with fine bubble systems that do not experience this problem. If good floc quality can be maintained, then the type of aeration should not be an issue.
6. We generally do not advocate the concept of using supplemental bacteria addition to outcompete filaments, since filamentous bulking is a growth condition related problem. Where bioaugmentation has a potential fit in this scenario would be in conjunction with chlorination to improve the effectiveness. The goal of chlorination is to kill the filaments without killing the floc formers. There is always some collateral damage to the floc formers. By utilizing bioaugmentation concurrent with and immediately after chlorination, the lost floc formers are replaced giving the system a greater chance of maintaining good quality floc. In the absence of correcting the underlying growth pressure problem, this will not solve the problem, but it will reduce the frequency and intensity of chlorination periods. These supplements contain floc-forming bacteria which maximize the BOD removal efficiencies and aid in settling. EBS can provide a bacterial supplementation, BioStar R, along with a bacterial acceleration chamber (BAC unit) to enable the client to grow the bacteria up on site. We usually see a 10 fold increase in the number of bacteria within 12 -15 hours of growth. The benefit is that the customer can buy 25 pounds of bacteria and grow it up themselves to 2500 pounds. EBS' bacterial supplements are specially formulated for growth in these tanks. We formulated it with extra nutrients and food to enable this growth. I have attached a brochure for the BAC unit with this report. If you are interested, we would be happy to discuss this option with you at your convenience.
7. While microscopic evaluation and microbiology optimization are key components to succesfully addressing activated sludge performance issues, there are operational and monitoring strategies that are equally important. EBS has extensive experience in auditing and troubleshooting industrial activated sludge systems, as well as developing and delivering operator training programs.