# WATER REUSE TECHNOLOGY DEMONSTRATION PROJECT

**Demonstration Facility Pilot Study**
**Biological Aerated Filter (BOD Removal Only)**
**Final Draft Report**

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By

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Department of Natural Resources and Parks
Wastewater Treatment Division
**Technology Assessment Program**

# Technology Assessment Program Contents



# Tables

# Figures



# Appendices

# Executive Summary

The biological aerated filter (BAF) is a high-rate, fixed-film biological secondary treatment process that provides oxidation of Biochemical Oxygen Demand (BOD) and ammonia in wastewater. This report summarizes the findings of BOD removal using the BIOFOR biological aerated filter (BAF #1) pilot unit. The pilot unit received primary effluent from the West Point Wastewater Treatment Plant. Treated effluent from the pilot unit was fed to the downstream BIOFOR biological filter (BAF #2) for nitrification and to the microfiltration (MF) units for further treatment.

The BAF system, BIOFOR, tested in this study was manufactured by Ondeo Degrémont. The influent flows upward through a media bed (BIOLITE, a proprietary expanded clay media in BIOFOR), with aeration supplied to create an aerobic environment. The biomass attached to the filter media removes soluble pollutants biologically and insoluble pollutants by filtration, eliminating the need for a separate solids-separation stage for effluent clarification.

The focus of this pilot test was to evaluate a BAF process as a secondary BOD removal treatment system to produce Class A reuse water. The performance goals are summarized below:

- TSS Removal: Effluent TSS < 20 mg/L, 90$^{th}$ percentile, or > 80% removal
- CBOD Removal: Effluent CBOD <20 mg/L, 90$^{th}$ percentile, or > 80% removal
- Effluent Turbidity: <10 NTU, 90$^{th}$ percentile
- Backwash Flow: < 8% of treated flow

The pilot study can be divided into three phases based on backwash frequency:

- **Phase I:** Operation of BAF #1 at 24-hour backwash frequency. In this phase, the flow rate of BAF #1 was increased gradually from 10 gpm to 23 gpm to determine its performance at a backwash frequency of once every 24 hours.
- **Phase II**: Operation of BAF #1 at 18-hour backwash frequency. In this phase, the flow rate of BAF #1 was increased from 21 gpm to 23 gpm to determine its performance at a backwash frequency of once every 18 hours.
- **Phase III:** Operation of BAF #1 at 12-hour backwash frequency. In this phase, the flow rate of BAF #1 was increased from 23 gpm to as high as 27 gpm to determine its performance at a backwash frequency of once every 12 hours.

Table 1 summarizes the results from the three test phases. Phases are further divided into sub-phases A and B for different loading conditions.

*Table 1. BAF #1 Summary of Performance*

| Parameter | Target | Phase IA[1] | Phase IIB[2] | Phase IIIA (1/10/02 to 2/2/02) | Phase IIIA (2/3/02 to 2/13/02) | Phase IIIB |
|---|---|---|---|---|---|---|
| Effluent TSS[3], mg/L | <20 | 46.6 | 31.8 | 25.1 | 25.1 | 40.7 |
| Effluent BOD[3], mg/L | <20 | 40.2 | 39.4 | 45.3 | 24.1[4] | 37.2[4] |
| Effluent Turbidity[3], NTU | < 10 | 18.9 | 9.4 | 9.7 | 9.7 | 12.2 |
| Backwash Flow | < 8% | 7% | 8% | 11% to 12 % | 12% | 8% |
| Hydraulic Loading, gpm/ft$^2$ | 1.6 to 8.2 [5] | 3 | 3.3 | 3.3 | 3.3 | 3.8 |
| TSS Loading, lb/kcf/d | 313[5] | 186 | 182 | 184 | 184 | 246 |
| BOD Loading, lb/kcf/d | 376[5] | 389 | 194 | 244 | 276 | 349 |
| Backwash Frequency, hr | NA | 24 | 18 | 12 | 12 | 12 |

[1] Highest BODt loading period in Phase I.

[2] Limited BODt samples analyzed prior to December 2, 2001.

[3] 90$^{th}$ Percentile Value.

[4] BODt samples analyzed with nitrification inhibitor from February 3, 2002 through February 27, 2002.

[5] Maximum Ondeo design loading.

The BAF #1 was unable to meet the performance goals at the 90$^{th}$ percentile, but was able to meet the goals at the 50$^{th}$ percentile (average). Table 2 summarizes the comparison of the performance goal and performance of the unit during pilot testing.

*Table 2. Comparison of Performance Goal and Performance of BAF During Pilot Testing*

| Performance Goal | BAF #1 Performance |
|---|---|
| ♦ Effluent TSS < 20 mg/L (90th percentile) | ♦ Did not meet target at 90$^{th}$ percentile. |
| | ♦ Met target at 50$^{th}$ percentile (average value) during Phase IIB and Phase IIIA. |
| ♦ Effluent TSS >80 % TSS Removal | ♦ Did not meet target. |
| | ♦ Average TSS removal from 48% in Phase IIIB to 68% in Phase IIIA. |
| ♦ Effluent BOD < 20 mg/L (90th percentile) | ♦ Did not meet target at 90$^{th}$ percentile. |
| | ♦ Met target at 50$^{th}$ percentile (average value) during second part of Phase IIIA after nitrification inhibitor was used in BOD analyses. |
| ♦ Effluent BOD >80 % BOD Removal | ♦ Did not meet target 90$^{th}$ percentile. |
| | ♦ Met target at 50$^{th}$ percentile (average value) during second part of Phase IIIA after nitrification inhibitor was used in BOD analyses. |
| ♦ Effluent Turbidity <10 NTU, (90th percentile) | ♦ Met target at 90$^{th}$ Percentile during Phase IIB and Phase IIIA. |
| ♦ Backwash <8% of treated flow | ♦ Did not meet target all the time. Backwash ranged from 7% to 12% under Phase II and Phase III operating conditions. |

Class A reuse regulations require that the wastewater be "oxidized". The BAF #1 provided oxidation of BOD and partial nitrification; however, it is not clear if this performance will satisfy DOE requirements for oxidation of wastewater. Based on the test results, the design criteria for full-scale implementation of a BAF to provide oxidation of wastewater are summarized as follows:

- Hydraulic loading = 3.3 gpm/ft$^2$

- Process air = 1.1 $scfm/ft^2$
- TSS loading = 185 lb/kcf/d
- BODt loading = 275 lb/kcf/d
- Backwash flow = 8.2 $gpm/ft^2$
- Backwash duration = 60 minutes
- Backwash frequency = once every 12 hours
- Design temperature = 12 $^oC$

## Introduction

The BIOFOR biological aerated filter (BAF #1), manufactured by Ondeo Degrémont, was tested as one of eight treatment processes for the King County Water Reuse Demonstration Project. Two biological aerated filters were used: BAF#1 was designed for BOD removal and BAF #2 for nitrification. The demonstration testing facilities were configured to convey West Point WWTP primary effluent, or effluent from the ballasted flocculation pilot (Densadeg) unit to BAF #1. The focus of this report was to evaluate the BAF #1 for BOD removal.

## Description of the Technology

The biological aerated filter (BAF) process is a biological fixed-film process. It is a very high rate and compact wastewater treatment process. At present, there are two different suppliers of BAF process equipment in the market: the BIOFOR BAF manufactured by Ondeo Degrémont, and the BIOSTYR BAF manufactured by USFilter. In both types of BAF, primary effluent flows upward through a media bed (BIOLITE, a proprietary expanded clay media in BIOFOR, or synthetic expanded floating polystyrene media in BIOSTYR), with aeration supplied to create an aerobic environment. The biomass attached to the filter media removes soluble pollutants biologically and insoluble pollutants by filtration, eliminating the need for a separate solids separation stage for effluent clarification. The waste stream must pass through fine screening and primary clarification to protect the media and nozzles from plugging. Only the BIOFOR BAF pilot plant from Ondeo Degrémont was used in this pilot study.

Figure 1shows the simplified schematic of the BAF treatment train tested during the pilot study and Figure 2 shows the simplified schematic of a typical BIOFOR BAF unit.

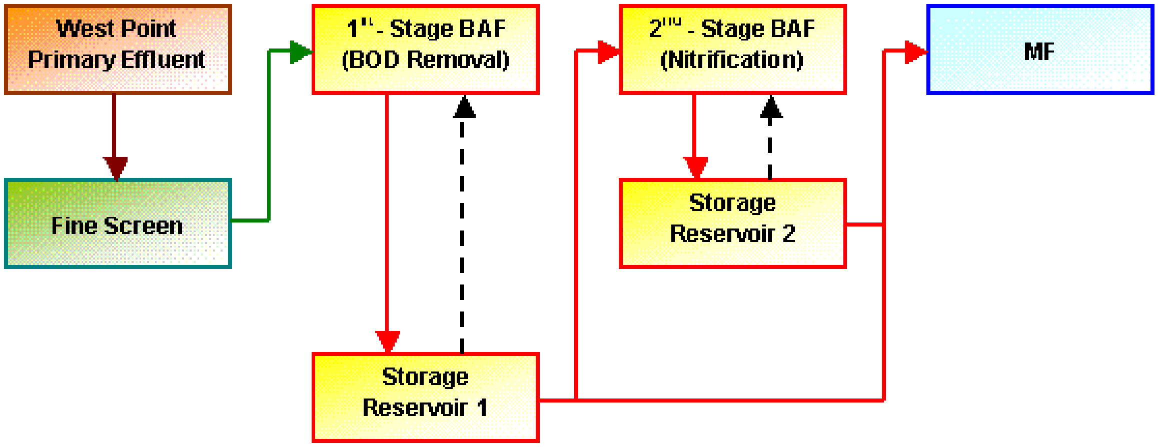


*Figure 1. Simplified Schematic of the BAF-MF Treatment Train*

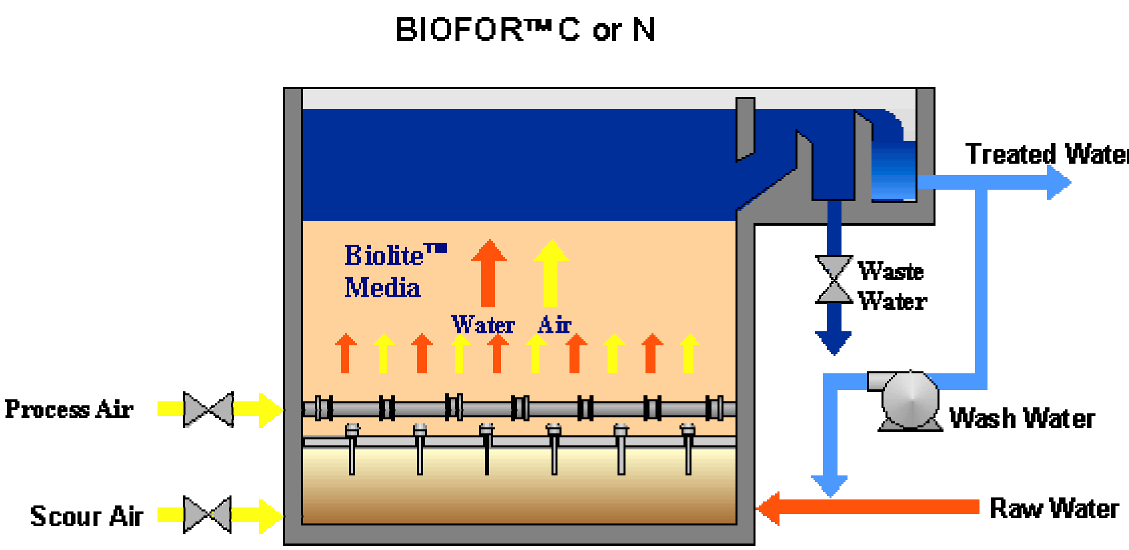


*Figure 2. Simplified Schematic of a BIOFOR BAF Unit*

Table 3 shows the list of full-scale BIOFOR BAF installations in the United States. Only two BOD removal systems are currently in operation; a 70 MGD unit is under construction. The first unit has been operational for seven years.

*Table 3. List of Full-Scale Biofor BAF Installations in the United States*

| Location | Biofor Type | No. of Filters | Filter Area ($ft^2$/unit) | Average Capacity (MGD) | Startup |
|---|---|---|---|---|---|
| West Basin, CA MWD for Chevron | Nitrification | 4 | 315 | 5 | 1995 |
| West Basin, CA MWD for Mobil | Nitrification | 4 | 315 | 5 | 1995 |
| West Basin, CA MWD for Arco | Nitrification | 1 | 315 | 0.9 | 1999 |
| NYC DEP, NY | Nitrification | 1 | 270 | 2 | 1997 |
| | Denitrification | 1 | 180 | | |
| Evesham, NJ | Nitrification | 3 | 192 | 1.7 | 1997 |
| Breckenridge, CO | Nitrification | 4 | 278 | 1.0 | 1998 |
| Roanoke, VA | BOD Removal | 6 | 1036 | 14 | 1998 |
| | Nitrification | 6 | 649 | | |
| Irvine Ranch, CA | Denitrification | 2 | 60 | 1.3 | 1998 |
| Corpus Christi, TX | BOD Removal | 6 | 314 | 1.8 | 2000 |
| Binghamton-Johnson City, NY | BOD Removal | 8 | 1400 | 70 | 2004 |
| | Nitrification | 8 | 1360 | | |
| | Denitrification | 4 | 840 | | |

# Pilot Testing

## Goals and Objectives

Performance goals for BAF #1 during the pilot study were as follows:

- TSS Removal: Effluent TSS < 20 mg/L, $90^{th}$ percentile, or > 80% removal
- CBOD Removal: Effluent CBOD <20 mg/L, $90^{th}$ percentile, or > 80% removal
- Effluent Turbidity: <10 NTU, $90^{th}$ percentile
- Backwash Flow: < 8% of treated flow

The pilot study objectives were to collect sufficient data to facilitate full-scale plant design, and to determine:

- Maximum sustainable BODt loading rate
- Treatment efficiency and reliability
- Design criteria

## Description of the Demonstration Facilities

Table 4 summarizes the features of the BAF pilot unit for BOD removal.

*Table 4. Summary of BAF Pilot Unit Facilities*

| | |
|---|---|
| Shipping Weight | 10,000 lbs |
| Operating Weight | 24,000 lbs |
| BAF Unit Footprint | 10' 4 ½" x 12' 7" |
| BAF Unit and Clearwell Footprint | 20' 4 ½" x 12' 7" |
| Overall Height | 22' 0" |
| Media Depth | 12' 0" |
| Reactor Diameter | 3' 0" |
| Filter Area | 7.1 $ft^2$ |
| Reactor Volume | 1,046 gallon |
| Bed Volume | 85.4 $ft^3$ |
| Flow Range | 11.4 to 58.2 gpm |
| Electrical Requirements | 480V, 3 Phase, 25 amp |
| | Raw Water Pump – 3.0 hp, 460/3/60 |
| | Backwash Pump – 1.5 hp, 460/3/60 |
| | Scour Air Compressor – 2.0 hp, 460/3/60 |
| | Process Air Compressor – 1.0 hp, 460/3/60 |
| Influent Connection | 2" half coupling |
| Effluent Connection | 6" male NPT |
| Service Water | ¾" female connection |

Figure 3 shows the BAF #1 pilot plant at the Westpoint Wastewater Treatment Plant.


*Figure 3. BAF #1 Pilot Plant at Westpoint Wastewater Treatment Plant*

## Testing Plan

The original testing plan for BAF #1 is included as Appendix A. Changes were made to the original test plan during the course of the pilot study, and those changes are noted on the insert to Appendix A.

The pilot study of BAF #1 was divided into three phases based on the backwash frequency:

- **Phase I:** Operation of BAF #1 at a 24-hour backwash frequency (June 15, 2001 to November 8, 2001). Seeding of BAF #1 was initiated on June 11, 2001 for 48 hours. The first set of samples for influent and effluent characterization was collected on June 15, 2001. In this phase of testing, the flow rate of BAF #1 was increased gradually from 10 gpm to as high as 23 gpm to determine its performance at a backwash frequency of once every 24-hours. The period from September 6, 2001 and September 23, 2001 was selected for in depth analysis and is referred to as Phase IA.
- **Phase II:** Operation of BAF #1 at an 18-hour backwash frequency (November 9, 2001 to January 9, 2002). In this phase of testing, the flow rate of BAF #1 was increased from 21 gpm to 23 gpm to determine its performance at a backwash frequency of once every 18-hours. This period was divided into two sub-periods referred to Phase IIA (November 9, 2001 through November 28, 2001 which was operated at 3.0 gpm/ft$^2$) and Phase IIB (November 29, 2001 through January 9, 2002 which was operated at 3.3 gpm/ft$^2$). The first BODt sample in Phase IIB was collected on December 2, 2001 and the last BODt sample in Phase II B was collected on January 6, 2002. Therefore this period within Phase IIB was selected for in depth analysis.
- **Phase III:** Operation of BAF #1 at a 12-hour backwash frequency (January 10, 2002 to February 27, 2002). In this phase of testing, the flow rate of BAF #1 was increased from 23 gpm to as high as 27 gpm to determine its performance at backwash frequency of once every 12-hours. This period was divided into two sub-periods referred to Phase IIIA (January 10, 2002 to February 13, 2002 which was operated at 3.3 gpm/ft$^2$) and Phase IIIB (February 14, 2002 to February 27, 2002 which was operated at 3.8 gpm/ft$^2$).

During Phase IIIA influent flow was set at 23 gpm which corresponds to a hydraulic loading of 3.3 gpm/ft$^2$, and the airflow was set at 8 scfm. Starting from samples collected on February 3, 2002, nitrification inhibitor was used during sample analysis. During Phase IIIB influent flow was set at 27 gpm which corresponds to a hydraulic loading of 3.8 gpm/ft$^2$.

Towards the end of the test period, an intensive sampling of the effluent TSS concentrations before and after backwash was conducted to optimize filter-to-waste duration. Also, at the end of the pilot study, BAF #1 was put into idle mode twice for durations of one to three days. Intensive sampling of the BAF effluent was conducted after each idle period to investigate the rate of treatment capability recovery after switching out of idle mode.

# Results

## BOD and TSS removal

### Overall Performance (June 15, 2001 to February 27, 2002)

Figure 4 through Figure 12 show the general operation and overall performance of BAF #1 for the entire test period from June 15, 2001 to February 27, 2002. Trend plots show the flow, load, and influent and effluent BOD and TSS during the test period. Removal efficiencies for the test period are also shown. These figures provide a general overview of the pilot testing.

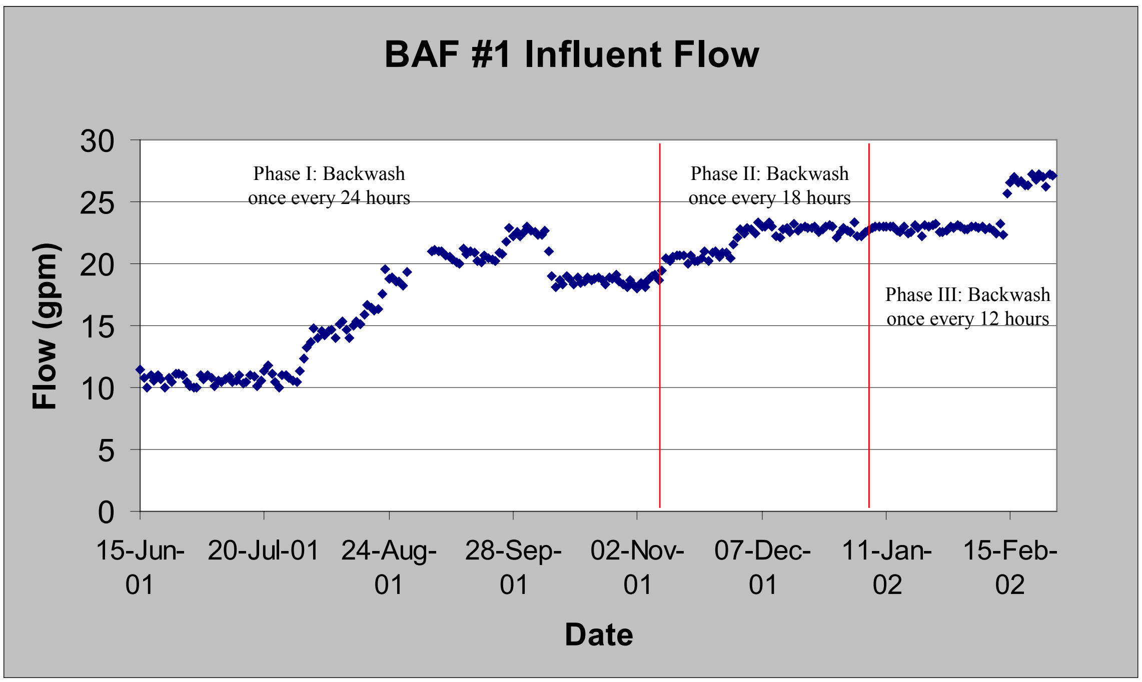


*Figure 4. Influent Flow (June 15, 2001 to February 27, 2002)*

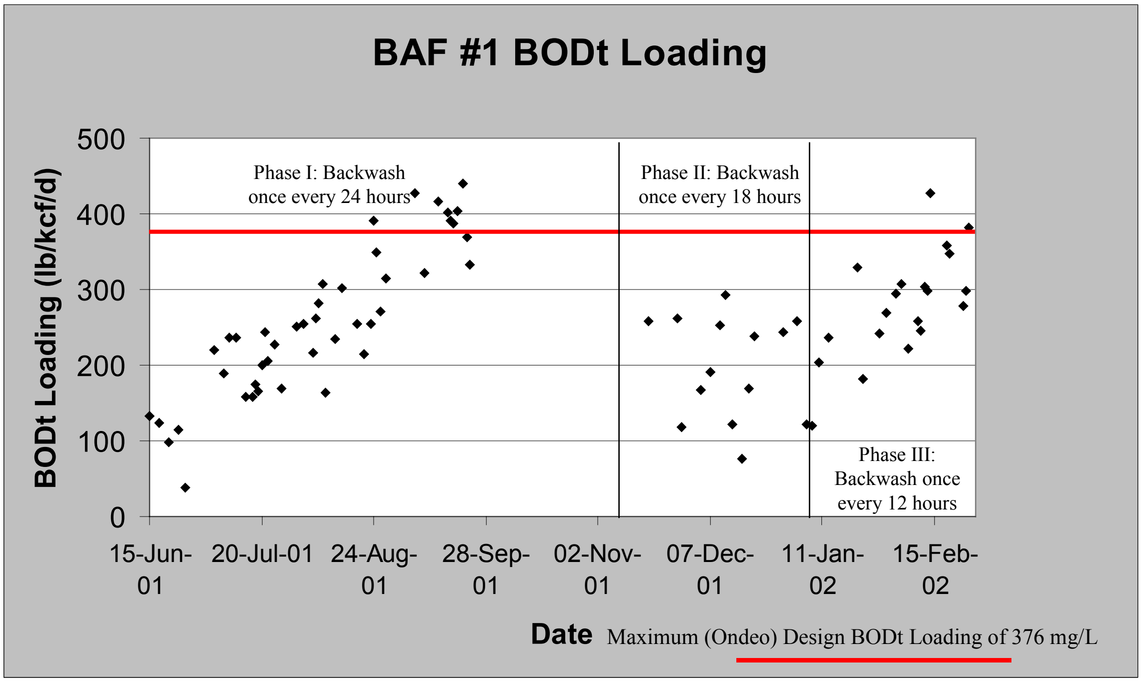


*Figure 5. BODt Loading (June 15, 2001 to February 27, 2002)*

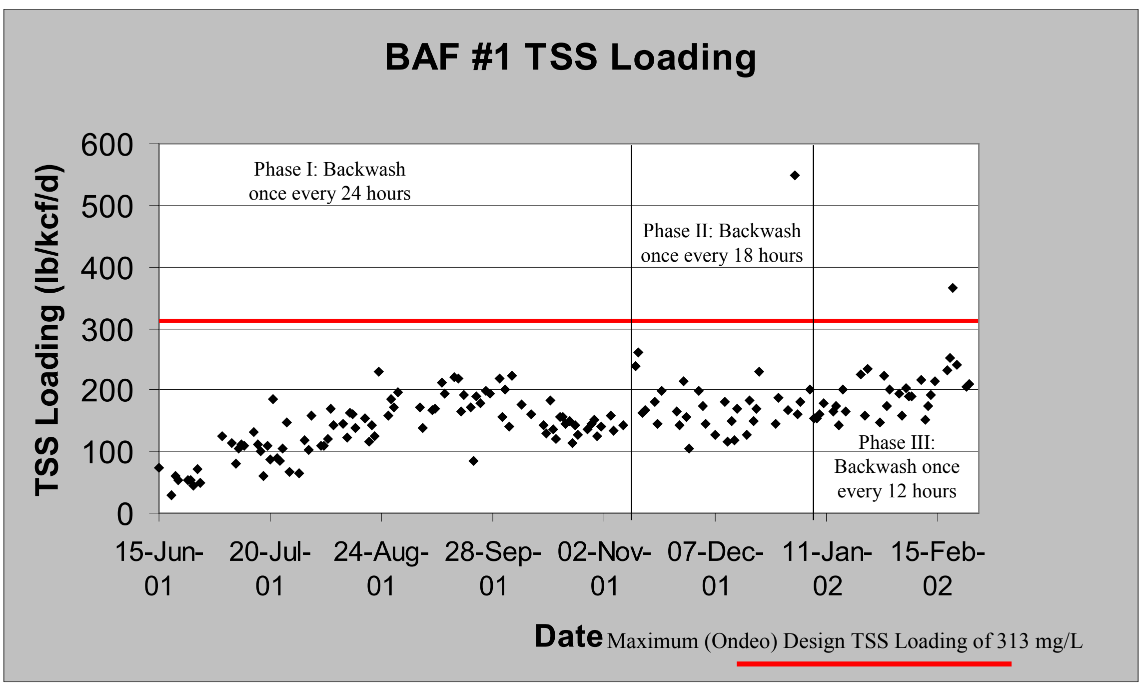


*Figure 6. TSS Loading (June 15, 2001 to February 27, 2002)*

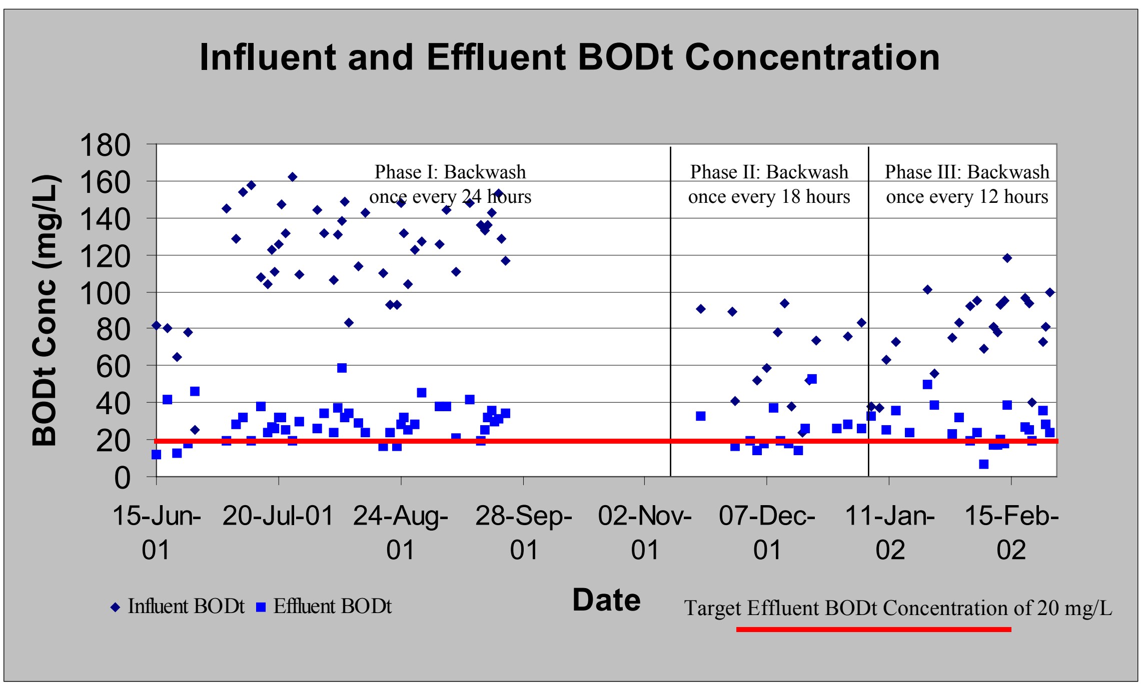


*Figure 7. Influent and Effluent BODt Concentration (June 15, 2001 to February 27, 2002)*

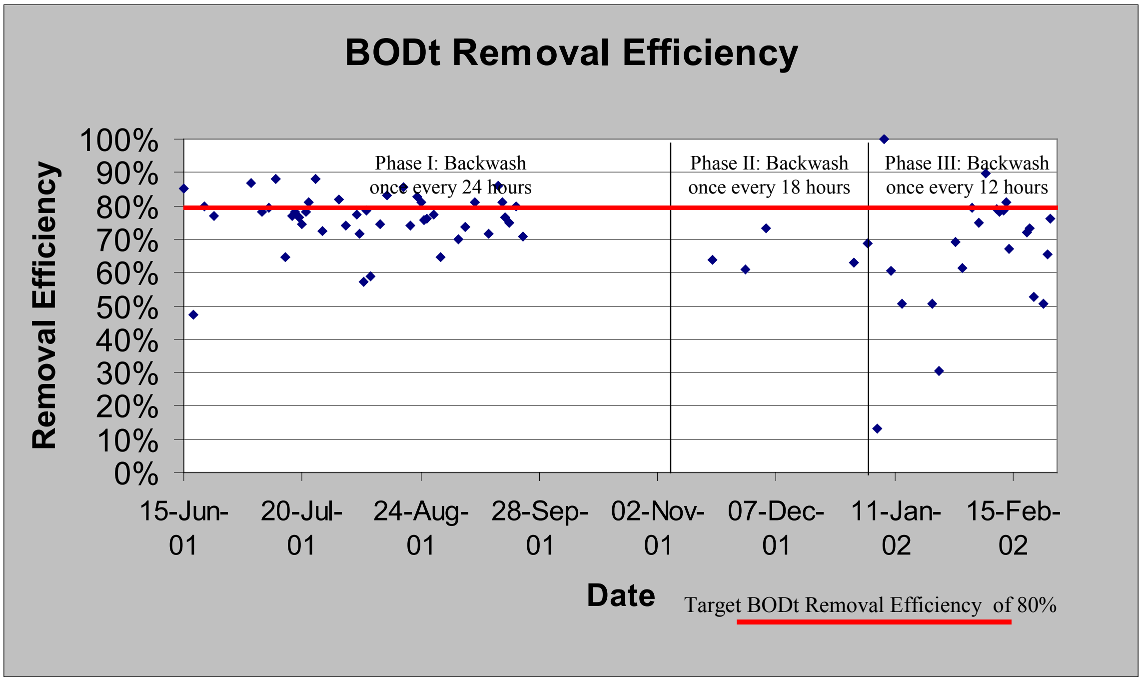


*Figure 8. BODt Removal Efficiency (June 15, 2001 to February 27, 2002)*

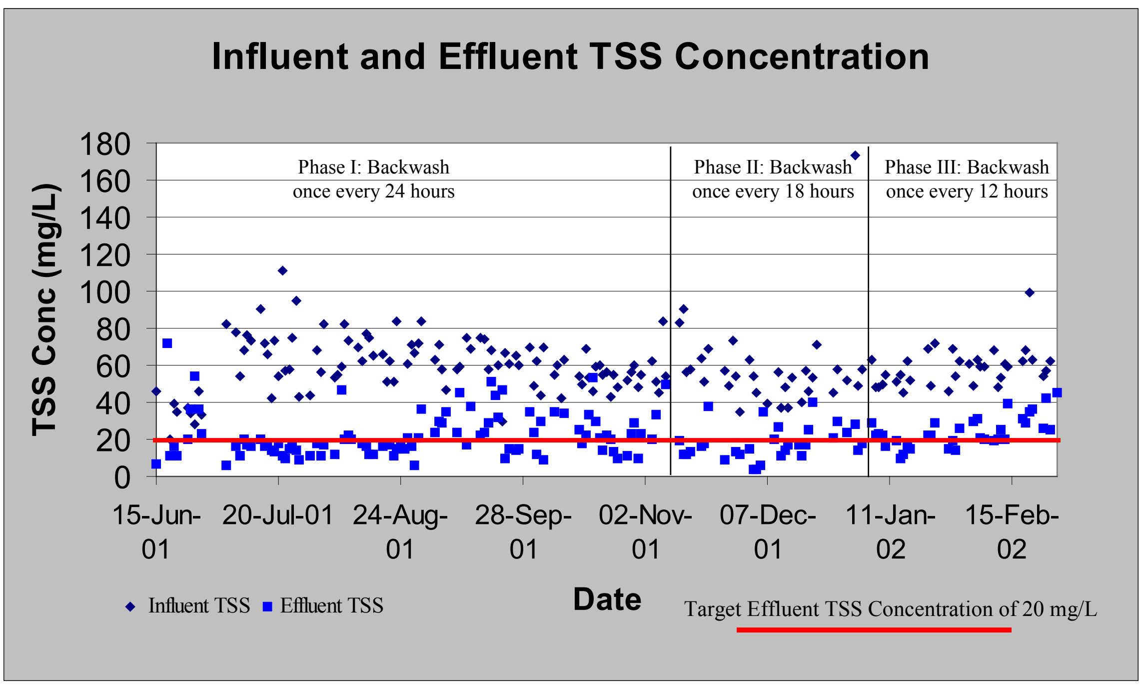


*Figure 9. Influent and Effluent TSS Concentration (June 15, 2001 to February 27, 2002)*

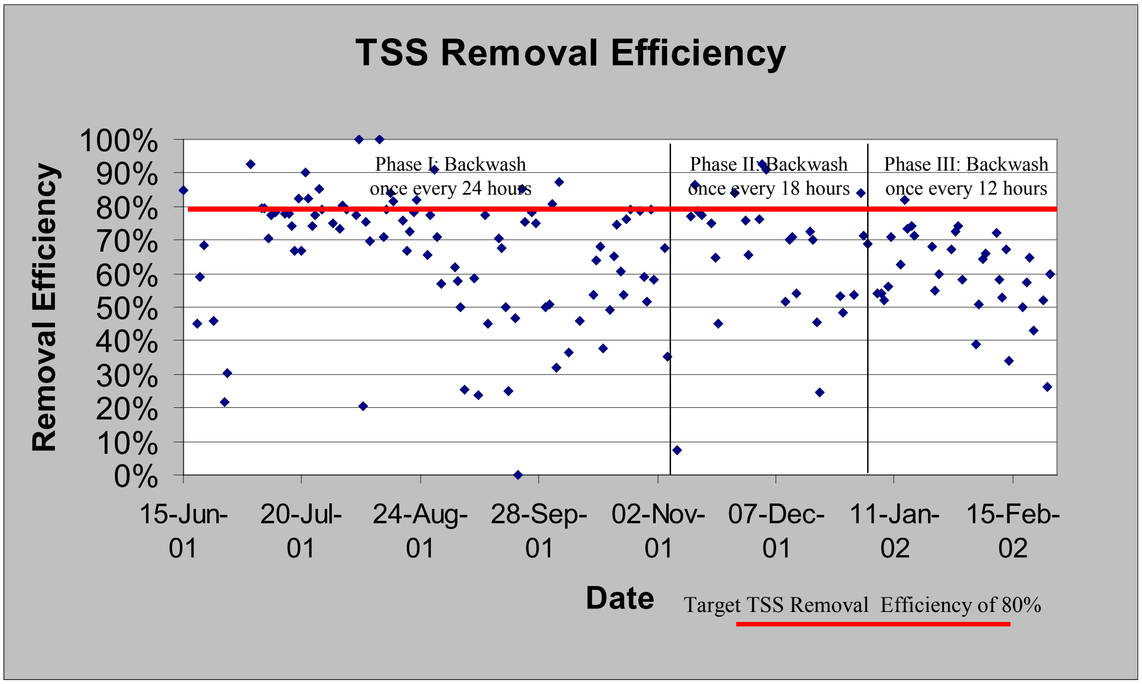


*Figure 10. TSS Removal Efficiency (June 15, 2001 to February 27, 2002)*

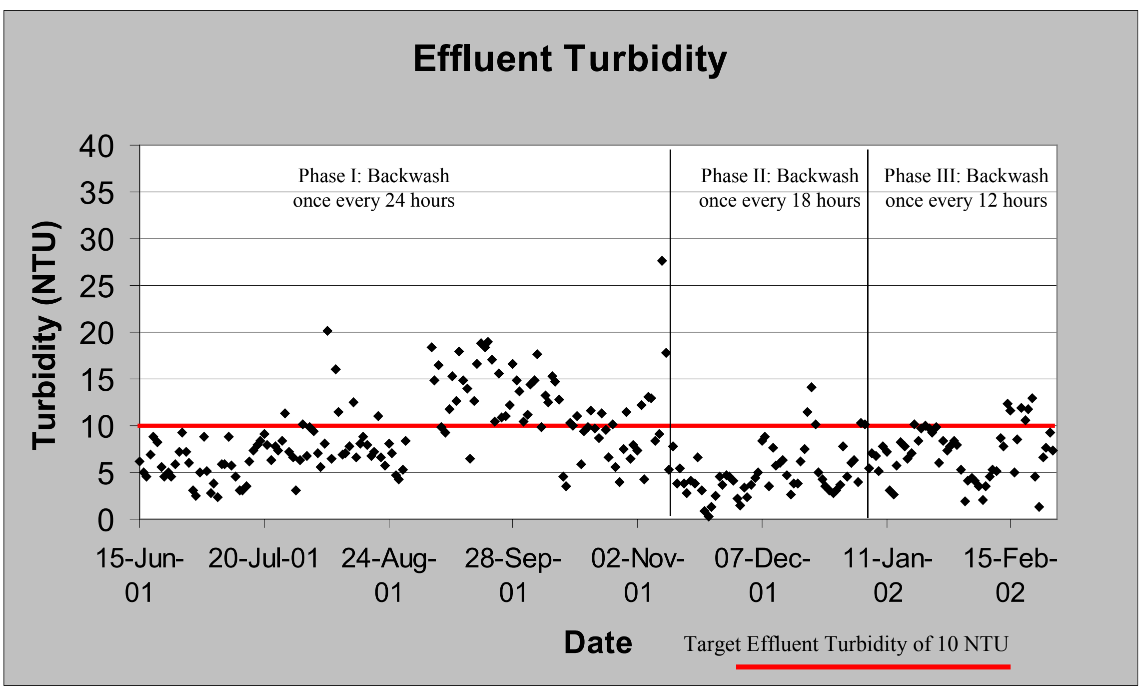


*Figure 11. Influent and Effluent Turbidity (June 15, 2001 to February 27, 2002)*

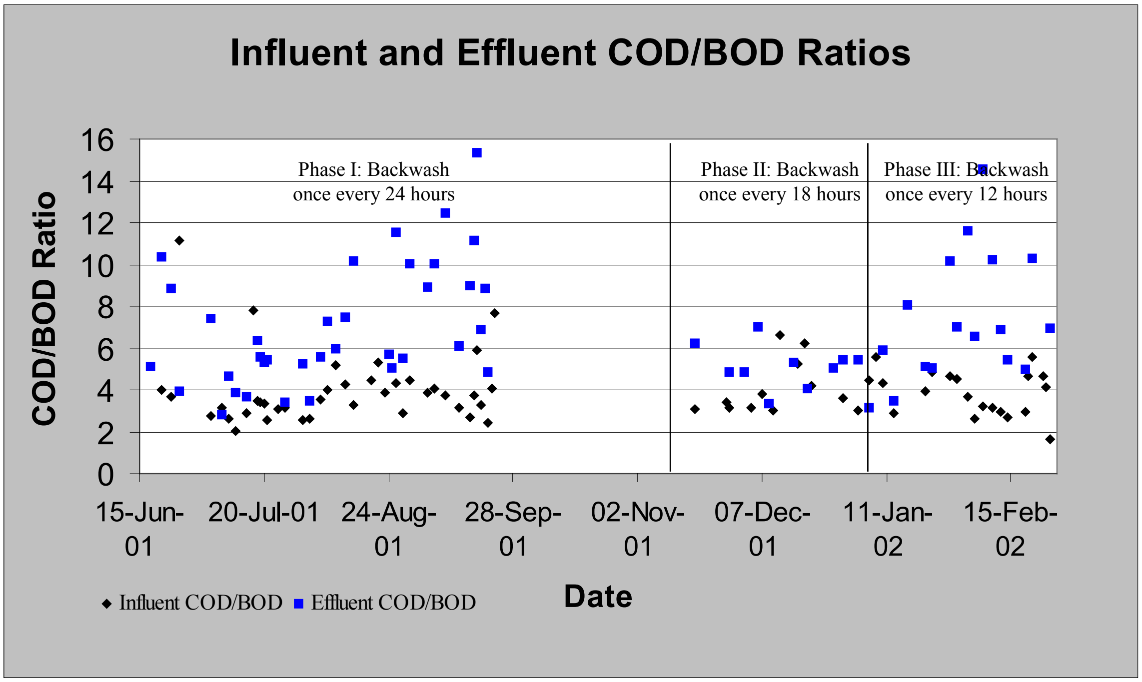


*Figure 12. Influent and Effluent COD/BOD Ratios (June 15, 2001 to February 27, 2002)*

## Phase IA Performance

Phase IA represents performance during maximum BODt loading period and operation under 24-hour backwash frequency

Appendix C contains the graphs showing the TSS and BODt loadings, effluent TSS and BODt concentrations, and TSS and BODt removal efficiencies during the maximum BODt loading period of Phase IA testing. The first three to four weeks of Phase I testing, BAF #1 was in the startup mode. Initially, the pilot unit was loaded at roughly 25% of the maximum (Ondeo) BODt loading of 376 lb/kcf/d. Then, the loading was gradually increased, by increasing the influent flow (as shown in Figure 4) at one-week to two-week intervals until the highest average BODt loading of 389 lb/kcf/d in Phase IA was reached. During Phase IA the influent flow to the BAF #1 was set at 21 gpm, which corresponds to a hydraulic loading of approximately 3 gpm/ft$^2$; the airflow rate was set at 7 scfm; and backwash time was set at once every 24 hours.

Table 5 summarizes the performance data of BAF #1 during this period.

*Table 5. Summary of BAF #1 Performances During Phase IA[1]*

| | Minimum | Average | Maximum | Standard Deviation | 90th Percentile[2] | Target |
|---|---|---|---|---|---|---|
| BOD in (mg/L) | 111.0 | 135.0 | 153.0 | 13.3 | 152.0 | NA |
| BOD out (mg/L) | 19.0 | 30.8 | 42.0 | 7.4 | 40.2 | <20.0 |
| | | | | | <20.0 for 7% of the time | (90th Percentile) |
| BOD Loading (lb/kcf/day) | 322.2 | 389.0 | 439.7 | 38.3 | >340.0 for 90% of the time | NA |
| BOD Removal Percentage | 71% | 77% | 86% | 5% | >71% for 90% of the time | >80% |
| | | | | | >80% for 33% of the time | |
| TSS in (mg/L) | 47.0 | 64.6 | 75.0 | 8.9 | 75.0[3] | NA |
| TSS out (mg/L) | 10.0 | 30.9 | 51.0 | 12.3 | 46.6 | <20.0 |
| | | | | | <20.0 for 19% of the time | (90th Percentile) |
| TSS Load (lb/kcf/day) | 139.2 | 185.8 | 221.9 | 25.4 | >153.2 for 90% of the time | NA |
| TSS Removal Percentage[4] | 24% | 52% | 85% | 22% | >25% for 90% of the time | >80% |
| | | | | | >80% for 10% of the time | |
| Influent Turbidity, NTU | No Data | No Data | No Data | No Data | No Data | NA |
| Effluent Turbidity, NTU | 6.5 | 14.2 | 19.0 | 3.6 | 18.9 | < 10 |
| | | | | | <10 for 12% of the time | (90th Percentile) |
| Influent NH4-N, mg/L | 20.7 | 21.4 | 22.0 | 0.9 | 21.9[3] | NA |
| Effluent NH4-N, mg/L | 15.7 | 17.9 | 20.9 | 2.7 | 20.2[3] | NA |
| Influent Alkalinity, mg/L of $CaCO_3$ | 167.0 | 171.7 | 176.0 | 3.3 | 175.9 | NA |
| Effluent Alkalinity, mg/L of $CaCO_3$ | 147.0 | 154.6 | 166.0 | 7.1 | 163.7 | NA |
| % of Backwash Water | NA | 7% | NA | NA | NA | 8% |
| Temperature, °C | 18.7 | 19.3 | 20.0 | 0.5 | >18.7 for 90% of the time | NA |

[1] Influent flow at 21 gpm, hydraulic loading at 3 gpm/ft$^2$, airflow at 7 scfm, backwash time at 24 hours

[2] Projected normal values.

[3] Due to small sample size, projected normal values higher than maximum value in sample set. Projected value within actual data range used instead.

[4]TSS data on September 22, 2001 was not included in statistical analysis. Effluent TSS concentration was higher than the influent TSS concentration.

## Phase IIB Performance

During Phase II (November 9, 2001 to January 9, 2002), the BAF was operated with an 18-hour backwash frequency.

During Phase IIA (November 9, 2001 through November 28, 2001) the pilot unit was operated at an influent flow of 21 gpm. However, only three influent BODt samples and two effluent

BODt samples were analyzed during this period. Therefore, the performance of BAF #1 in Phase IIA was not analyzed in detail. The average effluent BODt concentration was 24.5 mg/L and the average BODt removal was 62.5%. The average effluent TSS concentration was 16.7 mg/L and the average TSS removal was 73.9%.

During Phase IIB (December 2, 2001 through January 6, 2002) the pilot unit was operated at an influent flow of 23 gpm, which corresponds to a hydraulic loading of 3.3 gpm/ft$^2$; an airflow of 8 scfm; and a backwash frequency of once every 18 hours. During this period, eleven influent BODt samples and thirteen effluent BODt samples were collected. However, only four influent BODt and effluent BODt sample pairs were collected on the same days. As a result, only four BODt removal efficiency data points could be calculated.

Appendix D contains the graphs showing the TSS and BODt loading, effluent TSS and BODt concentrations, and TSS and BODt removal efficiencies of BAF #1 during Phase IIB.

Table 6 summarizes the performance data of BAF #1 during Phase IIB.

*Table 6. Summary of BAF #1 Performance During Phase IIB[1]*

| | Minimum | Average | Maximum | Standard Deviation | 90th Percentile[2] | Target |
|---|---|---|---|---|---|---|
| BOD in (mg/L) | 24.0 | 60.7 | 94.0 | 22.0 | 89.0 | NA |
| BOD out (mg/L) | 14.0 | 25.5 | 53.0 | 10.9 | 39.4 | <20.0 |
| | | | | | <20.0 for 31% of the time | (90th Percentile) |
| BOD Loading (lb/kcf/day) | 76.3 | 193.7 | 292.1 | 68.9 | >105.4 for 90% of the time | NA |
| BOD Removal Percentage[3] | 13% | 55% | 173% | 28.1% | >19% for 90% of the time | >80% |
| | | | | | >80% for 18% of the time | |
| TSS in (mg/L) | 37.0 | 57.0 | 173.0 | 28.1 | 93.0 | NA |
| TSS out (mg/L) | 4.0 | 19.4 | 40.0 | 9.6 | 31.8 | <20.0 |
| | | | | | <20 for 52% of the time | (90th Percentile) |
| TSS Load (lb/kcf/day) | 115.6 | 182.3 | 549.7 | 89.0 | >68.2 for 90% of the time | NA |
| TSS Removal Percentage | 25% | 64% | 93% | 17% | >42% for 90% of the time | >80% |
| | | | | | >80% for 18% of the time | |
| Influent Turbidity, NTU | No Data | No Data | No Data | No Data | No Data | NA |
| Effluent Turbidity, NTU | 2.4 | 5.8 | 14.1 | 2.8 | 9.4 | < 10 |
| | | | | | <10 for 93% of the time | (90th Percentile) |
| Influent NH4-N, mg/L | 2.7 | 8.4 | 14.0 | 4.0 | 13.5 | NA |
| Effluent NH4-N, mg/L | 0.3 | 4.5 | 8.5 | 3.0 | 8.3 | NA |
| Influent Alkalinity, mg/L of $CaCO_3$ | 54.0 | 111.1 | 151.0 | 31.3 | 146.9[4] | NA |
| Effluent Alkalinity, mg/L of $CaCO_3$ | 33.0 | 79.5 | 119.0 | 29.5 | 117.3 | NA |
| Influent NO3-N, mg/L | 0.15 | 0.82 | 1.95 | 0.62 | 1.62 | NA |
| Effluent NO3-N, mg/L | 1.13 | 2.08 | 3.30 | 0.65 | 2.92 | NA |
| % of Backwash Water | NA | | | | | |
| Temperature, °C | 11.1 | 12.0 | 13.6 | 1.0 | >10.7 for 90% of the time | NA |

[1] Influent flow at 23 gpm, hydraulic loading at 3.3 gpm/ft$^2$, airflow at 8 scfm, backwash time at 18 hours.

[2] Projected normal values.

[3] Only four data points in this time period.

[4] Due to small sample size, projected normal values higher than maximum value in sample set. Projected value within actual data range used instead.

## Phase IIIA and IIIB Performance

During Phase III (January 10, 2002 to February 27, 2002) the BAF was operated with a 12-hour backwash frequency.

During Phase IIIA (January 10, 2002 to February 13, 2002) influent flow was set at 23 gpm which corresponds to a hydraulic loading of 3.3 gpm/ft$^2$; and the airflow was set at 8 scfm. Starting from samples collected on February 3, 2002, nitrification inhibitor was used during sample analysis.

During Phase IIIB (February 14, 2002 to February 27, 2002) influent flow was set at 27 gpm which corresponds to a hydraulic loading of 3.8 gpm/ft$^2$.

Appendix E contains the graphs showing the TSS and BODt loadings, effluent TSS and BODt concentrations, and TSS and BODt removal efficiencies during Phase IIIA and Phase IIIB.

Table 7 summarizes the performance data of BAF #1 for Phase IIIA and Table 8 summarizes the performance data of BAF #1 for Phase IIIB.

*Table 7. Summary of BAF #1 Performances during Phase IIIA[1]*

| | Minimum | Average | Maximum | Standard Deviation | 90th Percentile[2] | Target |
|---|---|---|---|---|---|---|
| | | | 1/10/02 to 2/2/02 | | | |
| BOD in (mg/L) | 56.0 | 75.2 | 101.0 | 15.8 | 95.4 | NA |
| BOD out (mg/L) | 23.0 | 32.7 | 50.0 | 9.8 | 45.3 | <20.0 |
| | | | | | <20.0 for 10% of the time | (90th Percentile) |
| BOD Loading (lb/kcf/day) | 182.1 | 243.7 | 328.7 | 51.7 | >177.5 for 90% of the time | NA |
| BOD Removal Percentage | 30% | 54% | 69% | 14% | >36% for 90% of the time | >80% |
| | | | | | >80% for 0% of the time[3] | |
| Influent NH4-N, mg/L | 6.9 | 12.7 | 15.1 | 2.9 | 14.8[4] | NA |
| Effluent NH4-N, mg/L | 4.1 | 7.8 | 13.5 | 3.1 | 11.8 | NA |
| Influent Alkalinity, mg/L of $CaCO_3$ | 79.0 | 123.4 | 148.0 | 21.8 | 144.5[4] | NA |
| Effluent Alkalinity, mg/L of $CaCO_3$ | 58.0 | 91.8 | 121.0 | 18.6 | 115.6 | NA |
| Influent NO3-N, mg/L | 0.23 | 0.43 | 0.72 | 0.17 | 0.66 | NA |
| Effluent NO3-N, mg/L | 1.84 | 2.43 | 2.89 | 0.38 | 2.85[4] | NA |
| Temperature, °C | 9.7 | 11.0 | 12.2 | 1.3 | 12.2[4] | NA |
| | | | 2/3/02 to 2/13/02 | | | |
| BOD in (mg/L) | 69.0 | 86.1 | 95.0 | 10.2 | 95.0[4] | NA |
| BOD out (mg/L) | 7.0 | 17.4 | 24.0 | 5.2 | 24.1 | <20.0 |
| | | | | | <20.0 for 69% of the time | (90th Percentile) |
| BOD Loading (lb/kcf/day) | 222.5 | 275.5 | 307.1 | 33.2 | >233.0 for 90% of the time | NA |
| BOD Removal Percentage | 75% | 80% | 90% | 5% | >74% for 90% of the time | >80% |
| | | | | | >80% for 50% of the time | |
| Influent NH4-N, mg/L | 7.4 | 10.6 | 13.5 | 2.4 | 12.9[4] | NA |
| Effluent NH4-N, mg/L | 4.8 | 7.1 | 8.7 | 1.7 | 8.5[4] | NA |
| Influent Alkalinity, mg/L of $CaCO_3$ | 82.0 | 119.2 | 143.0 | 23.4 | 139.4[4] | NA |
| Effluent Alkalinity, mg/L of $CaCO_3$ | 24.0 | 81.0 | 109.0 | 33.7 | 105.0[4] | NA |
| Influent NO3-N, mg/L | 0.23 | 0.92 | 2.61 | 0.96 | 2.15 | NA |
| Effluent NO3-N, mg/L | 0.19 | 1.92 | 2.92 | 1.19 | 2.74[4] | NA |
| Temperature, °C | 11.4 | 11.8 | 12.1 | 0.5 | >11.5 for 90% of the time[4] | NA |
| | | | 1/10/02 to 2/13/02 | | | |
| TSS in (mg/L) | 45.0 | 57.3 | 72.0 | 8.7 | 68.4 | NA |

| | Minimum | Average | Maximum | Standard Deviation | 90th Percentile[2] | Target |
|---|---|---|---|---|---|---|
| TSS out (mg/L) | 10.0 | 18.1 | 29.0 | 5.5 | 25.1 | <20.0 |
| | | | | | <20.0 for 64% of the time | (90th Percentile) |
| TSS Load (lb/kcf/day) | 142.7 | 184.4 | 234.1 | 29.2 | >146.9 for 90% of the time | NA |
| TSS Removal Percentage | 55% | 68% | 82% | 8% | >59% for 90% of the time | >80% |
| | | | | | >80% for 7% of the time | |
| Influent Turbidity, NTU | No Data | No Data | No Data | No Data | No Data | NA |
| Effluent Turbidity, NTU | 1.9 | 6.6 | 10.2 | 2.5 | 9.7 | < 10 |
| | | | | | <10 for 92% of the time | (90th Percentile) |
| % of Backwash Water | NA | 11.5% | NA | NA | NA | 8% |

[1] Influent flow at 23 gpm, hydraulic loading at 3.3 gpm/ft$^2$, airflow at 8 scfm, backwash time at 12 hours.

[2] Projected normal values.

[3] Maximum value in data set is less than target value.

[4] Due to small sample size, projected normal values higher than maximum value in sample set. Projected value within actual data range used instead.

*Table 8. Summary of BAF #1 Performances during Phase IIIB[1]*

| | Minimum | Average | Maximum | Standard Deviation | 90th Percentile[2] | Target |
|---|---|---|---|---|---|---|
| BOD in (mg/L) | 40.0 | 86.1 | 118.0 | 24.9 | 107.2[3] | NA |
| BOD out (mg/L) | 19.0 | 28.3 | 39.0 | 7.0 | 37.2<br><20 for 12% of the time | <20.0<br>(90th Percentile) |
| BOD Loading (lb/kcf/day) | 277.4 | 348.5 | 426.5 | 54.6 | >277.8 for 90% of the time | NA |
| BOD Removal Percentage[3] | 51% | 65% | 76% | 10% | >52% for 90% of the time<br>>80% for 0% of the time[4] | >80% |
| TSS in (mg/L) | 54.0 | 65.5 | 99.0 | 14.2 | 83.7 | NA |
| TSS out (mg/L) | 25.0 | 32.9 | 42.0 | 6.1 | 40.7<br><20 for 0% of the time[4] | <20.0<br>(90th Percentile) |
| TSS Load (lb/kcf/day) | 205.2 | 245.7 | 366.7 | 56.1 | >207.9 for 90% of the time[3] | NA |
| TSS Removal Percentage | 26% | 48% | 65% | 13% | >31% for 90% of the time<br>>80% for 0% of the time[4] | >80% |
| Influent Turbidity, NTU | No Data | No Data | No Data | No Data | No Data | NA |
| Effluent Turbidity, NTU | 1.3 | 8.7 | 13.0 | 3.5 | 12.2[3]<br><10.0 for 65% of the time | < 10<br>(90th Percentile) |
| Influent NH4-N, mg/L | 4.2 | 11.5 | 17.0 | 5.1 | 16.2[3] | NA |
| Effluent NH4-N, mg/L | 1.0 | 8.0 | 13.2 | 5.2 | 12.9[3] | NA |
| Influent Alkalinity, mg/L of $CaCO_3$ | 55.0 | 120.4 | 148.0 | 37.9 | 146.0[3] | NA |
| Effluent Alkalinity, mg/L of $CaCO_3$ | 37.0 | 97.2 | 124.0 | 35.5 | 121.2[3] | NA |
| Influent NO3-N, mg/L | 0.20 | 0.56 | 1.04 | 0.42 | 1.02[3] | NA |
| Effluent NO3-N, mg/L | 1.10 | 2.12 | 3.07 | 0.75 | 2.87[3] | NA |
| % of Backwash Water | NA | 8% | NA | NA | NA | 8% |
| Temperature, $^oC$ | 9.7 | 10.9 | 12.0 | 1.6 | >9.9 for 90% of the time[3] | NA |

[1] Influent flow at 27 gpm, hydraulic loading at 3.8 gpm/ft$^2$, airflow at 8 scfm, backwash time at 12 hours.

[2] Projected normal values.

[3] Due to small sample size, projected normal values higher than maximum value in sample set. Projected value within actual data range used instead.

[4] Maximum value in data set is less than target value or minimum value in data set is larger than target value.

### Comparisons of BODt and TSS Removal in Different Phases

Figure 13 shows the effluent BOD attained as a function of the BOD loading rate for all the data during the pilot study. BOD concentrations in the effluent were widely scattered with little correlation to the BOD loading rate. Figure 14 shows similar results for TSS. Again, results were widely scattered. The wide scatter pattern in the data could be attributed to the different influent concentrations or backwash settings. Therefore the data are presented in terms of the different Phases identified above.

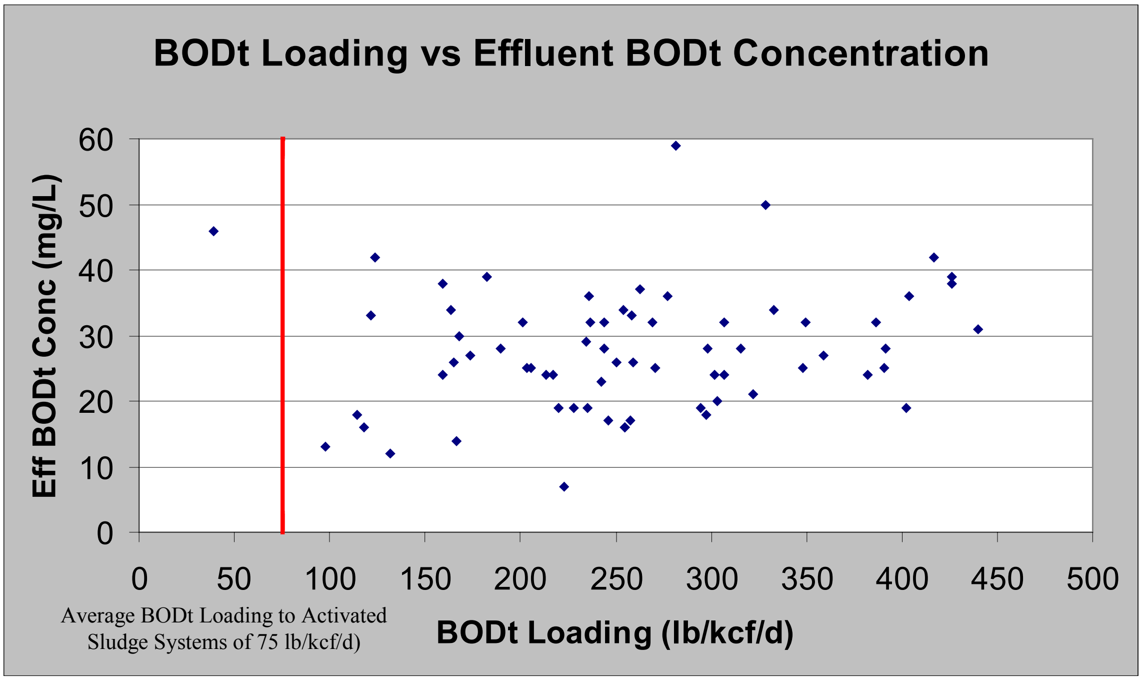


*Figure 13. BODt Loading vs Effluent BODt Concentration (June 15, 2001 to February 27, 2002)*

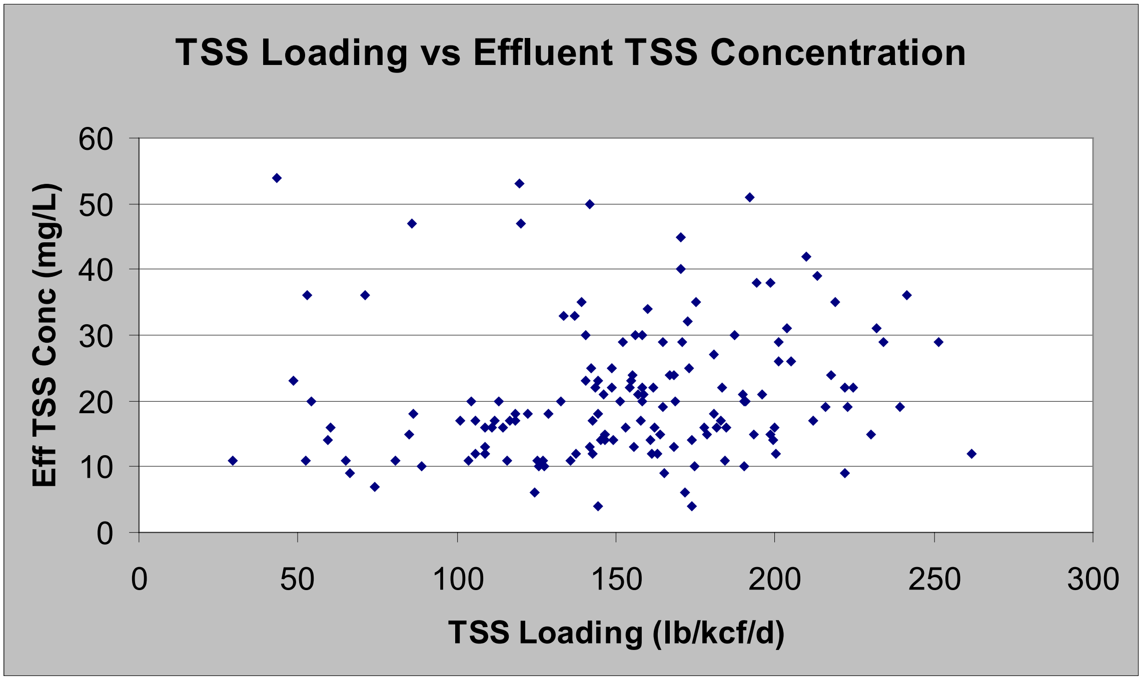


*Figure 14.TSS Loading vs Effluent TSS Concentration (June 15, 2001 to February 27, 2002)*

**General Observations**

- Startup time of 3 to 4 weeks is required for biomass acclimation.
- The typical BODt loading rate for a conventional activated sludge system is 75 lb/kcf/d. However, with the exception of one data point collected during start up, the loading rate for BAF #1 throughout the study was 100 to 440 lb/kcf/d, which was much higher than that of the conventional system. This means that a BAF system would have a smaller volume than a conventional activated sludge system treating the same type and amount of wastewater.
- As shown in Figure 12, the influent COD/BOD ratio ranged from 2 to 6, while the effluent COD/BOD ranged from 4 to 16. This large range in COD/BOD ratio and the significant differences between the influent COD/BOD ratio and the effluent COD/BOD ratio made it difficult to use the faster COD analyses as a surrogate for the more time consuming BOD analyses.

### BODt Removal

Table 9 summarizes the average BODt removal efficiencies of the three test phases.

*Table 9. Summary of Average BODt Removal Efficiencies at Different Test Phases*

| | Phase IA | | Phase IIB | | Phase IIIA | | | | Phase IIIB | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (1/10/02 to 2/2/02) | | (2/3/02 to 2/13/02)[1] | | | |
| | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. |
| BOD in, mg/L | 135.0 | 13.3 | 60.7 | 22.0 | 75.2 | 15.8 | 86.1 | 10.2 | 86.1 | 24.9 |
| BOD out, mg/L | 30.8 | 7.4 | 25.5 | 10.9 | 32.7 | 9.8 | 17.4 | 5.2 | 28.3 | 7.0 |
| Projected % of Time Eff. BOD Less Than 20 mg/L | 7% | | 31% | | 10% | | 69% | | 12% | |
| BOD Loading (lb/kcf/d) | 389.0 | 38.3 | 193.7 | 68.9 | 243.7 | 51.7 | 275.5 | 33.2 | 348.5 | 54.6 |
| BOD Removal | 77% | 5% | 55% | 28.1% | 54% | 14% | 80% | 5% | 65% | 10% |
| Projected % of Time BOD Removal More Than 80% | 33% | | 18% | | 0% | | 50% | | 0% | |
| Temperature, $^{o}C$ | 19.3 | 0.5 | 12.0 | 1.0 | 11.0 | 1.3 | 11.8 | 0.5 | 10.9 | 1.6 |
| Influent Flow, gpm | 21 | | 23 | | 23 | | 23 | | 27 | |
| Backwash Setting, hr | 24 | | 18 | | 12 | | 12 | | 12 | |

[1] Nitrification inhibitor in effluent BODt analyses, (i.e. values reflect CBOD concentration).

- During Phase I, Phase II, and first part of Phase IIIA testing, no nitrification inhibitor was added to effluent BODt samples during the BODt analyses. As a result, the effluent BODt values in these time periods reflect both the carbonaceous biological demand, as well as partial nitrogenous oxygen demand in the effluent of BAF #1. The amount of nitrogenous oxygen demand exerted varied from sample to sample. Therefore, it is difficult to quantify the BODt removal of BAF #1 during these test phases. At the beginning of the second part of Phase III testing, nitrification inhibitor was added to the effluent BODt samples during the BODt analyses.
- A comparison of the BODt removal percentages of Phase IA and Phase IIB suggests that it is easier to attain an 80% BODt removal at a higher influent BODt concentration than at a lower influent BODt concentration. However, the average effluent BODt concentration in Phase IA of 31 mg/L is higher than that of the average effluent BODt concentration in Phase IIB of 25 mg/L. Therefore, a removal percentage may not be the best parameter to represent the final quality of the treated effluent and should be regarded only as a secondary goal.

- It is difficult to draw a conclusion on the effect of backwash frequency on BODt removal efficiency. Because the influent BODt concentration cannot be kept constant, it was impossible to keep the BODt loading to the BAF unit constant, even though the influent flow was held constant at 23 gpm in Phase IIB and in the first part of Phase IIIA. The BODt removal percentages in both time periods are similar although the BODt loading in the first part of Phase IIIA was 26% higher than that of Phase II.

- Effluent BODt in Phase I, II and the first part of Phase IIIA were higher than expected. An observation was made that no nitrification inhibitor was used in BOD analyses. As discussed previously, the effluent BODt values in these time periods reflect both the carbonaceous biological demand, as well as partial nitrogenous oxygen demand in the effluent of BAF #1. In the second part of Phase IIIA testing, effluent BODt samples were analyzed with a nitrification inhibitor and the effluent CBOD values decreased substantially. The average effluent CBOD concentration was 17 mg/L, and the goal of less than or equal to 20 mg/L was met 69% of the time. The average BODt removal percentage was 80% and the goal of higher than or equal to 80% was met 50% of the time. The BODt loading in this phase was 73% of the maximum Ondeo design loading limit for a carbonaceous BAF.

- As shown in Table 10, the average effluent NH4-N concentrations and alkalinity were lower than that of the influent values in all test phases. The average effluent NO3-N concentrations were higher than the average influent NO3-N concentrations in Phase II and Phase III (NO3-N concentrations were not measured in Phase I). These results indicated that some nitrification occurred in BAF #1 and hence BAF #1 may potentially be able to handle a higher BODt loading than the level that had been tested. However, it is uncertain if the effluent BODt (inhibited) would be able to meet the target of 20 mg/L at the $90^{th}$ percentile.

*Table 10. Summary of Average Influent and Effluent NH4-N, NO3-N, and Alkalinity at Different Test Phases*

| | Phase IA | | Phase IIB | | Phase IIIA | | | | Phase IIIB | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (1/10/02 to 2/2/02) | | (2/3/02 to 2/13/02) | | | |
| | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. |
| NH4-N in, mg/L | 21.4 | 0.9 | 8.4 | 4.0 | 12.7 | 2.9 | 10.6 | 2.4 | 11.5 | 5.1 |
| NH4-N out, mg/L | 17.9 | 2.7 | 4.5 | 3.0 | 7.8 | 3.1 | 7.1 | 1.7 | 8.0 | 5.2 |
| NO3-N in, mg/L | No Data | No Data | 0.82 | 0.62 | 0.43 | 0.17 | 0.92 | 0.96 | 0.56 | 0.42 |
| NO3-N out, mg/L | No Data | No Data | 2.08 | 0.65 | 2.43 | 0.38 | 1.92 | 1.2 | 2.12 | 0.75 |
| Alkalinity in, mg/L $CaCO_3$ | 171.7 | 3.3 | 111.1 | 31.3 | 123.4 | 21.8 | 119.2 | 23.4 | 120.4 | 37.9 |
| Alkalinity out, mg/L $CaCO_3$ | 154.6 | 7.1 | 79.5 | 29.5 | 91.8 | 18.6 | 81.0 | 33.7 | 97.2 | 35.5 |
| Temperature, $^oC$ | 19.3 | 0.5 | 12.0 | 1.0 | 11.0 | 1.3 | 11.8 | 0.5 | 10.9 | 1.6 |
| Influent Flow, gpm | 21 | | 23 | | 23 | | 23 | | 27 | |
| Backwash Setting, hr | 24 | | 18 | | 12 | | 12 | | 12 | |

- Based on the results in the second part of Phase IIIA testing, a single-stage BAF unit is capable of producing an average effluent CBOD concentration of less than 20 mg/L at an average BODt loading of approximately 275 lb/kcf/d, but the performance would probably deteriorate at a higher BODt loading. It is also unlikely that a single-stage BAF unit can produce an effluent CBOD level of 20 mg/L for 90% of the time at a BODt loading of 275 lb/kcf/d. The capability of a two-stage BAF system to produce an effluent CBOD of less than 20 mg/L for 90% of the time is discussed in the nitrifying BAF #2 report. In general, the performance of a two-stage system was better than that of a single-stage system in terms of TSS, BODt, and NH4-N concentrations.

### TSS and Turbidity Removal

Table 11 summarizes the TSS removal efficiencies and turbidities for the three test periods.

*Table 11. Summary of Average TSS Removal Efficiencies and Turbidities at Different Test Phases*

| | Phase IA | | Phase IIB | | Phase IIIA | | Phase IIIB | |
|---|---|---|---|---|---|---|---|---|
| | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. | Avg. | S.D. |
| TSS in, mg/L | 64.6 | 8.9 | 57.0 | 28.1 | 57.3 | 8.7 | 65.5 | 14.2 |
| TSS out, mg/L | 30.9 | 12.3 | 19.4 | 9.6 | 18.1 | 5.5 | 32.9 | 6.1 |
| Projected % of Time Eff. TSS Less Than 20 mg/L | 19% | | 52% | | 64% | | 0% | |
| TSS Loading (lb/kcf/d) | 185.8 | 25.4 | 182.3 | 89.0 | 184.4 | 29.2 | 245.7 | 56.1 |
| TSS Removal | 52% | 22% | 64% | 17% | 68% | 8% | 48% | 13% |
| Projected % of Time TSS Removal More Than 80% | 10% | | 18% | | 7% | | 0% | |
| Turbidity in, NTU | No Data | No Data | No Data | No Data | No Data | No Data | No Data | No Data |
| Turbidity out, NTU | 14.2 | 3.6 | 5.8 | 2.8 | 6.6 | 2.5 | 8.7 | 3.5 |
| Projected % of Time Turbidity Less Than 10 NTU | 12% | | 93% | | 92% | | 65% | |
| Influent Flow, gpm | 21 | | 23 | | 23 | | 27 | |
| Backwash Setting, hr | 24 | | 18 | | 12 | | 12 | |

- The average TSS concentrations and TSS loadings were fairly consistent throughout the three test stages. The observed average effluent TSS concentration was reduced from 31 mg/L in Phase IA to 19 mg/L in Phase IIB after changing the backwash frequency setting from once every 24 hours to once every 18 hours. Further changing the backwash frequency setting from once every 18 hours in Phase IIB to once every 12 hours in Phase IIIA did not seem to have any significant improvement on the TSS removal by the BAF unit.
- Note that the positive impact of a higher backwash frequency on TSS removal in Phase IIB as compared to Phase I may have been magnified by the lower BODt loading in Phase IIB as compared to the loading in Phase IA. Also, the positive effect of a higher backwash frequency on TSS removal in Phase IIIA as compared to Phase II may have

been reduced by the higher BODt loading in Phase IIIA as compared to the loading in Phase IIB.

- Based on the Phase IIB and Phase IIIA testing results shown in Table 11, a single-stage BAF unit is capable of intermittently producing an average effluent TSS of less than 20 mg/L at a TSS loading of less than 185 lb/kcf/d and a BODt loading of less than 275 lb/kcf/d. However, the TSS removal performance of a single-stage BAF unit is not consistent, and the percentage of time it could achieve an effluent TSS of less than 20 mg/L would be much lower than the target 90%. The results of the pilot testing showed that the unit was unable to achieve 80% TSS removal percentage for more than 20% of the time.
- The average effluent turbidity in Phase IIB and the Phase IIIA met the target effluent turbidity of less than 10 NTU at the $90^{th}$ percentile. The pilot unit exhibited the best turbidity removal during the same test phases when TSS removal was the best among the whole test duration. The effluent turbidity in Phase IA was projected to be less than 10 NTU for only 12% of the time indicating the backwash frequency of once every 24-hours was too low. The effluent turbidity in Phase IIIB was projected to be less than 10 NTU for 65% of the time only. The reduced turbidity removal performance was probably due to an increase in both TSS and BODt loading during this period to 78% and 93% of the respective maximum design value that would be recommended by Ondeo.

## Pressure Buildup Patterns

There are two typical differential pressure buildup patterns. In the Type A pattern (as shown in Figure 15), following backwash, the differential pressure steadily increased until breakthrough is reached. The turbidity breakthrough is typically associated with a leveling off of the pressure increase. This pattern indicates that the solids-holding capacity is exceeded before the end of a filter run, and effluent quality deteriorates significantly as a result of solids breakthrough. An energetic backwash might be required if the Type A pattern is observed on consecutive days. In the Type B pattern (as shown in Figure 16), the differential pressure increases steadily throughout the entire filter run. Towards the end of the filter run, the effluent quality deteriorates slightly and there is no severe solids breakthrough. This pattern indicates that the normal backwash frequency provides sufficient bed cleaning to restore sufficient solids-holding capacity for the whole filter run.

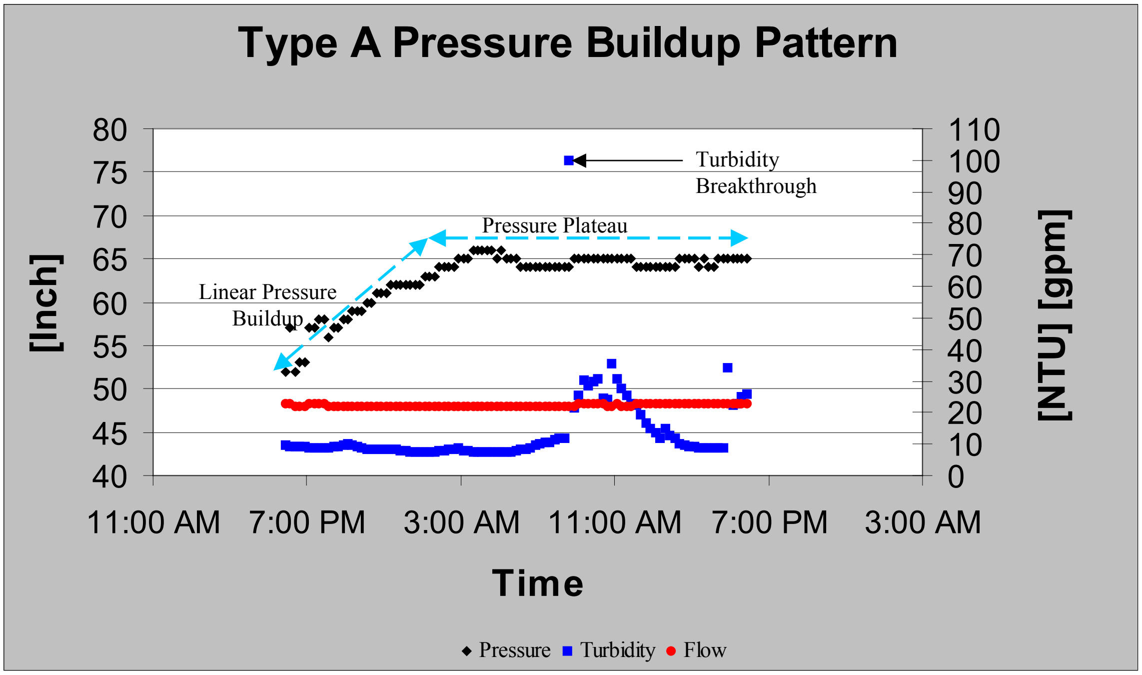


*Figure 15. Type A Pressure Buildup Pattern*

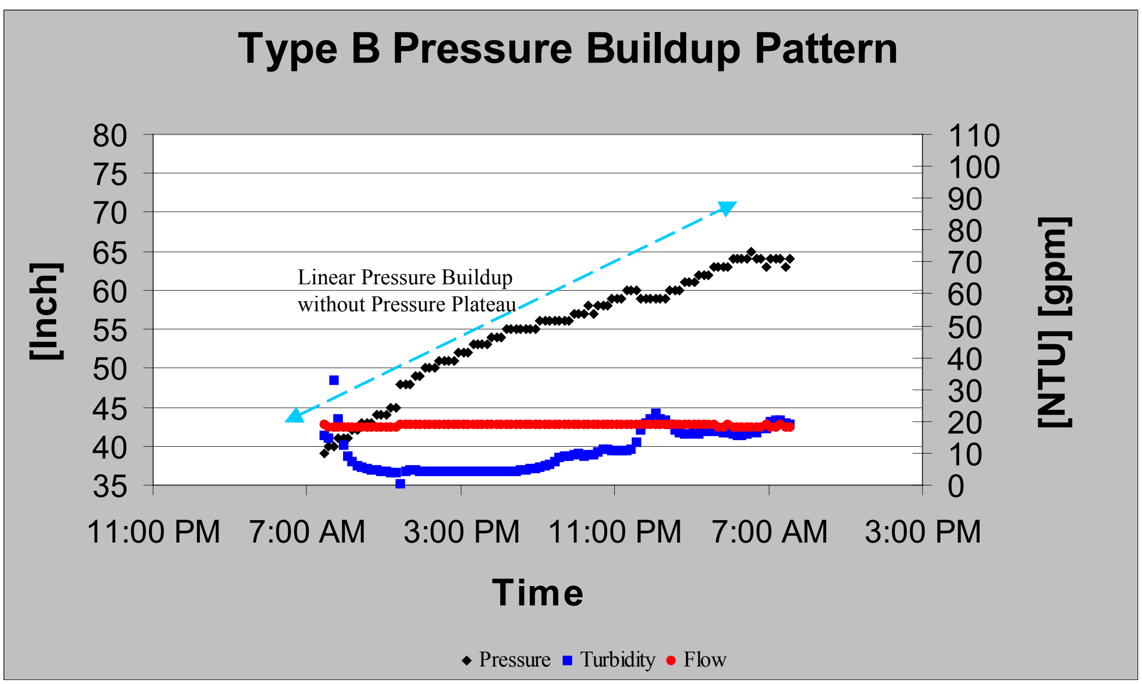


*Figure 16. Type B Pressure Buildup Pattern*

Appendix F shows the pressure buildup patterns for the entire test period. For the purpose of evaluating the pressure buildup patterns, the test period was divided into seven different time segments based on influent flow, airflow and backwash time settings. These time segments do not coincide exactly with the time periods in the previous sections that present the BODt, TSS, and other water quality data. The selection of the time periods in the previous sections was affected by both the operating conditions and the timetable of water quality analysis. Table 12 shows the influent flow, the airflow, the backwash time, the approximate range of differential pressure, and the rate of differential pressure increase for the different time segments.

*Table 12. BAF #1 Influent Flow, Airflow, and Backwash Time from September 2001 through February 2002*

| Test Phase | Time Segment | Duration | Influent Flow (gpm) | Airflow (scfm) | Backwash Time (hr) | Energetic Backwash Date | Range of Differential Pressure (In $H_2O$) | Rate of Differential Pressure Increase (In/hr) |
|---|---|---|---|---|---|---|---|---|
| I | 1 | 9/1/01 to 9/25/01 | 21 | 7 | 24 | 9/10/01 | 43 to 65 | 1.6 |
| I | 2 | 9/26/01 to 10/7/01 | 23 | 8 | 24 | NA | 51 to 66 | 1.5 |
| I | 3 | 10/8/01 to 11/8/01 | 19 | 6 | 24 | 10/12/01 | 43 to 66 | 1.3 |
| II | 4 | 11/9/01 to 11/28/01 | 21 | 7 | 18 | 11/10/01 | 47 to 66 | 1.4 |
| II | 5 | 11/29/01 to 1/9/02 | 23 | 8 | 18 | 12/18/01 | 52 to 65 | 0.9 |
| III | 6 | 1/10/02 to 2/13/02 | 23 | 8 | 12 | 2/1/02 | 54 to 63 | 0.8 |
| III | 7 | 2/14/02 to 2/27/02 | 27 | 8 | 12 | NA | 58 to 65 | 0.9 |

**Time Segment 1, 2, and 3 (as Listed in Table 12)**

- In Time Segment 1 (from September 1, 2001 to September 25, 2001) and Time Segment 2 (from September 26, 2001 to October 7, 2001), the differential pressure buildup during each filter run exhibited the Type A pattern as shown in Figure 15. This pattern repeated itself throughout September even immediately after an energetic backwash in early September. The turbidity spike observed at the end of each filter run was suspected to be a result of high BODt loading. At this high BODt loading, the biomass growth rate was so high that it grew beyond the holding capacity of the media towards the end of the first filter run immediately after the energetic backwash. As a result of a long filter run setting (24 hours) and a high BODt loading, the biomass accumulated beyond the holding capacity of the media towards the end of each filter run, and excess biomass was sloughed off as indicated by a spike in turbidity and a flattening of the differential pressure curve.

- An energetic backwash was performed on October 12, 2001. The differential pressure patterns in the days before the energetic backwash exhibited the Type A pattern. Afterward, the differential pressure buildup exhibited the Type B pattern (as shown in Figure 16) for each filter run. It appears that the energetic backwash was effective in restoring the Type B pressure pattern. In addition, the reduced hydraulic loading in Time Segment 3 (from October 8, 2001 to November 8, 2001), as well as a gradual decrease in BODt concentration in the influent in this time segment attenuated the pressure buildup. The Type B pressure pattern observed in the 15 days after the energetic backwash indicated that the maximum biomass holding capacity of the media was not immediately exceeded during each filter run at a backwash frequency of once every 24-hour.

- The differential pressure immediately after each backwash (i.e. initial differential pressure value at the beginning of each filter run) gradually increased following the energetic backwash on October 12, 2001 indicating the backwash frequency was still not optimum for the operating conditions during this time segment.
- The Type A pressure pattern exhibited during the last week of Time Segment 3 could be due to the media-holding capacity being exceeded at the end of each filter run, and that an energetic backwash was required to restore the linear pattern. However, the changes in the pressure pattern could also be partly attributed to the unit failure on November 2, 2001 and November 5, 2001 due to primary influent pump failure and failure to backwash on November 6, 2001 due to lack of backwash water.

**Time Segments 4 and 5**

- Backwash frequency was changed to once every 18 hours at the start of Time Segment 4 (from November 9, 2001 to November 28, 2001) and maintained at this frequency through Time Segment 5 (from November 29, 2001 to January 9, 2002). Although the hydraulic loading and TSS loading remained the same as those in Time Segment 2, the influent BODt loading was approximately 50% of that in Time Segment 1 due to a reduction in influent BODt concentration.
- The Type B pressure pattern was restored after the energetic backwash on November 10, 2001. With a combination of better backwash frequency and lowered BODt loading, biomass growth did not exceed the holding capacity of the media and no solids slough-off was observed during each filter run. The average effluent TSS concentration improved to 19 mg/L, and the average effluent turbidity improved to 4.6 NTU during the eight days after the energetic backwash on November 10, 2001.
- The BAF unit experienced backwash problems and other operation problems on November 16, 2001, November 18, 2001, November 28, 2001, December 2, 2001, December 10, 2001, and December 14, 2001. These problems may have caused the occasional random pressure pattern at about the same times and restoration back to a Type B pattern without an energetic backwash.
- Immediately after the energetic backwash on December 18, 2001, there were a few days of random pressure patterns. This may be caused by the backwash problem encountered during December 19 to December 23, 2001, when the backwash tank was not filled up in time for each backwash. After normal operation was restored on December 28, 2001, the flattening of the pressure curve towards the end of the run gradually diminished.

**Time Segment 6**

- Backwash frequency within this time segment was once every 12 hours. The BODt loading in Time Segment 6 was approximately 68% of that in Time Segment 1. The influent BODt concentration increased gradually since Time Segment 5. The TSS loading in Time Segment 6 was the same as that of Time Segment 1.

- The pressure pattern for most of this time segment exhibited Type B pressure patterns, i.e. no flattening towards the end of the run, with the exception of January 19 to 20, and January 25, 2002. It was reported that the unit was unable to backwash due to a lack of clean water in the clean water tank which caused the solids breakthrough and the flattened pressure pattern during these days. The Type B pattern was restored immediately after the regular backwash was restored.
- Two energetic backwashes were performed on February 1, 2002. The pressure patterns showed a steady increase of pressure in each cycle (Type B pattern) from February 1, 2002 through February 14, 2002 with the exception of some minor variations caused by backwash problems on February 5, 2002.

**Time Segment 7**

- The backwash frequency setting was maintained at once every 12 hours throughout Time Segment 7 (from February 14, 2002 through February 27, 2002). The BODt loading in Time Segment 7 was 89% of that in Time Segment 1, while the TSS loading in Time Segment 7 was 32% higher than that of Time Segment 1
- A blower failure was reported on February 14, 2002 when the flow was increased from 23 gpm in Time Segment 6 to 27 gpm in Time Segment 7. After the blower operation was restored, the pressure pattern shows that the differential pressure reached a plateau in every filter run. This indicated that the loading was too high for the unit to operate efficiently. The initial differential pressure value at the start of each filter run was generally increasing throughout the time segment. Another blower failure on February 24, 2002 caused further deterioration in the pressure pattern. Normal pilot testing was terminated on February 27, 2002 without any sign that the pressure pattern could be restored to a Type B pattern without an energetic backwash.

**Conclusions**

- At a BODt loading of less than 195 lb/kcf/d and a TSS loading of less than 180 lb/kcf/d (Phase II testing conditions), a backwash frequency of once every 18 hours was effective in maintaining a good pressure pattern and good TSS removal performance.
- In general, an energetic backwash would be necessary on a monthly basis to remove excessive solids and restore solids capture efficiency.
- An additional energetic backwash is required if a Type A pattern is observed on consecutive days.

## Backwash Volume

Table 13 summarizes the ratios of daily backwash volume to daily effluent production by BAF #1. There were two triggers for the initiation of a backwash. The first backwash trigger was a timer. Backwash was initiated if the filter run exceeded a preset duration of time. The second backwash trigger was differential pressure across the media. As the filter run progressed, differential pressure across the media increased as a result of solids captured by the media, and the growth of biomass (as a result of the consumption of organics). If the differential pressure exceeded the preset pressure setting before the preset filter run time was reached, a backwash was initiated regardless of the actual filter run time.

The volume of water used per backwash was measured manually by King County staff based on the volume of water taken out of the backwash water storage tank. The average water use per backwash was recorded in the weekly reports. Downstream pilot testing units such as BAF #2 and the microfiltration unit relied on BAF #1 effluent for their operation. The difference between the rate of BAF #1 effluent production and downstream effluent use was the rate at which backwash water was stored.

The backwash duration reported in the weekly reports included draining time, air scrubbing time, water wash time, and filter-to-waste time. The filter was offline during the whole backwash cycle. Therefore there was no treated water production during this time. Table 14 summarizes the BAF #1 backwash sequence setting. However, it was only during the water wash time that the unit consumed treated water from the backwash water storage tank. Therefore, even though the total backwash duration was increased by ten minutes in the last two time periods as shown in Table 13, the total volume of water consumed per backwash remained the same since the time was added to the filter-to-waste time and no water was consumed during this stage. However, the duration of water production was reduced by ten minutes.

The daily backwash water usage during each time period was estimated by multiplying the average number of backwashes per day during each time period by the average water use per wash.

The daily effluent production in each time period was estimated by multiplying the daily filter online time by the average influent flow during that time period. Daily filter online time during each time period was estimated by subtracting the daily offline time (number of backwash times duration per wash) from 1440 minutes.

*Table 13. Summary of Ratios of Daily Backwash Volume Used to Daily Effluent Volume Produced*

| Time Period | Avg. No. of Backwash Per Day | Equivalent Backwash Duration (hr) | Backwash Duration Setting (hr) | Backwash Volume (Gallon/d) | Duration Per Backwash (min) | Average Influent Flow (gpm) | Volume of Treated Water (Gallon/d) | Percentage of Backwash Water |
|---|---|---|---|---|---|---|---|---|
| 8/4/01 to 8/17/01 | 1.18 | 20 | 24 | 2270 | 48 | 15 | 20750 | 11% |
| 8/18/01 to 8/24/01 | 1.24 | 19 | 24 | 2386 | 48 | 17 | 23468 | 10% |
| 8/25/01 to 8/31/01 | 1.51 | 16 | 24 | 3086 | 48 | 20 | 27350 | 11% |
| 9/1/01 to 9/25/01 | 1.03 | 23 | 24 | 2105 | 48 | 21 | 29202 | 7% |
| 9/26/01 to 10/7/01 | 1.06 | 23 | 24 | 2209 | 48 | 23 | 31950 | 7% |
| 10/8/01 to 10/19/01 | 1.02 | 24 | 24 | 2044 | 48 | 19 | 26430 | 8% |
| 10/20/01 to 11/8/01 | 1.04 | 23 | 24 | 2126 | 48 | 19 | 26412 | 8% |
| 11/9/2001 to 11/28/01 | 1.39 | 17 | 18 | 2841 | 48 | 21 | 28839 | 10% |
| 11/29/01 to 1/9/02 | 1.19 | 20 | 18 | 2432 | 48 | 23 | 31806 | 8% |
| 1/10/02 to 1/27/02 | 1.69 | 14 | 12 | 3454 | 48 | 23 | 31254 | 11% |
| 1/28/02 to 2/13/02 | 1.75 | 14 | 12 | 3577 | 58 | 23 | 30786 | 12% |
| 2/14/02 to 2/27/02 | 1.49 | 16 | 12 | 3046 | 58 | 27 | 36547 | 8% |

*Table 14. Summary of BAF #1 Backwash Sequence*

| Backwash Step | Approximate Duration |
|---|---|
| Quick Drain | Controlled By Initial Water Level |
| Air Cushion | 2 min |
| Air Scour | 1 min |
| First Air + Water Wash | 3 min |
| First Rinse | 2 min |
| Second Air + Water Wash | 3 min |
| Second Rinse | 2 min |
| Third Air + Water Wash | 3 min |
| Air Cushion Purge | 1 min |
| Final Rinse | 15 min |
| Filter Settle | 0.5 min |
| Filter-to-Waste | 20 min (before 1/28/02)<br>30 min (since 1/28/02) |
| Launder Drain | 0.5 min |

Based on the data above we find that:

- As shown in Table 13, the percentage of backwash water used with respect to the amount of effluent treated would exceed the 8% target most of the time if backwash frequencies were set at or more often than once per 18 hours.
- The percentage of backwash water used ranged from 7% to 12% of effluent treated when operating the BAF unit under conditions similar to the pilot testing conditions in Phase II and Phase III testing was operated (i.e., average BODt loading from 195 lb/kcf/d to 350 lb/kcf/d, hydraulic loading from 3 gpm/sf to 3.8 gpm/sf, backwash frequency setting of once every 18 hours or more frequent).

## TSS Wastage

Table 15 shows the average daily TSS wastage and average BODt loading over different time periods. Figure 17 shows the relationship between average BODt loading and average daily TSS wastage.

TSS grab samples of the spent backwash water were taken at the beginning, in the middle, and at the end of the backwash cycle. The grab samples were then combined and analyzed for the TSS concentration of the spent backwash water.

Throughout the testing period (June 15, 2002 through February 27, 2002), only 25 spent backwash samples were collected for TSS analysis. Out of the 25 samples collected, only 6 TSS samples were collected on days (August 13, 2001, August 22, 2001, August 25, 2001, September 6, 2001, September 13, 2001, and January 18, 2002) after the recording of the actual number of backwash per day began (August 9, 2001). Out of the six TSS samples, only three TSS samples were collected on days (August 25, 2001, September 6, 2001, and September 13, 2001) that the corresponding influent BODt samples were collected.

As a result, the average TSS concentration of spent backwash water, the average effluent TSS concentration, and the average BODt loading over five time periods were used to estimate the relationship between biomass growth and organic loading, instead of using the three corresponding sets of TSS and BODt data.

Total TSS wastage from the pilot unit equals the amount of TSS lost in the effluent plus the amount of TSS wasted from the system during backwash. TSS wastage during backwash in a time period is estimated by multiplying the daily backwash volume (from Table 13) by the average TSS concentration in backwash water over the same time period. TSS lost in effluent in a time period is estimated by multiplying the daily volume of water treated (from Table 13) by the average effluent TSS concentration over the same period.

BODt loading in pounds per day is estimated by multiplying the average influent BODt concentration by the daily volume of water treated (from Table 13).

These results show that:

- The TSS concentration in the spent backwash water from the BAF unit was very dilute (Table 15). The average TSS concentrations ranged from approximately 220 mg/L to 1,100 mg/L, which is roughly 10 to 40 times more dilute compared to average TSS concentrations in waste activated sludge (WAS) from an activated sludge system (assuming a WAS TSS concentration of approximately 8,000 mg/L). Backwash solids must be thickened before sending them to the solids treatment processes.
- The amount of TSS wasted from a BAF (by backwash and TSS in effluent) exhibited a linear relationship with BODt loading (Figure 17). This relationship could potentially be used in sizing solids handling facilities. It was estimated that approximately 0.77 lb of TSS will be produced per pound of BODt loaded to the unit. This growth rate is typical in high-rate treatment systems.

*Table 15. Summary of TSS Wastage*

| Time Period | Average TSS Conc. in Backwash Water (mg/L) | TSS Wastage During Backwash (lb/d) | Average Effluent TSS Concentration (mg/L) | Effluent TSS Wastage (lb/d) | Total TSS Wastage (lb/d) | Average Influent BODt Conc. (mg/L) | BODt Loading (lb/d) |
|---|---|---|---|---|---|---|---|
| 8/4/01 to 8/17/01 | 965 | 18.3 | 20 | 3.4 | 21.7 | 123.4 | 21.5 |
| 8/18/01 to 8/24/01 | 1050 | 20.9 | 15 | 3.0 | 23.9 | 111.0 | 23.7 |
| 8/25/01 to 8/31/01 | 800 | 20.6 | 19 | 4.4 | 25.0 | 121.5 | 26.5 |
| 9/1/01 to 9/25/01 | 1005 | 17.6 | 30 | 7.4 | 25.0 | 134.2 | 33.1 |
| 1/10/02 to 1/27/02 | 219 | 6.3 | 18 | 4.7 | 11.0 | 73.3 | 20.2 |

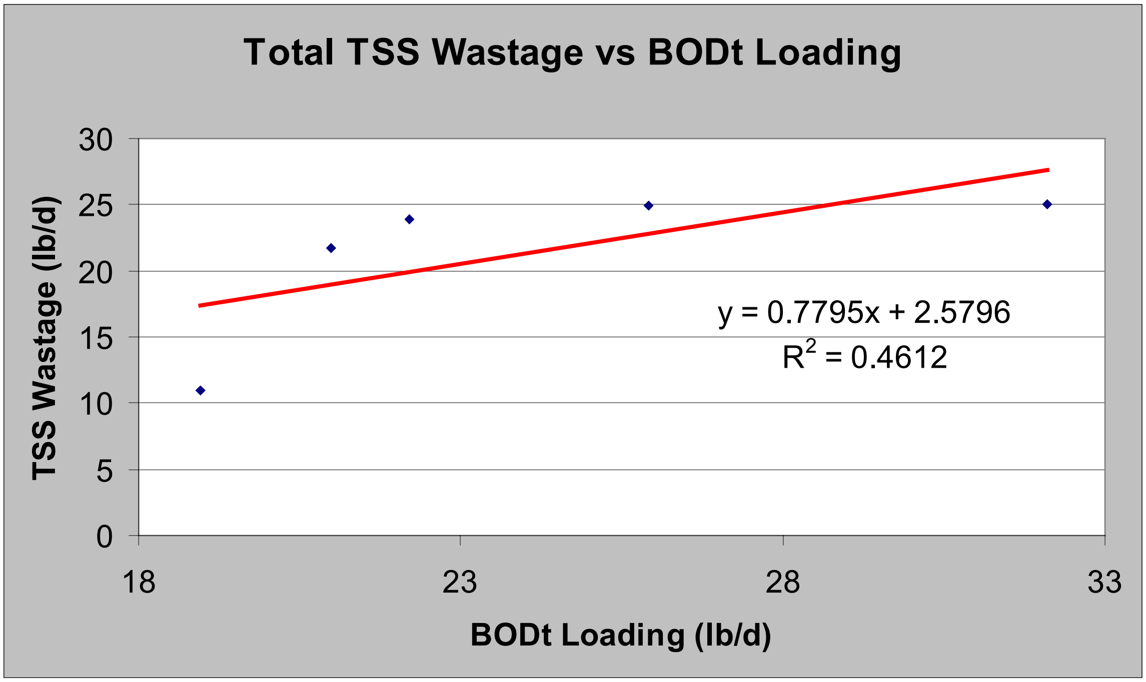


*Figure 17. Total TSS Wastage vs BODt Loading*

## Backwash Optimization

Figure 18 shows the effluent TSS concentration and turbidity immediately before and after a backwash on January 23, 2002. The operating conditions on that day were as follows: Backwash frequency at once every 12 hours, influent flow of 23 gpm, airflow rate of 8 scfm, and an influent TSS concentration of 49 mg/L. The figure shows that:

- The effluent TSS concentration dropped rapidly from over 50 mg/L immediately after backwash to 20 mg/L 30 minutes after backwash (Figure 18). The effluent TSS concentration remained relatively constant at approximately the 20 mg/L level from 30 minutes after backwash to 1.5 hours after backwash when TSS sampling was terminated for this test. The effluent turbidity exhibited a similar pattern.
- Before this test, effluent from the BAF unit was directed to waste for 20 minutes immediately after backwash. Therefore, it was concluded that extending the filter-to-waste time from 20 to 30 minutes would improve the BAF unit performance. Extending the filter-to-waste time to more than 30 minutes would not result in significant additional improvement.
- Adjusting the backwash cycle is a tool to optimize performance.
- In full scale plant, the impact of the initial less-than-optimal performance of the filter unit immediately after backwash would be diluted by the higher quality effluent produced by other online cells.

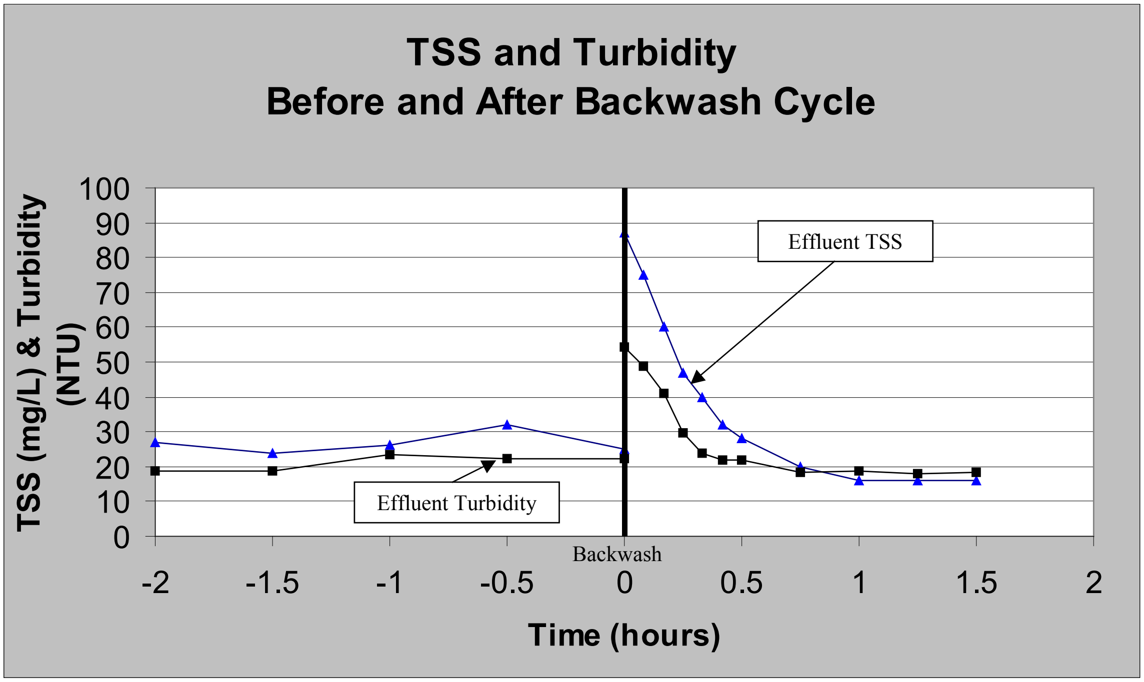


*Figure 18. Effluent TSS and TurbidityTrend Before and After Backwash*

## Idle Test

Two sets of idle tests were conducted to simulate the idle mode of a full-scale BAF unit. The purpose of the idle tests was to evaluate the time required to stabilize BODt and TSS removal when the filter unit was put back online after the unit had been in idle mode for a period of time. Samples were collected at ten-minute intervals for approximately two hours after the unit was put back online to monitor the BODt and TSS concentrations.

The first idle test was initiated at approximately 1:30 PM on February 27, 2002. The influent pump was turned off, and the air blower was set to turn on for approximately ten minutes every hour throughout the duration of the idle test. The unit was left in idle mode for 25.5 hours. On February 28, 2001, the unit was restarted at approximately 3:00 PM, and effluent samples were collected at ten-minute intervals for approximately two hours. All effluent samples were analyzed for effluent TSS concentration and effluent turbidity. Effluent samples collected at ten minutes, 20 minutes and 30 minutes after restart were mixed and analyzed for the initial average effluent CBOD concentration. Effluent samples collected at 90 minutes, 100 minutes, 110 minutes, and 120 minutes were mixed and analyzed for the final average CBOD concentration. An influent sample was collected for TSS and BODt analysis before the restart. The TSS and turbidity data is presented in .

For the first idle test, the influent BODt concentration was approximately 149 mg/L. The initial combined effluent BODt concentration (time = 10 through 30 minutes) was approximately 56 mg/L. The final combined effluent BODt concentration (time = 90 through 120 minutes) was approximately 26 mg/L.

The second idle test was initiated on March 1, 2002 at approximately 4:00 PM. The influent pump was turned off and the PLC controlled the air blower to turn on for approximately ten minutes every hour throughout the duration of the idle test. The unit was left in idle mode for 90.5 hours. On March 5, 2002, the unit was successfully re-started at approximately 10:20 AM, and samples were collected at ten-minute intervals for approximately two hours. All effluent samples were analyzed for effluent TSS concentration and effluent turbidity. Effluent samples collected at ten minutes, 20 minutes and 30 minutes after restart were mixed and analyzed for the initial average effluent CBOD concentration. The TSS and turbidity is presented in Figure .

No influent BODt samples were collected for the second idle test. The initial combined effluent BODt concentration (time = 10 through 30 minutes) was approximately 120 mg/L.

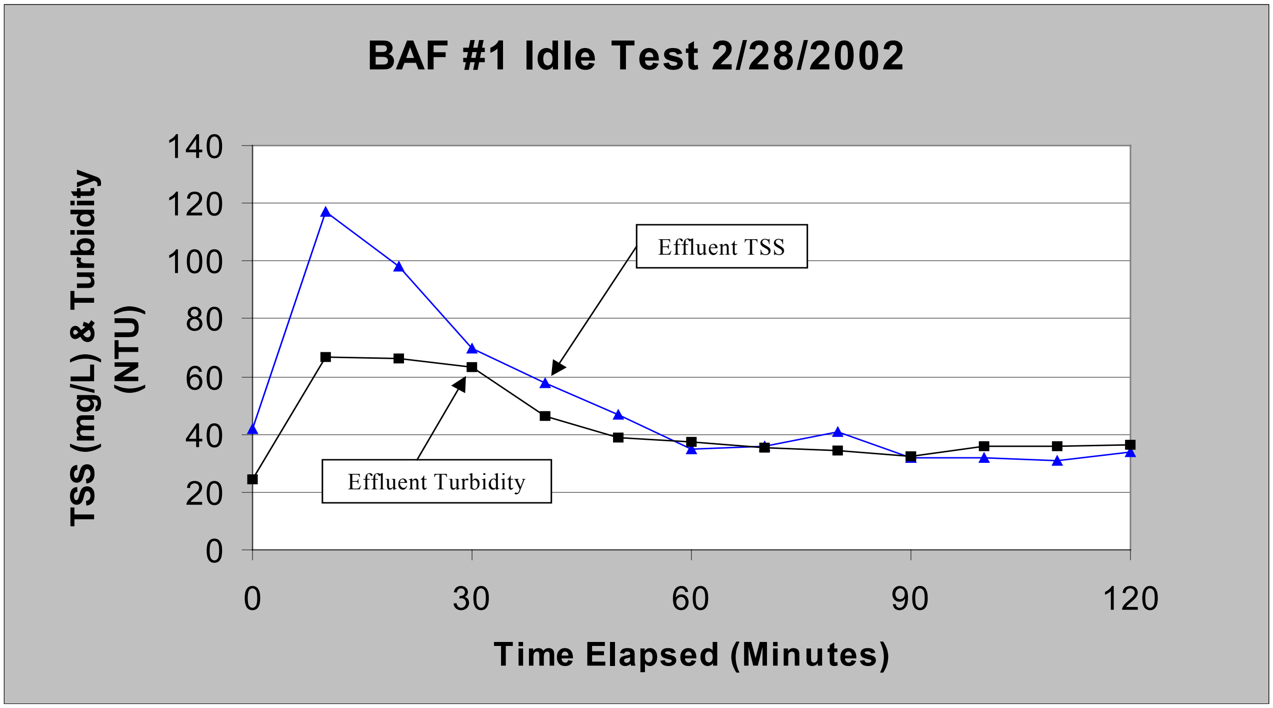


*Figure 19. Results of First Idle Test (February 28, 2002)*

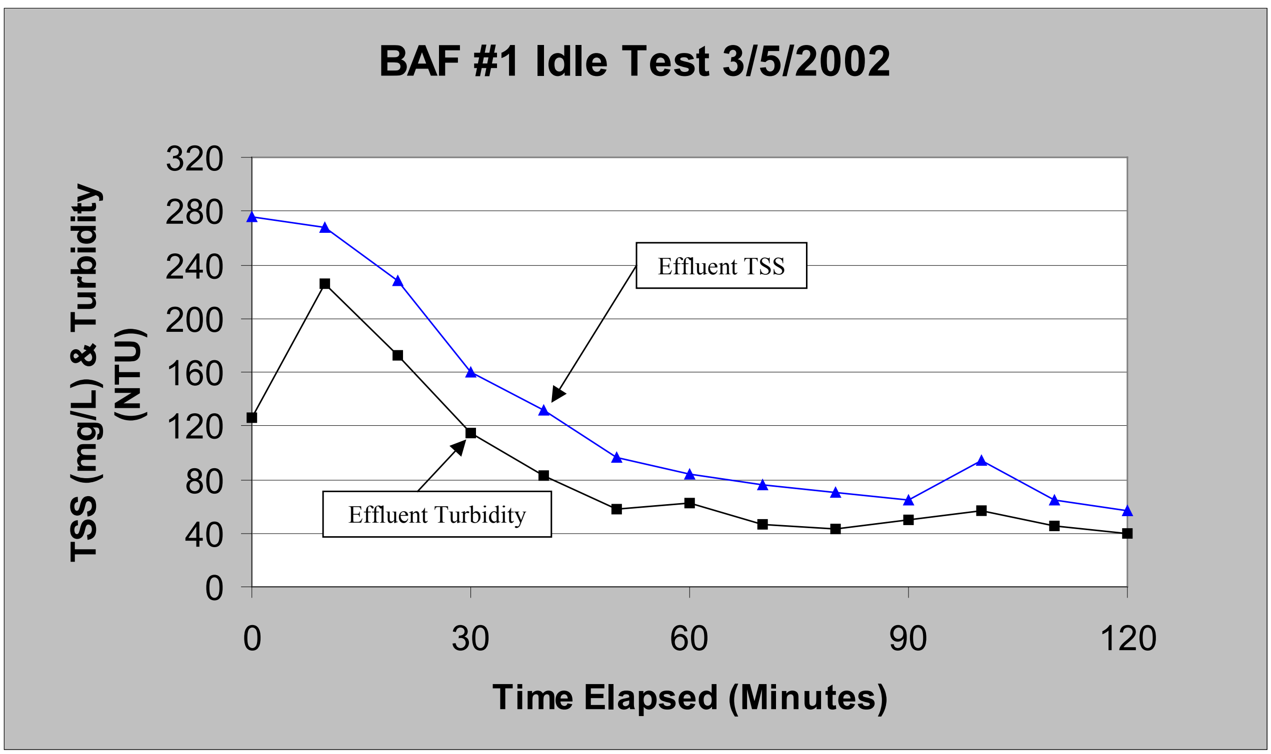


*Figure 20. Results of Second Idle Test (March 5, 2002)*

Based on the results, the following were concluded:

- In both idle tests, it took the unit approximately 50 minutes to stabilize the effluent TSS concentrations and effluent turbidities. The effluent TSS concentrations and effluent turbidities peaked at approximately ten minutes after the unit was put back online.
- The peak effluent TSS concentration and peak effluent turbidity in the second idle test were 2.3 and 3.3 times the peak effluent TSS concentrations and peak effluent turbidities in the first idle test. It seems that the longer the BAF system was put into idle mode, the worse the initial effluent quality in terms of TSS concentration and turbidity. It is speculated that during idle mode, the biomass in the BAF switched to an endogenous decay phase. Some of the biomass would die and be sloughed off the filter media. The dead cells would be consumed by the rest of the living biomass. The indigestible portion of the dead cells would accumulate within the filter media and would be flushed out when the system was put back online.

# Evaluation of Pilot Results

## Evaluation of Effectiveness of Technology to Meet Project Objectives

Table 16 shows the performance of the BAF #1 relative to the performance objectives established by the project team.

*Table 16. Comparison of Performance Goals and Results for Secondary Treatment*

| Performance Goal | BAF #1 Performance |
|---|---|
| ♦ Effluent TSS < 20 mg/L (90th percentile) | ♦ Did not meet target at 90th percentile.<br>♦ Met target at 50th percentile (average value) during Phase IIB and Phase IIIA. |
| ♦ Effluent TSS >80 % TSS Removal | ♦ Did not meet target.<br>♦ Average TSS removal from 48% in Phase IIIB to 68% in Phase IIIA. |
| ♦ Effluent BOD < 20 mg/L (90th percentile) | ♦ Did not meet target at 90th percentile.<br>♦ Met target at 50th percentile (average value) during second part of Phase IIIA after nitrification inhibitor was used in BOD analyses. |
| ♦ Effluent BOD >80 % BOD Removal | ♦ Did not meet target 90th percentile.<br>♦ Met target at 50th percentile (average value) during second part of Phase IIIA after nitrification inhibitor was used in BOD analyses. |
| ♦ Effluent Turbidity <10 NTU (90th percentile) | ♦ Met target at 90th Percentile during Phase IIB and Phase IIIA. |
| ♦ Backwash <8% of treated flow | ♦ Did not meet target all the time. Backwash ranged from 7% to 12% under Phase II and Phase III operating conditions. |

## Operational and Reliability Considerations

During the initial startup period in June and early July of 2001, BAF #1 experienced backwash problems a number of times. These problems were ultimately attributed to too much media in the filter unit, which was solved by gradually removing the filter media. Per discussion with the manufacturer, it is suspected that the ultrasonic level sensor inside the tank might have been installed incorrectly and putting it too close to the media.

During the operation of BAF #1, a number of operational issues were reported by the operation staff. In decreasing order of frequency, they are:

- Inability to backwash due to lack of clean water.
- Unit shut down due to blower failure.
- Unit shut down due to raw water pump failure.
- Panel PC or SCADA system failure.
- Clogged influent screen.

From November 9, 2001 to January 20, 2002, effluent from BAF #1 was used to feed the downstream BAF#2 and MF pilot units. Only a small portion of BAF #1 effluent was directed to a clean water storage tank for backwash. At times, the clean water tank did not fill up fast enough to meet the need of backwashing BAF #1. When the unit was unable to backwash, the media differential pressure continued to increase until it reached the maximum preset value. Then the unit automatically stopped and went into idle mode. However, when BAF #1 no longer had to feed the downstream units at the same time, this was no longer an issue. Also, in a full-scale facility, multiple BAF filters will operate at the same time with only one filter in backwash mode at any given time. As a result, the clean backwash water reservoir would fill up much faster.

The second most frequent operational issue encountered during the pilot study was unit shutdown due to blower failure. In a full-scale plant, the BAF complex would have backup blower capacity, programmed to start up automatically in the event of blower failure. Similarly, the backup raw water pump in a full-scale installation will minimize plant shut down due to raw water pump failure. Of note, blower problems observed during the pilot study were usually a consequence of a clogged fine screen. When the water level in the influent chamber was low due to the clogged fine screen, the BAF unit would stop operating and go into idle mode. Then, when the water level rose past a set point, the unit would start up, which caused the water level to drop and stopped the unit again. The on/off cycle would repeat until the blower failed.

During the pilot testing, the Panel PC of BAF #1 and the SCADA system experienced problems a few times. All the problems were resolved quickly. Computer problems are not a treatment process specific problem and should not be a deciding issue for full-scale implementation.

BAF #1 was shut down a few times when a clogged influent fine screen restricted the influent flow in October and November of 2001. The fine screen is required in the upstream process to prevent large debris from entering the BAF unit and potentially clogging or damaging the influent nozzles. Cleaning of influent screens at the Roanoke, Virginia BAF facility due to solids accumulation and algal growth, caused operation and maintenance problems. Therefore, in a full-scale facility, it would be necessary to select a fine screen with sufficient capacity and self-cleaning capability. Also, the influent flow distribution channel could be enclosed to minimize algal growth. Operational staff should routinely perform visual field check of the condition of the influent fine screen.

BAF treatment systems are simple to operate. Unlike activated sludge systems, there are no process operation parameters (SRT, sludge blanket depth in clarifier, RAS rate, etc) to adjust. Each BAF unit would be designed to operate at the optimum loading, and the number of filter units in operation would be flow paced. For process optimization, the backwash cycle could be optimized and airflow could be changed. Like any treatment system, it is necessary to maintain the system on a regular basis. For this BAF system, it would be necessary to clean the influent nozzles regularly and perform an energetic backwash per unit at least once a month. The frequency of energetic backwash could be optimized by monitoring the differential pressure pattern, as discussed in the previous section.

One operational complication of a BAF is that the process is designed to achieve multiple objectives. In one process there are conflicting requirements such as backwash frequency with effluent quality against waste volume, etc. Balancing and optimizing the process requires close monitoring and operator attention.

# Implementation

## Design Criteria

Table 17 shows the typical design criteria published by Ondeo and criteria confirmed by the pilot study.

*Table 17. Typical Design Criteria (Published by Ondeo)*

| Parameters | Ondeo Maximum Design Loading for CBOD Removal (Design Temperature 20 °C) | Pilot Study Conclusion (Design Temperature 12 °C) |
|---|---|---|
| Hydraulic Loading, gpm/ft$^2$ | 1.6 to 8.2 | 3.3 |
| (m/h) | (4 to 20) | (8) |
| Process Air, scfm/ft$^2$ | 0.2 to 1.1 | 1.1 |
| (m/h) | (4 to 20) | (20) |
| TSS Loading, lb/kcf/d | 313 | 185 |
| (kg/m$^3$/d) | (5) | (3) |
| $BOD_5$ Loading, lb/kcf/d | 376 | 275 |
| (kg/m$^3$/d) | (6) | (4.4) |
| Backwash Flow, gpm/ft$^2$ | 8.2 | 8.2 |
| (m/h) | (20) | (20) |
| Backwash Duration, min | ≈ 50 | ≈ 60 |
| Backwash Frequency | Once every 12 hours | Once every 12 hours |
| Excess Solids Production, lb TSS/lb BOD | NA | 0.77 |
| Backwash TSS Concentration, mg/L | NA | 200 to 1000 |

Pilot test results show that at the criteria listed in Table 17, a single-stage BAF unit would be able to achieve an effluent BODt concentration of 20 mg/L and an effluent TSS concentration of 20 mg/L. However, the pilot unit was unable to achieve this effluent quality at the targeted 90% of the time.

## Design Features

A single-stage BAF system operating under the conditions experienced during the pilot study would not be able to produce an effluent with 90$^{th}$ percentile BODt and TSS concentrations lower than 20 mg/L, nor would it be able to achieve an average BODt and TSS removal higher than 80%. However, it was demonstrated that a single-stage BAF unit would be able to produce an effluent with BODt and TSS concentrations of less than 20 mg/L on average as shown in the results in the second part of Phase III testing. Reuse regulations require the treatment process to oxidize the wastewater, and this requirement is fulfilled by the BAF process as demonstrated by the partial nitrification measured in BAF #1. A second stage biological aerated filter would probably be required to achieve a higher degree of biological treatment. Effluent filtration will be required for Class A reuse water.

### Control, monitoring, special features

- Online differential pressure measurement across filter media should be provided to observe the pressure pattern during the filter run. The shape of the pressure curve could assist the operator in deciding when to initiate an energetic backwash.
- An individual turbidity meter should be installed for each filter unit to provide real-time monitoring of the filter performance.
- Per discussion with manufacturer, in a full-scale BAF plant there are always more than three cells. When one cell is put into backwash, a minimum of two other cells would continue to treat the influent, and the treated effluent would continue to fill up the backwash storage reservoir. According to the manufacturer, depending on the total number of cells, the design hydraulic loading, and the backwash hydraulic loading, the backwash storage reservoir could be smaller than the volume required for one backwash. It would be prudent to design the backwash storage reservoir to have a minimum volume large enough to supply water for one backwash in larger systems (more than four active cells) and a minimum volume large enough to supply two consecutive backwashes in smaller systems.

### Pretreatment requirements

- Primary clarification is required to ensure the influent TSS concentration to the BAF system is less than 250 mg/L per Ondeo recommendation.
- Following the primary clarification step, a self-cleaning 2.5-mm opening size fine screen (per Ondeo recommendation) with a backup unit is required to treat the BAF influent to prevent potential clogging of the influent nozzles.

### Residual treatment

- Biomass generated in a BAF unit is expected to be 0.77 lb per lb of BODt applied. The concentration of TSS in spent backwash water is approximately 500 to 1,100 mg/L. Volume of spent backwash water generated is estimated to be approximately 10% to 15% of rated capacity of treatment plant. However, waste solids from BAF consist of small, dense particles that settle and compact readily by gravity.
- For satellite wastewater reuse plants, the spent backwash water containing waste TSS could be returned to the sewer for downstream treatment at the centralized wastewater treatment plant.

## Issues not Resolved by Pilot Test Program

- The performance of BAF at TSS loading above 250 lb/kcf/d was not determined. The influent TSS concentrations and TSS loading has been fairly constant throughout the pilot testing. The TSS loading was approximately 185 lb/kcf/d from the start of the pilot test through the second part of Phase III testing. The TSS loading was increased to 250 lb/kcf/d in the last part of Phase III testing by increasing the flow to 27 gpm, but the backwash frequency was not optimized.

- Performance of BAF at BODt loading above 270 lb/kcf/d was not determined. Although BODt loading was approaching Ondeo's recommended maximum loading rate of 376 lb/kcf/d during most of September, effluent BODt samples at that time were analyzed without adding a nitrification inhibitor. The effluent BODt data collected during this testing period could reflect the carbonaceous oxygen demand as well as partial nitrogenous oxygen demand. The BODt loading was approaching Ondeo's recommended maximum loading rate of 376 lb/kcf/d rate during the last part of Phase III testing. The average effluent BODt concentration was higher than 20 mg/L. Optimizing the backwash frequency may improve the performance.
- The performance of BAF under intermittent peak loading and reduced air flow conditions was not tested during the pilot study.
- The relationship between scouring effect by process air supply and effluent solids has not been determined. A higher process air supply can keep the biofilm thin and active but may cause excessive scouring and reduced solids capture efficiency. The manufacturer suggests that there is little risk of excessive scouring if the process air flow remains within the manufacturer recommended flow range.
- Operation of a two-stage BAF sequence appears attractive. A second stage BAF can be designed for carbonaceous polishing or nitrification (as in the case of BAF #2). In a two-stage operation, the first stage could potentially be loaded above the 376 lb/kcf/d limit since the polishing unit would be available.

# Appendix A - Test Plan

# Appendix B - Operator Log

# Appendix C - Data Plots for Phase IA - 24 Hour Backwash Interval

# Appendix D - Data Plots for Phase IIB – 18 Hour Backwash Interval

# Appendix E - Data Plots for Phase III - 12 Hour Backwash Interval

# Appendix F - Pressure Buildup Patterns

# Appendix G – Pilot Unit Photos

# Appendix A - Modifications to BAF #1 Test Plan During Course of Pilot Testing

## *Test Stages vs Test Phases*

- In the test plan (last modified in early December 2001), the pilot study would be divided into three distinct test stages. However to avoid confusion with treatment process stages (one-stage BAF treatment vs two-stage BAF treatment), Test Stages were renamed Test Phases in pilot study report.

## *Changes to Stage 1 Testing – Determination of Maximum Sustainable BODt Loading Rate*

- In the test plan, Stage 1 testing was designed to determine the maximum sustainable BODt loading rate. The December revision states that the BAF performance was observed to have deteriorate at 21 gpm based on data available at that time and it was anticipated at that time the maximum sustainable flow would be 23 gpm. Such decision was based on BOD test conducted without nitrification inhibitor.
- It was anticipated that BAF #1 would switch to Densedeg effluent for five weeks. However, this alternative was not pursued due to equipment problems with Densedeg to provide a reliable feed.
- A large portion of the pilot study was used to determine the highest loading instead of just in the first stage of the test as stated in the test plan.
- Backwash frequency became an important performance operating criteria. The overall pilot test could be divided into three phases with different backwash frequency. In each test phase, the flow was increased and performance monitored to evaluate the highest loading in each phase.
- The pilot testing effort was complicated by varying influent BOD concentration throughout the test. The BOD concentration in September 2001 was much higher than that in December 2001 through February 2002. With a varying influent BOD concentration, it was impossible to hold influent BOD loading constant.

## *Changes to Stage 2 Testing – Class A Demonstration*

- The test plan anticipated that Stage 2 Testing – Class A demonstration would be conducted with BAF #1 influent at 23 gpm and then at a higher flow of 28 gpm. Effluent from BAF #1 would be fed to the MF unit in October through December of 2001. However, due to equipment and process stability problems, this treatment train configuration was not terminated until end of January 2002. The influent flow to BAF #1 was maintained at 23 gpm in January 2002 due to unsatisfactory BAF #1 treatment performance (based on uninhibited BOD test). After switching to CBOD test and obtaining good CBOD results, flow was increased to 27 gpm in the last two weeks of February 2002.

### *Changes to Stage 3 Testing – Additional Testing*

- Stage 3 Testing – Additional Testing would include intermittent peak loading test, reduced air flow test, and idle test.
- The intermittent peak loading test was not conducted.
- The reduced airflow test was not conducted.
- The test plan envision three idle tests. Only two idle tests were conducted in late February 2002 and early March 2002. In the first test, the unit was left idle for 25 hours and restarted. Effluent samples were collected at 10 minutes intervals. TSS and turbidities were analyzed. Three samples collected in the first half hour were combined to analyzed for initial effluent CBOD. Four samples collected 1.5 hours after restart were combined to analyzed for final effluent CBOD. In the second idle test, the unit was left in idle mode for 90 hours. Effluent samples were collected at 10 minutes intervals. TSS and turbidities were analyzed. Three samples collected in the first half hour were combined to analyzed for initial effluent CBOD. No combined final effluent CBOD was analyzed.

# King County Water Reuse Demonstration Project

# Biological Aerated Filter Test

The Biofor biological aerated filter (BAF #1), manufactured by Ondeo Degrémont, is being tested as one of the eight treatment processes for the Demonstration Project. The demonstration testing facilities are configured to convey West Point WWTP primary effluent, or effluent from the ballasted flocculation pilot unit to the Biofor unit. The focus of the testing will be to evaluate the Biofor for BOD removal. This version of the test plan addresses the testing for the next two to three months before the second Biofor pilot unit (BAF #2) is installed and started up for nitrification testing. In general, when BAF #2 is ready for testing, BAF #1 would be operated at a constant flow rate to provide a stable upstream condition. A separate test plan would be prepared for the testing of nitrification in the second Biofor pilot unit.

## Full Scale Plant Design Philosophy

A full scale Biofor treatment process would be designed with multiple cells. Each cell would be sized to operate at the optimum TSS and BOD loading rate. The number of units in operation at any given time would be dependent on the total influent flow to the treatment plant. The number of cells in operation would be increased or decreased to match the flow so that the TSS and BOD loading to each cell would remain relatively constant and optimum. Cells that are put in idle mode at any given time would be aerated intermittently (5 to 10 minutes per hour) to keep the unit aerobic. Idle cells would be cycled back into operation mode by alternating with active cells to limit the duration of inactivity. This will allow the biological activity to resume quickly in units which have been put into idle mode previously.

In order to collect sufficient data to facilitate full scale plant design, it is necessary to determine the maximum sustainable TSS and BOD loading rate, the reaction of the BAF unit to intermittent peak loading, and the maximum duration of the idle mode without severely affecting the treatment efficiency when put back into operation. Of note, in a full scale plant design, the number of operating cells is proportional to influent flow. Therefore, the fluctuation in peak loading would be less than that seen in an activated sludge plant for secondary treatment. Also, for reuse purpose, it is not necessary to design the system to handle all the primary or secondary effluent from a wastewater treatment plant. It would be possible to just treat a portion of the flow for reuse and discharge the rest without tertiary treatment. This would reduce the peak loading, as well as seasonal loading variation, to the BAF treatment process. Therefore, the intermittent peak to be tested for reuse treatment would be lower than that of the intermittent peak for a regular wastewater treatment plant. The full scale reuse plant should be designed to handle the intermittent peak flow caused by one BAF unit taken offline for backwash. The rest of the remaining units in operation would have to handle the increased in flow that was originally handled by the unit in backwash mode. It was anticipated that the full scale unit would have four BAF units online during normal operation. Only one unit would be allowed to backwash at any given time. Therefore, the system should be designed to handle a 32% intermittent increase in flow.

## Test Goals

Performance goals for BAF #1 are as follows:

- TSS removal: >80% or Effluent TSS < 20 mg/L, $90^{th}$ percentile
- BOD removal: >80% or Effluent BOD <20 mg/L, $90^{th}$ percentile
- Effluent turbidity: < 10 NTU, $90^{th}$ percentile
- Backwash flow: < 8% of treated flow

BAF #1 unit has been on site since May 30, 2001. It had been operational since June 14, 2001. The initial start up flow was set at 11 gpm and this corresponds roughly to a hydraulic loading rate of 1.6 gpm/sf and a TSS and BODt loading rate of 3.2 $kg/m^3$ of filter media/day. The current flow rate at the time of preparing this test plan is approximately 21 gpm and the corresponding hydraulic loading rate is approximately 3 gpm/sf and a TSS and BODt loading rate of 6.1 $kg/m^3$ of filter media/day.

The published maximum hydraulic loading rate, TSS loading rate, and BODt loading rate of 8.2 gpm/sf, 5 $kg/m^3$ of filter media/day, and 6 $kg/m^3$ of filter media/day respectively for the Biofor system. In this pilot study, although the current hydraulic loading rate is still below the published maximum value, the BODt loading is already marginally above the published maximum values. As a result, the BODt loading is limiting in this pilot study.

The remaining testing time before the second Biofor (BAF #2) unit is installed and started up for testing would be dedicated to the following objectives:

- What are the maximum sustainable BODt loading rates to BAF #1?
- Demonstration of Class A water reuse in combination with different unit processes.
- What is the response of BAF #1 to intermittent peak loading?
- What is the response of BAF #1 to reduced airflow?
- How long can the BAF unit be put into the idle cycle and return to full operation mode with little loss of treatment efficiency?

The schedule for testing of intermittent peak loading, reduced airflow and idling cycle would be modified according to schedule of other treatment units.

## Test Stages

There will be up to three stages in the remaining evaluation. Both are defined below.

### Stage 1 – Determination of Maximum Sustainable BODt Loading Rate

The flow rate to BAF #1 would be increased gradually on a weekly basis to determine the maximum sustainable BODt loading rate to the pilot unit.

The data collected will be used to develop the design criteria for a full scale BAF treatment system for BOD removal.

**Stage 2 – Class A Demonstration**

After determination of the maximum sustainable BODt, the BAF unit would be operated at the corresponding maximum sustainable flow rate to demonstrate Class A water reuse in combination with the microfiltration (MF) unit. The BAF unit would also be operated at a flow rate higher than the maximum sustainable flow to evaluate the performance of the MF unit at higher turbidities/solid loading.

**Stage 3 – Additional Testing**

If time allows, this stage will be used to observe the reaction of the BAF process to intermittent peak loading condition, reduced airflow condition, and determination of idle period.

During the intermittent peak loading test, the online effluent turbidity meter would be used to provide an indication of the dynamic response of the process to intermittent peak loading.

During the reduced airflow condition test, the BAF would be operated at the maximum sustainable flow rate and the airflow to the unit would be gradually reduced to determine the lowest possible airflow without severely affecting treatment performance.

The idle period testing would be designed to determine how long a BAF unit could be left idle during a low flow situation and switched out of the idle mode quickly when flow increases. The PLC might have to be reprogrammed to provide automatic intermittent aeration to keep the unit aerobic.

The stage 3 test of BAF #1 would coincide with stage 3 test of BAF #2.

## Test Schedule, Conditions and Sampling

The test schedule, conditions and number of samples for laboratory analyses for the three proposed test stages of BAF #1 are listed in Table 1. The proposed overall test schedule for BAF #1 and BAF #2 is shown in Table 2.

**SAMPLING**

- Influent – Sampler #2 or 3. Composite samples by automatic sampler
- Effluent – Sample #6. : Composite samples by automatic sampler
- Spent Backwash Water – Sample #6g. Grab sample only. Hand composite during backwash by taking three equal aliquots at start, midway, and at end of backwash cycle.

Other analytical and process parameters and frequency of measurements are as follows:

- Influent Turbidity (NTU) – twice a day

- Influent Temperature ($^oC$) once a day
- Influent pH – once a day
- DO (mg/L) – once a day
- Effluent Turbidity (NTU) – twice a day
- Effluent Turbidity Flow (Lpm) – twice a day
- Effluent Temperature ($^oC$) – once a day
- Effluent pH – once a day
- Filter Differential Pressure (in $H_2O$) – twice a day
- Media Pressure (in $H_2O$) – twice a day
- Plenum Pressure (in $H_2O$) – twice a day
- Filter Water Level (in) – twice a day
- Influent Flow (gpm) – twice a day
- Backwash Frequency
- Process Airflow (scfm) – twice a day
- Filter Differential Pressure Before Backwash – once a day [Not sure if online or not]
- Filter Differential Pressure After Backwash – one a day [Not sure if online or not]

**TEST CONDITIONS**

**Stage 1 – Determination of Maximum Sustainable BODt Loading Rate**

Gradually increase flow rate weekly from 21 gpm until it reaches 23 gpm. The corresponding BODt ranges from 6.1 to 6.7 kg/$m^3$ of filter media/day. Increase blower output in proportion per manufacturer suggestion. Based on data collected during the previous weeks of testing, it was observed that the performance of the BAF was already deteriorating at 21 gpm. This stage of test would terminate after running the unit at 23 gpm for a week. It is anticipated that the maximum sustainable flow to the BAF unit using primary effluent is around 23 gpm. Another series of tests could be conducted to determine the maximum loading rate to BAF #1 using effluent from the Densedeg ballasted flocculation unit. This alternative is only feasible if the test plan of the Densedeg (DND) unit have sufficient time for it to be operated at steady state condition and may have to take place after the first set of Class A water reuse demonstration. It is anticipated that due to the higher treatment efficiency of DND as compared to a regular primary clarifier, a higher flow rate (hence hydraulic and organic loading rate) could be achieved.

**Stage 2 – Class A Demonstration**

During this stage of testing, the BAF unit would be operated at 23 gpm (unless determined otherwise) for two weeks using primary effluent. Effluent from the BAF unit would be fed to the MF unit. Then the BAF unit would be operated at a higher flow of 28 gpm for one week and the effluent of the BAF unit at this operating condition would be fed to the MF unit to evaluate the performance of the MF unit under higher turbidities.

If the test plan of the DND unit has sufficient time for it to be operated at steady state condition, a new set of test could be conducted using DND effluent. The maximum sustainable flow to the BAF using DND effluent would be determined before another round of Class A demonstration using DND, BAF and MF units would be conducted. It is anticipated that the maximum sustainable flow to the BAF using DND effluent would be higher than that of using primary effluent. Assuming an effluent BODt from the DND is around 80 mg/L, it is anticipated that the maximum sustainable flow to BAF using DND effluent could be around 30 gpm.

**Stage 3 – Additional Testing**

In this test stage, three different groups of additional testing would be conducted depending on the available time. The three groups of tests are intermittent peak loading testing, reduced airflow testing, and idle period testing.

In the intermittent peak loading test, increase the flow rate from the steady state value of 23 gpm (i.e. BODt loading rate of 5.5 kg/$m^3$ of filter media/day) to 30 gpm (i.e. BODt loading rate of 7.3 kg/$m^3$ of filter media/day) and sustain the peak loading rate for four hours. Increase blower output in proportion per manufacturer suggestion. The online turbidimeter would be used to monitor the dynamic response of the process to peak loading. This represents a 32% peak a full scale unit would see when one of the four BAF unit is taken offline for backwash. Take effluent samples during steady state for base line performance info and during peak loading period to capture the peak turbidity. A total of three intermittent peak loading tests per week should be conducted

In the reduced airflow test, the BAF would be operated at flow rate of 23 gpm and an airflow of 6 scfm. The airflow would be reduced twice a week while keeping the influent flow at 23 gpm. Samples will be taken daily to monitor the performance of the system at different airflow and evaluate the lowest airflow required to maintain treatment performance.

In the idle period test, the pilot unit would be left idle for some period of time and then resumed back to operation for some period of time. If time allows, three sets of idle period test could be conducted. In the first two sets of tests, the filter will run for one day, followed by a one day of idle period, and then run for another day after the idle period. In the third set of test, the unit would be allowed to run for two days, followed by two days of idle period and then run for another two days after the idle period. Samples for each parameter (Inf CODt, Inf TSS, Inf $NH_4^+$, In Alk, Eff CODt, Eff TSS, Eff $NH_4^+$, Eff $NO_3^-$, Eff Alk, Backwash TSS) will be collected during the active run as base line performance info. Up to 3 sets of hourly samples per parameter would be collected during start up after each idle period to monitor the time for the biological treatment activity to resume back to target efficiency. There should be a backwash before the unit is put into idle mode.

The stage 3 test for BAF #1 should coincide with the stage 3 test for BAF #2.

**BAF #2 Testing Period**

With the exception of Stage 3 – Additional Test period, BAF #1 would be operated at 23 gpm/sf during the BAF #2 testing period – unless a different loading is determined. One sample from BAF #1 for each parameter (Inf BODt, Inf CODt, Inf TSS, Eff BODt, Eff CODt, Eff TSS, Backwash TSS) shall be collected per week for monitoring of steady state operation of BAF #1.

**CONTACTS**

Since this testing is occurring in a very brief period, and many test conditions will be evaluated, it is important to maintain frequent, if not daily communications between the USFilter operators and staff, King County and the consultant team (HDR and Black & Veatch). The following is a list of the project team members.

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It is essential that the project team hold frequent conference calls as needed. Bob Bucher will coordinate the calls. At a minimum, they will include Steve Tarallo and/or Sudhakar from Ondeo Degrémont and JB Neethling or Kenneth Hui, HDR.

**Table 1. Proposed Sampling Plan for Laboratory Analyses**

| | Flow Rate (gpm) | TSS Loading (kg/m$^3$/d) | BODs Loading (kg/m$^3$/d) | Hydraulic Loading Rate (gpm/sf) | Influent | | | | | Effluent | | | | | BAF Backwash |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | BODt | BODs | CODt | CODs | TSS | BODt | BODs | CODt | CODs | TSS | TSS |
| **Stage 1 Determination of Maximum BODt Loading Rate** | | | | | | | | | | | | | | | |
| Week 1: 10/1/01 - 10/5/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| **Stage 2 Class A Demonstration** | | | | | | | | | | | | | | | |
| Week 2: 10/8/01 - 10/12/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 3: 10/15/01 - 10/19/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 4: 10/22/01 - 10/26/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 5: 10/29/01 - 11/2/01 | 28 | 3.8 | 8.3 | 3.9 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| **Stage 2b (Optional) Determination of Maximum Flow Rate Using Densedeg Effluent Followed by Class A Demonstration** | | | | | | | | | | | | | | | |
| Week 6: 11/5/01 - 11/9/01 | 25 | 2.3 | 4.5 | 3.5 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 7: 11/12/01 - 11/16/01 | 30 | 2.7 | 5.5 | 4.2 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 8: 11/19/01 - 11/23/01 | 35 | 3.2 | 6.4 | 4.9 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 9: 11/26/01 - 11/30/01 | 32 | 2.9 | 5.8 | 4.5 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| Week 10: 12/3/01-12/7/01 | 32 | 2.9 | 5.8 | 4.5 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 1 |
| **Steady Run for BAF #1 During Stage 2 Testing of BAF #2** | | | | | | | | | | | | | | | |
| Week 11: 12/10/01 - 12/14/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 12: 12/17/01 - 12/21/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 13: 12/24/01 - 12/28/01 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 14: 12/31/01 - 1/4/02 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 15: 1/7/02 -1/11/02 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 16: 1/14/02 - 1/18/02 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 17: 1/21/02 - 1/25/02 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Week 18: 1/28/02 -2/1/02 | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Stage 3 Additional Testing (Exact Timing to be Determined)** | | | | | | | | | | | | | | | |
| Week 19: 2/4/02 -2/8/02 | | | | | | | | | | | | | | | |
| Intermittent Peak Loading Test | | | | | 2/test | 2/test | 2/test | 2/test | 2/test | 2/test | 2/test | 2/test | 2/test | 2/test | 1/test |
| Steady State Flow | 23 | 3.1 | 6.8 | 3.2 | | | | | | | | | | | |
| Peak Flow Condition | 30 | 4.1 | 8.9 | 4.2 | | | | | | | | | | | |
| Week 20: 2/11/02 - 2/15/02 | | | | | | | | | | | | | | | |
| Reduced Airflow Test | | | | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Reduce Airflow from 6 to 3 scfm | 23 | 3.1 | 6.8 | 3.2 | | | | | | | | | | | |
| Week 21: 2/18/02 - 2/22/02 (Resume Operation on Tue 2/26/02) | | | | | | | | | | | | | | | |
| Idle Period Test | | | | | | | | | | | | | | | |
| Initial Active Period (1, 2 days) | 23 | 3.1 | 6.8 | 3.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Idle Period (1, 2 days) | 0 | 0.0 | 0.0 | 0.0 | | | | | | | | | | | |
| Resume Operation | 23 | 3.1 | 6.8 | 3.2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |

Stage 3 Test For BAF #1 will coincide with Stage 3 Test for BAF #2

Influent Assumptions

| | | |
|---|---|---|
| TSS (Primary)= | 60 | mg/L |
| BODs (Primary)= | 130 | mg/L |
| TSS (Densedeg)= | 40 | mg/L |
| BODs (Densedeg)= | 80 | mg/L |

**Table 2: Overall Schedule for BAF #1 and BAF #2**

| Week Beginning | | 10/1/2001 | 10/8/2001 | 10/15/2001 | 10/22/2001 | 10/29/2001 | 11/5/2001 | 11/12/2001 | 11/19/2001 | 11/26/2001 | 12/3/2001 | 12/10/2001 | 12/17/2001 | 12/24/2001 | 12/31/2001 | 1/7/2002 | 1/14/2002 | 1/21/2002 | 1/28/2002 | 2/4/2002 | 2/11/2002 | 2/18/2002 | 2/25/2002 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAF #1 Week # | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | |
| BAF #1 | | Stage 1 | Stage 2 | | | | | | | | | Steady Run at 23 gpm | | | | | | | | Stage 3 (To be Determined) | | | | |
| BAF #1 Alternate Schedule | | Stage 1 | Stage 2 | | | | Stage 2b | | | | | Steady Run at 23 gpm | | | | | | | | Stage 3 (To be Determined) | | | | |
| BAF #2 | | | | | Stage 1 | | | | | | | | | | | Stage 2 | | | | Stage 3 (To be Determined) | | | | |
| BAF # 2 Week # | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | |

**BAF # 1 Schedule**

Stage 1 - Determination of Maximum $BOD_t$ Loading

Stage 2 - Class A Demonstration with Primary Effluent

Stage 2b - Class A Demonstration with Densedeg Effluent

Stage 3 - Additonal Testing (Intermittent Peak Loading, Reduced Airflow, and Idle Period)

**BAF #2 Schedule**

Stage 1 - Start Up

Stage 2 - Determinaton of Maximum TSS, BOD, $NH_4^+$ Loading

Stage 3 - Additonal Testing (Intermittent Peak Loading, Reduced Airflow, and Idle Period)

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 06/01/01 | | Repaired float switch in influent screen bottom well. Continued working on mechanical install. Electrical connection mode - no power energized. | |
| 06/02/01 | | | |
| 06/03/01 | | | |
| 06/04/01 | | Continued work on mechanical installs. Received PLC processsor from Vendor via UPS. Working on procedures for BAF operation. Expect operation by Thurs of this week. | |
| 06/05/01 | | Vendor representative onsite (Sudhakar Viswanathan). Talking with Sudhakar about scheduling for statup: load media, media soak for 24 hrs and then backwash several times, low flow (10 gpm) feed for 48 hrs with no backwash to establish biomass, increase process flow. Vendor inspected influent nozzles - photographs taken. Vendor installed grave around nozzle assemblies (Two layers: 3/4"-1" round rock covered nozzles, 3/8-3/4 on top.) Total coverage of 8"-10". Intitally sloped and then hatch secured. Proceeded to level from top of column using 20ft section of 2" sch80 pvc. Vendor filled column with water to prepare for media install and leak check of hatch. Forced to remove actuator from column drain valve and manually close. Arranged to use maint crane in a.m. to load media through roof. | |
| 06/06/01 | | Maintenance provided crane support for media install - completed by 0815 hrs. Installed (1) 2000" bag of media prior to arrival of vendor. Vendor guided install of 1/2 of 2nd bag (~1000 lbs). Water added to just below overflow. Media will soak for 24 hrs (start time 0830). Vendor received Allen-Bradley OIS PC for control panel FedEx prior to 1200 hrs. Vendor installed and discovered AB PLC5 and AB PC are not communitcating. Troubleshooting remainder of aternoon with no luck. Plan to continue in early am. Contractor completed mechanical installations. Also installed coupling guard on air blower. Vendor discovered cracked fitting on flush pump discharge check valve. Repairing with help of contractor. Provided vendor with copy of test plan and primary eddluent WP full-scale data. | |
| 06/07/01 | | Vendor continued troubleshooting PLC5/PC communication problem. With help of I/C contactor, discovered that PLC program not "properly" installed. Vendor had IDI I/C type email copy of program to West Point. Installed program and up/running. Performed rotational checks of all skid motors to verify proper feeder wiring. Filled CW tank with C2 water in preparation for backwash cycles to clean media. Completed 3 backwash cycles which included a combination of scour air and wash water. Each cycle required approx. 1 hr. 4th cycle is planned for tomorrow morning. Backwashing completed at 1930 hrs. During backwashing, discovered leaking PVC fitting (45 degree angle) on 4in discharge line. Plan to have contractor fix in a.m. tomorrow prior to 4th backwash cycle. | |
| 06/08/01 | | Contractor completed repair on 4in drain line. Completed 4th backwash of filter. Due to gronting of pipe supports and tanks, delayed statup until tomorrow morning. DH+ communication link completed and verified operational. Provided IDI rep with BAF1 hardware procedure (H-01) which included sections from bAF1 instruction manual - will review and red-mark. Vendor removed serveral 5 gal buckets of media from pilot - adjusted from initial fill. | |
| 06/09/01 | | Test facility failure led to delay of 48 hr seeding start until Monday. | |
| 06/10/01 | | No activity. | |
| 06/11/01 | | Initiated 48 hr seeding @ 1030 hrs with feed flow of 10 gpm. Feed source is primary effluent (summary of operating conditions: feed source - primary effluent, feed flow - 10 gpm, aeration rate 11 scfm.) 2128 hrs checking operation of pilot: feed flow = 10.2 gpm, aeration rate = 11.94 scfm, noted some foaming @ effluent overflow. Plan to initiate sampling on Wed. 6/13, 800 hrs. Also will start dailing operations sheet logging. Noted on process air flowmeter - messaging reading "calibration due - see manual" will talk with vendor in a.m. | |
| 06/12/01 | | Continued with 48 hr seeding. Secured system for approx. 24 hrs to install check valve wgts in lift station. Expect to complete 48 hr run @ 1530 hrs tomorrow. Plan to backwash and then initiate processing ingluent @ 10 gpm. Foaming continues @ BAF discharge. Process air flow decreased to 6 scfm in an attempt to reduce foam. Also installed spray hose from C2 source to "knock-down" foam around liq. level sensor. Orientation provided by vendor on interfacing with control system. Password protection (name: operator1, password: ***), alarm acknowledgement, setpoints. Vendor receiwing hardware procedure. Expect marked-up version tomorrow. PRocess control checks (daily): influent flow, airflow (process), DP across, process configuration on touch screen (valve red (open) or freen (closed)). Notes regarding AB PC WW package: Security - log in (operator1 bob), flashing blue - faulted equip on PID, alarm summary (only can acknowledge alarms when logged in). | |
| 06/13/01 | | Continued with 48 hr seeding. Completed seeding at 1400 hrs. Initiated backwash prior to starting processing feed. Process feeding started at 1500 hrs. Backwash set at 24 hrs, conditions: feed (setpt) - 11 gpm, process air (setpt) - 6.0 scfm, media/plenum pressures - 185 inH2O. Vendor provided following process parameters: reactor volume = 1046 gal, filter area = 7.0 sf, media depth = 12 ft, bed volume = 85.4 cf. Sudhakar left at 1900 hrs to fly back to Richmond, VA. 2100 hrs received page from Val Bobber regarding primary effluent feed from East primary. Plant outage is in the works to shutdown East Primary, which means no flow to Water Reuse Facility. Request that effluent cannel be maintained with enough water to run through the evening. Will address (hopefully find solution) in the morning. | |
| 06/14/01 | Post backwash (1st after feeding initiated on 6/13) | Operating throughout the day. Backwash did not intitiate @ 1500 hrs. Display flashing message ("backwash required"). Discovered that because system had been starting in semi-automated mode that backwash will not initiate. Performed backwash manually and then re-initiated program in auto mode. Started autosamplers S2 and S6 on primary influent and BAF1 effluent to collect composites for Fri morning delivery to process lab. Solved the primary effluent feed problem by running primary effluent weir @ 100% (lowest point) and running IPS @ 112.5 ft. This allows for 2 ft of water to remain in the primary effluent channel. Will hold this throughout East Primary shutdown. Formatted "revised" daily operations shett to simplify. See log book for sample. Plan to have Susan produce weekly opdate spcifid to water reuse for distribution to Ops supervisors. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
| --- | --- | --- | --- |
| 06/15/01 | First measurement taken following startup @1310 hrs. Initiated backwash in semi-auto mode. | 400 hrs received call from Ops A crew that unit was overflowing. 450 hrs arrived to find unit shutdown and evidence of water on floow. AB panel PC screen was not functioning (touch screen). Asked operations what occurred: found process overflowing from top, feed pump was still running. Acknowledge alarms on touchscreen (vlave failures). Turned OFF power to panel to secure pump. Paged. Tried to get power/screen to operate on AB PC. Power button pushed - solid green light on mortar symbol and flashing green light on power symbol, still no screen. Call IDI and talked with Sudhakar & Joe Valent. Connected keyboard and mouse to external ports. Tried cycling power with no luck and pressed reset button on interior side panel of PC per Joe with no luck. After trying power again - lost power entirely to PC (no lights or fan noise). 1015 hrs call Hoes Valent back - he is contacting Allen Bradley. Checked OIS computer for alarm signals from BAF1 skid, following listed: (3:31 6/15) Biological aerated filter 1 influent pump trip, (3:31 6/15) Biological aerated filter 1 common fail. | This suggests that overflow could only be caused be failure of effluent valve. Composite samples sent to Process lab: S2 and S6 (6/14/01). Process lab noted that S6 foamed excessively after being mixed in lab (normal prep for tests) S2 did not foam. Discussed AB PC problem with Joe Valent (IDI) and Eric (ABtech support). Eric informed us that AB PC has BIOS setting which when triggered will not allow power up of PC. BIOS setting is based on an attempt to power PC with no 120 VAC power available. Solution is to unplug and plug back in power cod. It worked! Back up and running.Biofor restarted @ 1310 hrs. Filter runtime clock set back to 0. Therefore, backwash will beging at 1310 hrs tomorrow. Collected process readings shortly after startup. Received preliminary results from process lab (see log book). Calculated total backwash flow based on last backwash performed @ 1515 hrs (6/14). Total backwash flow = 1,690 gal. (recorded before and after backwash pump flowmeter) |
| 06/16/01 | Did not backwash, should be automated. Running in auto mode / fied filtration / normal backwash. Filter run timer: backwash start setpt 24 hrs, filter shutdown setpt 30 hr. Filter DP: backwash start setpt 65 inH2O, filter shutdown setpt 70 inH20. Filter infulent flow rate: fied flow setpt 11gpm, variable flow setpt 17 gpm | 1) Process air flow flux 5.5 - 6.5 scfm 2) Collected backwash 6.5 min into final wash; initiated backwash sequence @ 19.9 hrs 3) cleaned turbidity meter & bubble trap (lost flow to meter ~0930-1000 hrs); 4) bleached S6 suction line & overflow bucket | |
| 06/17/01 | 0820 hrs. Backwash stuck @ 1st step (quick drain). SCADA screen showing 5in on level sensor prior to intiiating backwash 38in on level. Vendor doc states appro 90 sec to remove 3 ft.(38-5=33) Need to lower media level by 3 in. 0820 hrs Manual raked media to side of column and backwash started. SCADA showing 4in on level sensor. | 1) Acknowledged SCADA alarms (0844 hrs): 7/16 1335 lift station 2 pump 1 high temp, 7/16 1335 lift station 2 pump 2 high temp, 7/16 1337 lift station 2 high level (due to Roberto securing control panel for pump rewire); 2) 1130 cleaned BAF CW tank using C2 water - removal of algae growth | 0820 hrs Manual raked media to side of column and backwash started. SCADA showing 4in on level sensor. |
| 06/18/01 | 0731 Alarms - filtered run aborted; backwash required. Alarm summary - (6/17-11:31:22) Filtration in progress. Filter 1B filtration aborted. Filter idle in progress. Filter backwash required. (6/18-6:47) Process air blower 1B failure. Cross checked field DO meter to lab. Field meter appro. -0.2-0.3 difference comparing field DO reading - vs. sample bottle. Auto backwash still doesn't work; initiated backwash @1012; filter running in semi-auto. | 1) at 0918: Cleared the following SCADA alarms: 7/17 1336 BAF1 backwash pump low, 7/18 0338 combustible gas detector 1 high. At 1130: 7/18 1125 BAF1 raw water pump trip, 1125 BAF1 raw water low level, 1130 lift station #2 low level, 1130 lift station #2 pump overload. Cleared lift station #2 alarms by lifting hatch and "shaking" floats. Unable to clear combustible gas detector reading 10% (#2-0). Maint recalibrating; calibration gas 29% meter reading 39%; no way to adjust meter (Michelle Warnock). 2) 1230 Cleaned turbidity meter. 3) Collected backwash @1121, 11.5 min into filter to waste 4) 2035 Tim T. "D" Crew: acknowledge alarms, reset strobe lights, H2S detector 1-high and 2-high, combustible gas detector 1-high, 1-HiHi, 2-Hi, 2-HiHi | Auto backwash still doesn't work; initiated backwash @1012; filter running in semi-auto. |
| 06/19/01 | Difficulties calibrating pH probe - changed electrode. From SCADA alarm summary (6/19-22:36) BAF raw H2O lowlevel. Raw water pump trip. Wide spot 2 low level. No sample collection due to raw water pump trip out @22:36. | 1) Plant shutdown 0400 - 0520 to return w. eff. channel to service. 2) Received voice message that S2 sampler suction line plugging - no flow to overflow bucket. ? Due to plant shutdown? Cleaned/bleached overflow bucket; installed larger diameter suction line to overflow bucket. 3) acknowledge SCADA alarms: 7/19 0816 combutible gas detector 2 HiHi, 7/19 0816 CGD 2 High, 7/19 0819 CGD 1 HiHi, 7/17 0820 CGD 1 High. 4) Shinn contractors in working: set off following alarms 1032 wide spot 1 low level; 1032 feed pump 2 general alarm, 1032 feed pump 1 general alarm. 5) Did not collect backwash sample (missed sequence); 6) 1530 Cleaned turbidity meter 7) 1520 Cleaned S6 overflow bucket. | No sample collection due to raw water pump trip out @22:36. |
| 06/20/01 | Unable to view screen; blower off (730). Influent turbidity - took grab from overflow bucket; previous grabs were manual grabs using sampler. | Initiated backwash sequence @ 1137 @23.4 hr filter run time. 2) collected backwash sample @ 1205, 5 min into final rinse 3) During backwash cleaned fine screen and baskets; cleaned turbidity meter including bubble trap. 4) acknowledge high LEL alarm @ 2215; alarm came in @1925 5) 2015 noticed the influent sampler tube came off the water and only has approx 1.5 inches of sample taken, put tube back, strap needs to be tightened. 6) LEL sensor reads 0.6 (south) & 0.7 (north) | |
| 06/21/01 | Missed pre-backwash data. | 0720 changing out sample bottles on S2 and S6, reset units, samples to lab, reset LEL alarms. At 0425 hrs arrived to find skid in shutdown. Missed required backwash period (30 hr) bt ~5 min, proceeded to restart at panelview and found panelview not functioning. Panelview screen black and touch screen not functioning. Tried (/_\) key with no luck. Cycled power with no response and attempted again after pulling power cod and reinstalling worked (see note 5, 6/15). Booted PC up and proceeded to semi-auto backwash. At 0430 hrs noted alarms associated with skid shutdown: (Facility OIS) Biological Aerated Filter 1 Common BAF1_FAIL - 4:18:54; (BAF Skid Panelview) Filter backwash req'd - 4:22:02, Placed Filter in OFF mode - 4:28:03, could not acknowledge panelview alarms with skid in backwash. Skid facility feed pump FP4 is being held off by facility PLC until BAF skid alarms are acknowledged. Acknowledge worked after backwash completed. Documetation of BAF "normal" backwash sequence (per panelview screen). Collected backwash grab sample 10.5 min into final rinse. talked with shift ops - as of late yesterday, maintenance has been dewat | This flow will then enter East primary effluent channel and potentially be pumped via Test Facility sumbersible. The quality (odors, scum, etc) of this water is not good. Expect to see additional odors and sample analysis data fluctuations. |
| 06/22/01 | Alarm summary: (6/22-5:17:03) filter backwash required. | 0720 changed out samples bottles on S2 and S6, reset samplers and sample bottles to lab - the "master key" works every time! Filter in auto-mode; backwash still not initiated after 24 hrs, put in backwash @ 0830 hrs. Missed effluent DO reading. Checking initi8al five screen bucket - should be OK through the weekend. Samplers off for the weekends. Backwash sample collected 5 min into final rinse. At 1020 hrs turned on scrubber fan. Plan to run throughout day and check operation. At 1705 hrs plan to leave scrubber fan running with rollup door open. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 06/23/01 | | At 0600 hrs initiated backwash in semi-auto mode. Backwash stuck in step 1 (quick drain). At 450 sec of quick drain, checked media level on top of column. Media was mounded with cone in center of column. Also reading on SCADA = 10 in. Level required to be @ ~4 in to continue backwash sequencing. Racked media away from center with no luck so lifted sensor upqard until air blower started (next backwash step). Backwash continued to 2nd step after 650 sec. Will email and call IDI on Monday to discuss this problem. we do not want this happening in AUTO backwash mode! Cleaned S2 and S6 sampler overflow buckets. Need to replace 3/8 in sample line on S2 tap with 1/2 in sample line. Found 3/8 in X 1/2 in fitting plugged with debris. Skid returned to filtration in semi-auto mode. | |
| 06/24/01 | Grab backwash final rinse - 9.8 min into cycle. | Trained Durbin on checklist and samples. Started samplers. Experience same problem with backwash sequence as that onb 6/23 - raked and lifted level sensor, backwash continued to step 2 after 999 sec. Skid returned to filter in semi-auto mode at 1020 hrs. | |
| 06/25/01 | Initiated backwash sequence @22.2 hrs (0834 hrs) - had to rake media, progressed to step 2 after 526 sec. | Initiated backwash at 22.2 filter run time (0834 hrs), had to rake media to lower level. Bakcwash grab collected 9.8 min into final rinse. Integrity of S2 sample questionable; no flow discharging from overflow bucket; cleaned bucket and verified flow from suction side; sampler in service. Hosed skid find screen and trays. Skid in filtration mode at 0944 hrs. Talked with IDI (Sudhakar) about backwash hanging up on 1st step - quick drain. We agreed to remove several buckets of media to solve. Restraint is hold media level above uppermost sampling tap. Plan to remove media during backwash sequencing tomorrow. Document amount of media removed. Continued to troubleshoot of CW1 tank level sensors. developing as-built wiring schematic. | |
| 06/26/01 | Collect 26 grab @ 1001, filter to waste 9 min. | During 1st step of backwash, removed 2X 4 gal buckets of media from column. This should eliminate the hang-up in 1st step of backwash (reference note 6, 6/25). Monitor during tomorrows backwash. Backwash grab collected ~13 min into filter to waste at 1018 hrs. Cleaned turbidity probe. At 2020 hrs noticed red light flashing - no siren. Odoro control - "no flow" alarm, building smells bad. H2SO4 gas monitors reading 4.1 & 3.7 ppm, #1 LEL reading 7%. Spoke with BB. | |
| 06/27/01 | 0842 - unit only online for 10 minutes following provess air blower failure. Verify flow rate to turbidity meter - 0.4-0.6 gpm. Initiated backwash @ 20.2 hrs - 0914 hrs; level stopped @ 6ft; raked media - will remove more media 6/28. | (Alarm summary) filter 1B filtration aborted - 06:27, Process air blower failure - 06:27; (SCADA alarm summary) H2S detector 1 high - (6/26) 20:36, H2S detector 2 high - 07:15. Reset process air blower; returned to filter 08:30 hrs. (SCADA alarms) H2S detector 2 high - 0951 hrs, H2S detector 2 high 1320 hrs. | |
| 06/28/01 | s2 - suction line plugged. Overflow bucket pluffed - sample integrity? | Backwash still in semi-auto; media still coning in center; raking required to reduce filter level to 4 inches to continue backwash sequence. Trained a screw (MD and Rick Salisbury) on checklist and samplers. Flow to turbidity meter continues to flux - NTUs appear to be high. | |
| 06/29/01 | | At 1020 hrs adjusted effluent turbidity meter flowrate from ~ 100 mL/min to 600 mL/min. Turbidity spiked from 3.5 NTU to 25 NTU - slowly decreasing over time. At 1110 hrs missed required backwash timer by 10 minutes. Silenced skid alarm and proceeded into backwash. Completed semi-auto backwash at 1220 hrs. Reqired CW tank level switches per IDI. Placed unti in Auto mode and will test AUTO backwash tomorrow. No DO or pH reading today - plan to run tomorrow. Reset H2S alarm on computer screen at 2315 hrs by M Dawson. | |
| 06/30/01 | | Reset H2s alarm on computer screen at 2340 hrs by Mike Dawson. | |
| 07/01/01 | | at 0800 hrs restarted samplers. At 1348 hrs backwash in AUTO initiated per skid SCADA completed at 1439 hrs. 2018 - 2024 hrs received H2S high and high-high alarms. At 2035 hrs troubleshooting unit shutdown. 1440 hrs BAF1 raw water low level and raw water pump trip. Reset alarms at SKID and tried to start. Found unit in idle mode. During startup received process air blower high pressure alarm. Also noted dark water from process air blower. At 2235 hrs process air pressure high alarm. 9 psig showing on process air blower discharge. Process air blower will not reset. Removed temperature gage to relieve pressure - air/water mixture out of tap. After venting noted pressure gage and pressure switch stuck @ greater than ambient pressure. Tapped with wrench to pressure gage dropped to 0 psig and high pressure alarm (pressure switch) cleared. STarted unit in AUTO - filtration. Process air blower showing 15 scfm but running very slowly for several minutes. Eventually process air blower stopped & flow slowly decreased from 15 scfm to 8.5 scfm with process air not running flowmeter showing 8.3 scfm (offset reading?). If flowmeter is mass flow - ar | |
| 07/02/01 | 0930 - Secured PE feed pump to calibrate LEC & H2S. Note - backwash intiated by high differential pressure. | At 0900 hrs secured PE feed to test facility (& pilot) to run calcibrations on LEL and H2S detectors. Completed at 1130 hrs. Working startup of pilot unit. Noted in OFF mode (from yesterday) that process air blower started - assumed this is 5 minute run/hr to maintain biomass. Need to check IDI notes. Noted that process air blower dicharge flowmeter had returend to 0.0 scfm. Noted process air ON from 1135 to 1140 hrs. Pilot started at 1145 hrs, total downtime of 21 hrs. Assumed process air operating @ 5 min/hr during OFF period. Cleared fine screen on pilot skid. Noted that process air blower flowmeter reading on SCADA screen is erratic (jumping from 5.5 to 6.5 - 6.0 scfm setpt). Local indication @ the flowmeter is steady. Will continue to mintor. At 2345 hrs Tim T; unable to reset H2S alarm, also not able to log in to acknolwedge alarms. At 0200 hrs (7/3) water leaking from under biofor filter. Voice mail to SA. | |
| 07/03/01 | 1052 - backwash in progress - filter run time 23.1. | Floor drain under skid plugged; overflow from turbidity meter and overflow bucket S-6 flooding floor; added additional hosing to drain lines director to another floor drains. No composite sample collection. Bleached S2 line; cleaned S6 overflow bucket. Cleaned turbidity meter. Automatic backwash sequence started at 1052 filter run time only 23.1. At 1212 hrs - no flow to turbidity meter. Acknowledged the following alarms at 1216: H2S detector 2 hihi - 1134, H2S detector 1 hihi - 1135, H2S detector 1 high - 1135, BAF1 raw H2O pump trip - 1146, Raw H2O low level - 1146, H2S detector 2 high - 1150, H2S detector 2 high - 1150. Bringing the East Effluent channel back on line. STarted pumping at 1045 hrs. Reference to note 5 - backwash initiated by differential pressure of filter (65 in H2O) and not by time (24 hrs). This is woth noting since it is the 1st occurance of high differential pressure. No sample collection until friday. Need to turn ON autosamplers on Thursday morning. | |
| 07/04/01 | BAF unit stuck in backwash for 13.5 hours. See attached printout to OD. | 0140 hrs red alarm flashing - all 4 monitors reading 0 %ppm, spot tanks 2 and 3 water level below overflow piping (J Durbin). 1219 hrs reset H2S alarm, secured red beacon (Wolvinston). 2245 hrs system in backwash (Durbin). 0035 hrs system still in backwash mode/adjust sensor - system back on line (Durbin/Tramble). | |

| Date | Comment 1 | Comment 2 | Comment 3 |
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| 07/05/01 | Backwash performed early to remove media from column (55 gal. buckets removed.). BB adjusted to 0.45 for effluent turbidity flow post backwash. | BAF stuck in backwash cycle from 1143 hrs (7/4) until 0115 hrs (7/5). This was due to liquid level sensor waiting for media level to drop below 5 inches. Most likely media was mounded and only was fixed after shit ops pulled liq level sensor to trip into 2nd step in backwash sequence. "Will pull additional media today!" At 1330 hrs replumbed BAF1 effluent turbdiity line to eliminate flow fluctuations. Line now terminates at effluent discharge tee downstream of BAF skid effluent valve. At 1300 hrs cleaned sampler offflow buckets and started samplers S2 and S6. Initiated backwash and removed 5 X 5 gal buckets of media to eliminate problem of hanging up during Auto backwash. Will monitor tomorrow. | |
| 07/06/01 | Initiated backwash early to check media level (post removal yesterday) and to establish consistent more backwash cycle. | At 0825 hrs pulled composite samples and delivered to lab. Backwash started at 0840 hrs and successfully proceeded through all steps with no hangups - looks like media removal worked. Collected backwash grab sample (S6g) during end of 1st rinse. Need to stndardize sample collection at same time each backwash. Continue to collect at end of 1st rinse step. Unit back in filtration at 0938 hrs. At 1540 hrs acknowledged H2S high alarm. | |
| 07/07/01 | | At 1205 hrs system in backwash mode. Had to adjust level sensor to job to next step (DD). | |
| 07/08/01 | | 1300 hrs System in backwash mode, adjusted level sensor to job to next step (TT). | |
| 07/09/01 | Cleaned both overflow buckets. S6 - sample line plugged; no flow to overflow bucket; collected a grab. Unplugged sample line. Cleaned fine screen and trays. | At 1345 hrs no flow to turbidity meter and no flow to spot tank #2 (Durbin). Collected S6g at end of 2nd air/water rinse in backwash sequence. Cleaned turbidity meter at 1545 hrs. At 2200 hrs acknwoledged H2S alarm and reset strobe light (TT). | Cleaned fine screen and trays. |
| 07/10/01 | Field pH probe 00S - used lab pH meter. Cleaned out S6 overflow bucket. | At 740 hrs, no flow to turbidity meter - resumed flow. No flow to S6 sampler; unplugged sample line; collected a grab. Cleaned turbidity meter at 0855 hrs. Increase flow on turbidity meter at 1125 hrs. At 1025 hrsno flow to turbidity meter, no flow to spot tank #2 (Durbin). At 1410 hrs initiated energetic backwash per IDI. Energetic backwash hung-up at 1st step (quick drain) raked to proceed (showing 5 in, decreased to 4 in). After energetic backwash, returbed to filtration to record. Energetic backwash stopped after air-scour step: showing backwash in progress; air scour blower not runnin but showing 3 scfm on flowmeter; filter level @ 6 in; semi-auto mode/backwash/energetic; process air operating. Aborted energetic backwash and attempted 2nd try (level @ 6 in. / manually adjusted to move past 1st step). Noted air scour operating @ 33 scfm vs. 3.8 scfm per manual. Completed normal backwash - will troubleshoot energetic backwash prblem tomorrow w/ IDI. At 1539 hrs acknowledged H2S high alarm. | |
| 07/11/01 | Initiated backwash @1312 (20.9) | At 1312 hrs initiated backwash, filter run time 20.9 hrs. S6g sample collected at 1337 hrs, 4 min into final rinse. At 130 hrs no turbidity meter flow, raked screen, H2S 02/0/5. LEL 4/0 (Durbin). | |
| 07/12/01 | Cleaned turbidity meter. SCADA alarm 1310 - H2S detector high. | At 600 hours secured facility scrubber fan in support of BAF checkpoints with IDI via telephone. At 0845 hrs completed energetic backwash with ladder logic editing support from IDI (Joe Valent). Discovered (2) logic errors which stopped program. Also adjust liquid level setpoint for quick drain from 4 in to 8 inches. At 0940 hrs initiated standard backwash per IDI instructions. Restarted facility scrubber fan. Collected grab sample following energetic backwash (for visual inspection only). | |
| 07/13/01 | 1600 hrs adjusted effluent turbidity flow to 0.6 lpm. | 0045 hrs no turbidity flow, ACK alarms, H2S alarm 0.3/0.5, LEL 0/4. Sampler S6 not on (Durbin). At 0835 hrs delivered S2 and S6 samples to lab. S6 sampler not "on" - noted last night. Collected grab sample from S6. At 2200 hrs acknowledged OSC lift station 2 low level alarm (MW). | |
| 07/14/01 | | At 2315 hrs adjusted flow to turbidity meter to 0.6, was at 0.275 (MW). | |
| 07/15/01 | | Opened lift station 2 lid and reset float switch with "shake" of stainless cable. Note: This re-occurring problem with be fixed tomorrow by WTP maint. Elect -low level alarm flow & off float will be wired in series with pump start circuits. At 915 hrs cleaned BAF1 effluent turbidimeter and inlet rotometer. At 900 hrs cleaned S2 sampler and started. At 920 hrs cleaned S6 sampler and stared. Cleaned (replaced) primary effluent fine screen "trash" bucjet. | |
| 07/16/01 | 746 hrs process air flow fluxing greatly, between 5.5 to 6.6. Backwash initiated at 19.9 hrs filter run (854 hrs) | Process air flow flux 5.5 - 6.5 scfm. Collected backwash 6.5 min into final wash; initiated backwash sequence at 19.9 filter run time hrs. Cleaned turbidity meter and bubble trap; lost flow to meter `9:30-10:00 hrs. Bleached s^ suction line and overflow bucket. | |
| 07/17/01 | | At 0844 hrs acknowledged SCADA alarms: Lift station 2 pump 1 High temp (1335); Lift station 2 Pump 2 High Temp (1335); Lift station 2 High Level (1337). Due to Roberto securing control panel for pump rewire. At 1130 hrs cleaned BAF CW tank using C2 water removal of algae growth. | |
| 07/18/01 | | At 918 hrs cleared the following SCADA alarms: BAF1 backwash pump low (1336); Combustible gas detector 1 high (0338). At 1130 hrs: BAF1 raw water pump trip (1125); BAF1 raw water low level (1125); lift station 2 low level (113); lift station 2 pump overload (1130). Cleared lift station 2 alarms by lifting hatch and "shaking" floats. Unable to clear combustible gas detector reading 10% (#2-0). Maint recalibrating; calibration gas 29% meter reading 39%, no way to adjust meter (Warnock). At 1230 hrs cleaned turbidity meter. Collected backwash at 1121, 11.5 minutes into filter to waste.At 2035 hrs acknolwedged alarms, reset strobe lights (H2S detector, 1-high and 2-high, combustible gas detector 1-high, 1-hi-hi, 2-hi, 2-hi-hi (TT). | |
| 07/19/01 | Plant shutdown (730 hrs?) | 400-520 hrs plant shutdown to return west effluent channel to service. Received voice message that S2 sampler suction line plugging - no flow to overflow bucket. ? Due to plant shutdown? Cleaned and bleached overflow bucket ; installed larger diameter suction line to overflow bucket. Acknowledged SCADA alarms: Combustible gas detection 2 high high (0816); Combustible Gas detector 2 high (0816); Combustible gas detector 1 high high (0819); Combustible gas detector 1 high (0820). Shinn contractors in working set off following alarms: wide spot 1 low level (1032); feed pump 2 general alarm (1032); feed pump 1 general alarm (1032). Did not collect backwash sample (mixxed sequence). Cleaned turbidity meter at 1530 hrs. Cleaned S6 overflow bucket 1520 hrs. | |
| 07/20/01 | Initiated backwash at 23.4 hrs filter run (1137) | Initiated backwash sequence at 1137 hrs (23.4 filter run time). Collected backwash sample at 1205 hrs, 5 min into final rinse. During backwash cleaned fine screen and baskets, cleaned turbidity meter inclduing bubble trap. At 0245 hrs acknolwedged high LEL alarm (1925). Noticed the influent sampler tube came off the water and only has approx. 2.5" of sample taken. Put tube back, strap needs to be tighter at 2015 hrs. LEL sensor reads 0.6 south $ 0.7 North. | |
| 07/21/01 | | 0720 hrs cahnging out sample bottles on S2 and S6. Reset-units, samples to lab, reset LEL alarms. (MD). | |
| 07/22/01 | | At 720 hrs changed out sample bottle on S2 and S6, reset samples and sample bottles to lock up lab, the "master key" works every time! (MD). | |

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 07/23/01 | No DO readings, meter being used for hollywood project. Initiated backwash at 18.8 hrs filter run time (911 hrs). | S2 suction sample line to over flow bucket plgged, collected a grab. Need to increase size of tap. Initiated backwash at 0911 hrs (18.8 filter run time) to make collection of backwash sample, collected backwash ~5 min into final rinse. Cleaned fine screen. S6 line to overflow bucket also plugged, need to increase line size; bleached bucket and lines. Cleaned turbidity meter; bubble trap and rotometer; even with tap fully open only getting 0.4 lpm. | |
| 07/24/01 | S2 NTU for 7/23 - 68.1 | Mixxed backwash sequence, no sample collected. | |
| 07/25/01 | (752 hrs) turbidity meter plugged, rotometer needs to be cleaned. | At 1145, turbidity rotometer plugged; cleaned. Turbidity line and skid cap plugged - cleaned. Rotometer continues to plug with stuff from line - will need to bleach line to remove grwoth buildup - will perform on Thursday. At 1800 hrs increased PE feed flow by fully opening PV1. Flow increased from 70 gpm to 150 gpm. Increased flow to eliminate potential for solids settling in supply piping. Data review revealed that solids deposition was occuring. If problem occures @ fine screen or WS3 (overflowing), reduce flow back to 70 gpm using PV1. Process lab viewed BAF effluent (S6) under microscope. Pin floc indeitified which may be cause of high tBOD values. Will repeat viewing tomorrow and photograph for record. At 2044 hrs acknowledged and reset alarms and strobe lights: H2S detectors 2 and 1 high and hi-hi (TT). | |
| 07/26/01 | | At 0845 cleaned turbidity meter. At 0950 initiated backwash easly - IDI (ondeo) representatives onsite. (Steve Terrelle / Art Shapiro / Roger Perrin). S6 grab (backwash) collected at end of 2nd rinse cyce, 1007 hrs. Troubleshooting backwash cycle with Ondeo folks. At 1600 hrs started effluent sampler (ops noted OFF at 1255 hrs). At 1255 hrs adjusted effluent turbidity flowmeter to 0.8 lpm (was > 0.1 lpm). Reset LEL alarms (TT). | |
| 07/27/01 | Backwash change filter-to-waste time increased from 15 to 20 min. | At 900 hrs deliverd S2 and S6 samples to process lab. At 915 hrs initiated backwash in semi-auto. Completed backwash - including filter to waste step using feed water. BAF feed pump (submersible in facility) is currently in LOCAL control. If facility SHUTDOWN occures - pump must be secured @ local panel. Pump in LOCAL to support BAF1 backwash cycle. BAF backwash grab sample collected as composite as following: 1st rinse, 2nd rinse, final rinse, filter to waste. Samples combined and single composite sent to process lab. Emptied facility fine screen bucket. Cleaned S6 sample overflow bucket and turbidity meter. S2 and S6 samplers setup for sunday start - only need to pusth START sampling. Changed BAF1 backwash step duration: Filter to waste increased from 15 to 20 minutes. | |
| 07/28/01 | No data collected. | | |
| 07/29/01 | | Acknowledge H2S alarm- 3.1 (south), 2.3 (north); Cleaned BAF effluent turbidimeter. Also rerouted drain line to floor drain near scrubber fan. Started S2 and S6 autosamplers. Relocated HP printer from Test Facility to Office. | |
| 07/30/01 | Initiated backwash at 21.7 hrs filter run time (952 hrs). | Acknowledge alarms: 7/29 1506 lift station #2 low level, 7/30 0729 H2s Detector 1 high; 0710 turbidity meter plugged, no flow. Bleached line from initial tap to trap and cleaned out rotameter. Cleaned overflow buckets S2 and S6. Started using new DO probe. Collected composite backwash per BB 7/27. Backwash sequence initiated at 0952, 21.7 filter run hours. Sampler count (S2 & S6): 21. | |
| 07/31/01 | (709) BAF placed in IDLE mode to support facility piping change @ WS tanks. Setpoint changed to 13 gpm (1515 hrs). | 0710 secured BAF1 (IDLE mode) to perform facility plumbing modification - DV6 changed to ball valve. LEL alarm in facility - instrumentation drift. Instrument vendor called to troubleshoot. 1000 returned BAF1 to filtration mode. Need to semiauto backwash at 1300 hrs. Initiated backwash at 1304; no backwash sample collected. Bleach S6 sampler suction lines & overflow bucket - algal growth. 1407 start S2 and S6 autosamplers. 1515 process change - feed flowrate increased from 11 gpm to 13 gpm. Plan to hold until Thursday and then increase to 15 gpm per Ondeo (Troy). | |
| 08/01/01 | | 0740 collect samples. 0806 acknowledge SCADA alarms7/31 1812 H2S detector 2 high. Still unable to clear facility alarm #1 reading 11%. 1013 initiated backwash and collected samples per BB 7/27. Cleaned skid fine screen and trays. 1500 acknowledge SCADA alarm H2S detector 2 high. 2300 reset LEL alarms & checklist - Mick Dawson | |
| 08/02/01 | (738 hrs) Turbidity meter leaking. (1430 hrs) Increased flow from 13 gpm to 15 gpm. Need to have filter in manual, neet to open to waste valve prior to starting. 2.43 filter overflow. | 0740 samples to lab. 0800 cleaned leaking turbidimeter. Performed monthly cleaning of process air network, followed by backwash sequence observations: filter should be in "manual" mode, waste valve should be open prior to start, to manually operate cleaning, put need to log in @ 2nd level of security. 1235 no effluent turbidity flow, reset to 0.8 lpm. 1430 increase feed flow from 13 gpm to 15 gpm. 1445 noticed wide tank 2 level dropping. | |
| 08/03/01 | Backwash in progress 816 hrs. | 0825 initiate backwash due to high filter differential pressure. Collected backwash sample but missed collection at last step, ie, to waste. 0950 hrs cleaned turbidimeter overflow bucket S6. 1306 acknowledge alarms 1300 H2S detector 1 high, 1305 H2S detector 2 high. | |
| 08/04/01 | | Acknowledged H2S #2 alarm, reset strobe (MW). At 1110 hrs noticed wide spot tank #2 the "top" portion fo the sump pump is showing, due to lower level of the water in the tank. | |
| 08/05/01 | Lowered flow to 0.7 lpm, turbidimeter overflowing at 0.9 | At 0730 hrs started autosamplers S2 and S6, also cleaned out S6 sampler overflow bucket. Readjusted DV14 to rerecieve more flow back into WS2 tan. Need to keep sumbersible pump covered (referece 8/4). Turbidimeter overflowing at 0.9, lowered to 0.7 (MW). 2350 hrs acknolwedged alarm FF1 area turbidity HI. | |
| 08/06/01 | unable to read effluent turbidimeter; needs cleaning | Cleaned turbidity meter ~ 1800; bleached all lines. Bleached all lines and overflow buckets for S2 and s6. | |
| 08/07/01 | | Bakcwash sequence intiated at 1153 hrs. Process air blower 1B failure at 1157 hours. Alarm ACK at 1242. Cleaned tubridimeter at 1250 hours. | |
| 08/08/01 | Unit in idle since 0800 to facilitate construction; returned to backwash 1340. | At 0805 hrs primary effluent feed secured for facility work. Planned downtime of 2 hours. Backwash filter in semi-auto following shutdown. Backwash intiated at 1340 hours; filter back in AUTO 1454 hrs. Samplers S2 and S6 started at 1438 hours. | |
| 08/09/01 | 1320, operator could not get SCADA screen to work | At 600 hrs, sample collection; 15 counts S2 volume line need to check sampler volume. Turbidimeter overflowing, cleaned at 1000 hrs. Cealend sampler overflow buckets, finescreen. | |
| 08/10/01 | | At 0830 hrs collected S2 and S6 samples and trasnported to process lab. S2 composite only had ~250 mL - due to power OFF to sampler (contractor work on Thurs 8/9). Move power for S2 sampler to new utulity outlet. At 0850 hrs BAF skid interface screen not functioning. Rebooted PC to re-establish. Eill talk to IDI next week about reason why screen "blacks" out. At 1530 hrs initiated abckwash in semi-auto mode. Collected grab (composited) from backwash. Returned auto-filtration mode. | |
| 08/11/01 | | At 1200 hours started samplers. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
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| 08/12/01 | | At 930 hours started samplers. Liftstation 2 had pump overload and low level alarms. Contacted Bob B, jiggled float switches for pump level came up and alarms cleared (MW). At 1457 hrs lift station alarms returned. Jiggled float switches and acknowledged alarm. Also BAF turbdiity alarms present will notify Bob B (MW). At 2055 hrs liftstation alarm on low alarm, jiggled the float alarms cleared (SU). | |
| 08/13/01 | | At 1130 hours adjusted turbidity flow, too much dirt /0.2, increased to 0.8 (flushed turbidity flowmete, NTU up to 40.0) and drop to 6.37 NTU. At 0135 hrs adjusted turbidity meter to 0.5 NTU (SU). At 0355 hrs lift station pump #2 on - low level alarm on - jiggled float cleared the alarm (SU). Alarms: Lift station 2 pump 1 overload (743); lift station 2 pump 2 overload (758); lift station 2 low level (759). Jiggling, still unable to clear. Samples to lab at 740 hrs. Cleaned turbiditymeter; and overflow buckets, fine screen and trays. Sampler turned on at 945 hrs. | |
| 08/14/01 | Performed backwash, process air network cleaning, energetic backwash (aborted in air cushion purge step) | At 0040 hrs acknowledged alarm on lift station 2 low level, pump 2 overload. Jiggled the float and cleared the alarm (SU). Left alarm on, computer to track time (SU). Collected S2 and S6 samplers at 730 hrs. Backwash sequence started on AUTO ~943 hrs. Performed process air network cleaning ~1109, performed energetic backwash ~1135, energetic backwash aborted @ 1146 due to clean water tank low level. Sequence stopped in an air cushion purge step ~ 0.6 min into step. Only missed 2nd rinse step (7 min). 1530-1600 hrs removed and replaced effluent turbidity tubing (3/8 - 1/2). | |
| 08/15/01 | Energetic initiated @1006, 21.9 hr filter run time (1007 - 1033); initiated std backwash immediately following energetic (1034-1105); sequence aborted 13.6 min into final rinse; manually filter to waste for 20 min by manually opening valve to waste (FV-8B) and turning on process air and feed. S2 sample a grab. | At 1007 hrs initiated energetic backwash, filter run time of 21.9 hours. Immediately initiated normal backwash sequence aborted at step final rinse (13.6 min into 15 min step); manually compledted backwash step filter to waste by manuallu opening valve to waste (FV-8B); turning on process air and feed - duration step 20 minues. Filter put in idle; WS2 tank submerged pump turned off - fine screen overflowing. Turbdidimeter cleaned. At 1200 hours secured PE feed to unit for facility work (checkout of mov1 vlave). At 1330 hours restarted unit un auto-filtration. At 1200-1300 hrs cleaned backwash tank (algae growth on interior walls). S2 sample a grab; container not centered. | |
| 08/16/01 | Effluent turbidity flow pegged out; difficult to get a constant flow continue air bubbles. | S2 container not centeredl partial sample. Clean turbidimeter at 815 hrs. At 1015 hours rebooted test facility PC. | |
| 08/17/01 | | Samples to lab; samplers off - for weekend; bleached S2 and S6 overflow buckets, cleaned fine screen and turbidity meter. At 1445 hrs increased feed flow from 15 to 17 gpm. Plan to remain at 17 gpm until early next week and then increase to 19 gpm. At 1500 hrs restarted BAF unit - troubleshooting AUTO control setpoint. Discovered feed flow control valve in manual (vs. auto). | |
| 08/18/01 | | at 900 hrs no samples. At 1740 hrs adjusted effluent turbidity flow from o to 0.7 lpm. | |
| 08/19/01 | | Started sampler, cleaned sampler drain (SU). | |
| 08/20/01 | | Noted backwash occurred at 0405 hrs. Need to monitor throughout week, when occuring. Cleaned sampler overflow buckets, transferred S2 and S6 samples to Process lab at 0830 hrs. Cleaned BAF effluent weir and sides with broom. Cleaned skid 3 mm screen. | |
| 08/21/01 | Effluent turbidity flow adjusted to 0.7 lpm. Bob Bucher | Pulled S2 and S6 sampler - delivered to lab at 900 hrs. At 100 hrs cleaned effluent turbidimeter and adjusted flow. Cleaned S6 sampler. Talked with Teresa about "intensive" week sample analysis. She will be holding NH4-N until next week Monday to batch. | |
| 08/22/01 | Flow setpoint changed 17-19 hours after backwash on 8/22. Bob Bucher | At 1540 hrs initiated backwash to collect backwash sample, filter run time 17.8 hrs. Completed backwash and returbed to AUTO-filtration mode. Increased feed setpoint from 17 to 19 gpm. Cleaned S6 sample bucket and turbidity meter/ Need more operator sheets - tomorrow. Record in logbook for tonight. | |
| 08/23/01 | Adjusted turbidity flow to 0.6 lpm by Bob Bucher (1330 hrs). Turbidimeter cleaning required - high flow @ control valve is causing a riased NTU (Bob Bucher, 2015 hrs). | 0845 hrsd Samples collected and transported to process lab (S2 and S6). Left message with Joe Valent to setup time for revised PLC logic for backwash sequence with facility feed pump. | |
| 08/24/01 | | At 0845 hrs pulled S2 and S6 samples and transported to Process Lab. Cleaned S6 sampler and effluent turbidimeter. Joe Valent (ondeo) revised PLC logic to provide contact for backwash - facility feed pump control interface. Portland Eng will reprogram facility side on Tues - afterwards we will reun BAF1 feed pump in AUTO. | |
| 08/25/01 | | At 800 hrs collected S2 and S6 and backwash samples and transproted to lab. Lost ~100 mL of S2 sample to the floor. Cleaned S2 sampler setup. No evening daily operations sheet entry! Noted that skid fine screen overflowing during backwash. Cause - facility feed pump set to deliver >20 gpm for process operation. When in backwash, this flow is directed through 2in overflow which can not handle. On Tues I/C contractor will correct logic so facility feed pump will secure during backwash. For now, allow to overflow to floor during backwash. Cleaned turbidimeter and S6 sampler overflow bucket. | |
| 08/26/01 | | At 0805 hrs collected S2 and S6 samples and delivered to Process Lab. Cleaned turbidimeter and S6 sampler overflow. Noe that BAF is now backwashing MORE THAN 1 Time per day! This is due to increased loading, I.e. increased feed flow. | |
| 08/27/01 | | At 630 hrs adjusted turbidimeter flow meter from 0 to 0.5 lpm. S2 and S6 samples to lab at 740 hrs. Cleaned skid find screen, bleached overflow buckets and lines for S2 and S6, cleaned turbidimeter and rotometer. | |
| 08/28/01 | At 708 system in backwash - 13.2 hrs filter run time; filter differential pressuure was 77". No IDI reading, panel not working. | | |
| 08/29/01 | At 1211 reboot computer. | At 0120 hrs BAF condtrol panel won't come out, no readings. At 1215 hrs initiated backwash in Semi-Auto mode to checkout new logic, successful. At 1210 hrs rebooted skid control panel PC, backwash now operational with BAF feed pump in AUTO position. At 1300 hrs put BAF in IDLE mode to support MV1 valve checkouts. At 1415 hrs BAF in Auto-filtration. | |
| 08/30/01 | At 110 hrs, no panel indicator available. At 730 hrs, skid screen down. At 2024 hrs, adjusted process: Feed flow 19 to 21 gpm, process air from 6 to 7 scfm, filter backwash DP setpoint from 65 to 70 inches, and filter shutdown DP setpoint from 70 to 75 inches. | At 0110 hrs no BAF control monito, no readings. Computer is down, flushed influent sampler drain, hosed around screen area bucket overflowed, cleaned scrap debris off screen influent. At 0800 hrs #1 fine screen (primary influent) overflowed; bucket overflow line plugged with grit; Burman indicated skid been overflowing since Thursday. Cleaned S2 and S6 sampler overflow buckets, turbidimeter, and skid fine screen. At 1300 hrs conference call with IDI. Discussed current available data through 8/17, discussed continued feed flow increases. Also need to increase abckwash DP setpoint from 65 to 70 inches. Mentioned that HDR will be included in next conference call. At 2025 hrs process control chances, feed flow from 19 to 21 gpm, process air flow from 6 to 7 scfm, backwash DP setpoint from 65 to 70 inches. filter shutdown DP setpoint from 70 to 75 inches. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
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| 08/31/01 | | From 1300 hrs to 1330 hrs put unit in idle for facility modifications. At 220 hrs cleaned screen and pumped bucket. | |
| 09/01/01 | | At 1240 hrs cleaned turbidimeter with bleach. Cleaned S6 over flow bucket and bleached suction line to bucket. At 1415 hrs process air blower failure; system went into idle; reset blower and system returned to filter mode. | |
| 09/02/01 | | At 1150 hrs cleaned turbidimeter and adjusted turbidimeter flow. | |
| 09/03/01 | | At 0400 hrs cleaned the bucket and bin under the fine screen #1. Also raked the screen clean and washed down floor areas around screen. At 100 to 1030 hrs cleaned sampler overflow bucket and effluent turbidity. Looking at relocating effluent sampler to top deck and installing hose into process weir. At 1015 hrs effluent and influent samplers started. Primary influent pump feeding MBR tripped on overload. Closed DV6 and opened DV13 to provide primary effluent to WS3 and MBR unit. At 1430 hrs adjusted turbidimeter flowrate back to 0.6. | |
| 09/04/01 | | Cleaned turbidity meter and rotometer. | |
| 09/05/01 | 1115 hrs; initiated backwash with 18.2 hrs filter runtime. | At 0810 samples were sent to the lab; flushed overflow buckets. Cleaned turbidimeter at 1030 hrs. Initiated manual backwash at 1115 hrs; filter run time of 18.2 hrs; cleaned scum buildup on weirs, beach and walls; collected backwash grab sample. At 1430 hrs discovered unit in semi-auto with no operational mode indentified (FILTER, BACKWASH, or IDLE). Could not get unit to start in AUTO. Found low level alarm in feed screen tank and switched feed pump to manual to reinitiate flow. Worked, but will not return to AUTO. Discussed with Portland Eng. with Wonderware secured during backwash unit was not able to return to facility feed pump AUTO mode. Link broken in communicator. Fixed problem at 1825 hrs and returned to AUTO-FILTRATION. | |
| 09/06/01 | At 0024 hrs, changed turbidity flow to 1, was initially at 0. | At 0030 hrs adjusted effluent turbidity flow from 0 to 1.0, NTU at 0 = 9.5, NTU at 1.0 = 13.54. | |
| 09/07/01 | | Bleached overflow bucket and lines for S2 and S6; left flow valve closed; needs to be opened on Sunday. Cleaned turbidity meter and rotometer at 10o0 hrs. | |
| 09/08/01 | | | |
| 09/09/01 | | At 0920 hrs cleaned turbidity meter and started S6 sampler. | |
| 09/10/01 | At 0934 hrs initiated energetic backwash. | At 0934 hrs performed energetic backwash and cleaned turbidity meter. | |
| 09/11/01 | | Cleaned turbidity meter and bleached S6 overflow bucket. | |
| 09/12/01 | At 0811 hrs PH readings seem high, recalibrated probe. Cleaned turbidimeter; rotometer (1240 hrs) bleached line from skid. S6 sampler in service at 1250 hrs. | S6 sampler left in standby. | |
| 09/13/01 | DO probe checked aainst lab (9/12): lab = 7.78 mg/L, portable = 7.76 mg/L. At 0836 hrs turbidimeter flow from 0.2 to 0.8 lpm. | At 1030 hrs performed process air network cleaning followed by backwash; cleaned scum buildup off sides and weir. Collected backwash grab sample. Following backwash experience pump failure (1146 hrs), reset and put back in Auto filtration, but failed again. Reset breaker in field panel, this worked. Filter back in service at 1425 hrs. Reminder: wide spot tank 2 pump is operated in auto during process air network cleaning put in off. Increased primary influent flow rate from 85 gpm to 125 gpm using PV1. Need to hold flow greater than 100 gpm to maintain line velocity. | |
| 09/14/01 | At 0844 hrs temp probe not functioning. | At 0125 hours effluent sampler and MBR not on "no sample." At 1534 hrs filtration aborted (post backwash) due to influent feed pump failure. Reset feed pump and blowers, was able to retun to Auto filtration mode. | |
| 09/15/01 | | At 0100 hrs both samplers off. | |
| 09/16/01 | At 1330 hrs S2 and S6 samplers started. | | |
| 09/17/01 | At 0839 hrs can't read turbidity meter. | At 0900 hrs cleaned turbidity meter, rotometer, skid fine screen and basket. Trained backup staff. | |
| 09/18/01 | At 0727 hrs buildup in turbidimeter observed. | At 0850 hrs cleaned turbidity meter, rotometer, and flushed S6 overflow bucket. | |
| 09/19/01 | | | |
| 09/20/01 | | | |
| 09/21/01 | At 1746 hrs initiated backwash to support cleaning of BW tank. | Bleached S6 overflow bucket and lines. Cleaned turbidimeter, bleached lines and rotometer. At 1746 hrs initiated backwash in support of manual clean of BW tank (outside). At 1815 hrs cleaned outside backwash tank (algae buildup). | |
| 09/22/01 | | No activity. | |
| 09/23/01 | | No comments. | |
| 09/24/01 | | Cleaned turbidimeter, rotometer, skid find screen. Bleached S6 overflow bucket. | |
| 09/25/01 | | No comments. | |
| 09/26/01 | | At 0945 hrs increased flow and aeration to unit. Flow increased from 21 to 23 gpm. Aeration increased from 7 to 8 scfm. Plan to hold this condition until early next week. | |
| 09/27/01 | At 0915 hrs started S5 sampler. At 0930 hrs started S2 sampler. | At 1045 hrs cleaned turbidity meter and overflow bucket S6. | |
| 09/28/01 | | Bleached all lines; turbidity meter, rotometer, and sample S6 overflow bucket. Slime buildup has increased with increased process flows. | |
| 09/29/01 | | No comments. | |
| 09/30/01 | | No comments. | |
| 10/01/01 | At 0837 hrs process air blower 1B failure; reset blower return to filtration. Lost filter run time when blower failed. Initiated manual backwash at 1042 hrs. At 2245 hrs adjusted elffuent turbidity flow from 0 to 0.5 gpm. | At 0837 skid alarm: process blower 1B failure; reset blower and returned to filtration. Initiated manual backwash at 1042 hrs, collect backwash grab, cleaned sides and weir of scum. At 1550 hrs adjusted effluent turbidity flow from 0.2 to 0.7 Lpm. At 1600 hrs feed tank low alarm, unit shutdown to idle. Troubleshooting: reset process air blower on screen; verified facility feed pump operational by operating in hand; restarted system in auto-filtration. | |
| 10/02/01 | At 1042 hrs adjusted effluent turbidity meter flow from 0 to 0.4 gpm and cleaned turbidimeter. | No comments. | |
| 10/03/01 | At 1956 hrs - start of feed tank low level signal. | At 0940 hrs cleaned turbidimeter and flushed S6 overflow bucket. | |
| 10/04/01 | At 1649 hrs reset turbidity flowmeter. | No comments. | |
| 10/05/01 | At 0958 hrs reset turbidity flowmeter from 0.0 to 0.5 gpm. | No comments. | |
| 10/06/01 | At 1330 hrs adjusted turbidity meter from 0.0 to 0.4 gpm. | No comments. | |
| 10/07/01 | At 1002 hrs last signal feed tank low level. At 1015 hrs cleaned overflow weir. At 1030 hrs cleaned feed screen. | Discovered unit has been cycling in/out of filtration due to low feed tank level. This has been occurring since 10/3 (Wednesday). Approximately 2 mines filtration OFF each time it occurred. Cleaned feed screen and ncreased flow to skid by fully closing | |

| Date | Comment 1 | Comment 2 | Comment 3 |
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| 10/08/01 | Changed setpoints, flow from 23 to 19 gpm, and air flow from 8 to 6 scfm at 1610 hrs. Adjusted turbidity flowmeter at 0822 hrs. Recalibrated pH meter and DO meter. | Adjusted flow from 0.2 to 0.6 on turbidity meter flow, cleaned turbidity meter at 0930 hrs. At 1420 hrs unit secured (idle mode) to support LEL detectir calibration. Primary effluent pump secured. At 1610 hrs restarted unit and changed setpoints for new | |
| 10/09/01 | At 0900 hrs no flow, unit off line from 0708 to 1107 hrs. PE feed pump tripping in overload. Skid secured for evening in Semi-auto idle. | No S6 sample. At 0830 hrs found BAF unit receiving flow. Review of SCADA alarms revealed the skid had been down since 0710 hrs. At 0730 BAF alarm, at 0734 Prim Eff pump 2 overload, at 0737 feed pump 4 failure, at 0737 BAF raw water pump trip, at 0737 r | |
| 10/10/01 | Skid returned to filtration at 1010 hrs. | Continued problems with Facility primary effluent pump. Steve Zamperin checked pump - running current on 3 legs at 4.3 A (6.5 A full load on nameplate). Restarted and will contact Steve if tripped again. | |
| 10/11/01 | Nightstaff noted that skid was offline at 0050 hrs. At 0700 hrs primary effluent pump tripped. At 1139 hrs biofilter feed tank low. | Found facility primary effluent pump tripped again. Dennis Olsen (CM Elect) looked at pump. At bucket, instantaneous trip setpoint on the breaker was increased and the overload trip setpoint was increased. Pump restarted at 0845 hrs and will monitor. | |
| 10/12/01 | At 0820 hrs no flow. | At 0316 hrs primary effluent pump tripped out. Will have Maint troubleshoot. No S6 or S2 sample. At 1320 hrs restarted BAF1 unit and primary effluent pump in manual. At 1325 hrs initiated energetic backwash. Reset turbidimeter flow on BAF effluent. | |
| 10/13/01 | At 0841 hrs adjusted flow 5 minutes prior to reading. | At 1518 hrs found BAF unit in alam 0 filtration abort. Attempted restart with no success. Feed water in WS tank #2 and feed pump in auto. Checked condition of skid pumps - aeration blower required reset. Reset on screen. Restarted unit in auto-filtra | |
| 10/14/01 | At 0646 hrs adjusted and cleaned turbidimeter. | At 0650 hrs adjusted turbidimeter flow and cleaned turbdiimeter. | |
| 10/15/01 | No comments. | At 1040 hrs cleaned turbidimeter. At 0940 hrs adjusted turbiditmer flow. At 2330 hrs removed scum build up off influent trainer. | |
| 10/16/01 | At 0145 hrs removed scum build up off the influent strainer. | At 0145 hrs removed scum build up off influent strainer. It built up quickly. | |
| 10/17/01 | Back in service at 1258 hrs. | At 0853 hrs BAF down to facilitate installation of a new valve on the BAF sotrage tank #1. The valve will allow the BAF2 to use BAF1 effluent. BAF1 back in service at 1258 hrs. S2 sampler relocated to WS tank #2. Cleaned turbidimeter and rotometer, and adjusted flow at 1554 hrs. | |
| 10/18/01 | Adjusted flow at 0928 hrs. | No comments. | |
| 10/19/01 | Screen locked up at approximately 0933 hrs. | No screen - only green light on power button symbol; left email with Sudhakar. Cleaned S6 overflow bucket, bleached lines (including all turbidimeter lines). At 1449 hrs screen is now viewable, took readings. | |
| 10/20/01 | | No comments. | |
| 10/21/01 | Adjusted flow 0855 to 0921 hrs. | From 0855 to 0921 hrs cleaned turbidimeter and adjusted flow. | |
| 10/22/01 | At 1558 hrs cleaned turbidity meter. | At 1550 hrs cleaned turbidimeter. Ancknowledged SCADA alarms: 10/22 0558 - feed pump #2 general alarm, feed pump #1 general alarm; 0605 hrs - lift station 2 high level; 0749 hrs influent flow meter fail. Last night shift had acneklowedged 0103 hrs - comb gas ref #1 high high. Called maint in to check high LEL meter reading - 16%. (Bob Hopper & ?) indicated that sensor is bad; LEL #2 is only reading 3% a hand held meter is reading 0%. Still unable to clear facility alarm. | |
| 10/23/01 | Backwash occurred at 0750 hrs. | Cleaned turbidimeter at 1150 hrs. | |
| 10/24/01 | | Backwash at 0810 hrs. Cleaned scum buildup on sides and weir. | |
| 10/25/01 | LEL detector #1 sensor bad - parts due in on Friday. Shuld be able to clear alarm at that time. At 1300 hours performed clean. | LEL facility alarm still on; checked with maintenance; received the wrong part, reordered. Expected on Friday. Continue to get SCADA alarms: 1119 feed pump 2 general alarm; 1119 feed pump 1 general alarm; 1120 wide spot #1 high level alarm; 1144 lift station high level; 1155 primary influent flow meter failure. At 1230 hrs throttle influent flow to 325 gpm at 1155 - apparently had over flowing WS tank #1; water and screening on floor around tanks, MBR, fine screens. WS tank #3 still low - plug in line from #1 to #3. Cleaned turbidimeter, bleached lines (sampler and turbidity) and overflow bucket S6. | |
| 10/26/01 | | At 0908 hrs cleaned turbidity flowmeter. | |
| 10/27/01 | Ar 0858 hrs adjusted flow from 0 to 0.6 lpm. | At 0855 hrs adjusted turbidimeter flowrate from 0 to 0.6 Lpm. | |
| 10/28/01 | | No comments. | |
| 10/29/01 | | Cleaned and adjusted flow on turbidimeter. | |
| 10/30/01 | | No comments. | |
| 10/31/01 | | Cleaned S2 overflow bucket; bleached line; cleaned turbidimeter. | |
| 11/01/01 | | No comments. | |
| 11/02/01 | At 0145 hrs turned on primary water pump, it kicked out on overload. Widespot tank empty. At 0915 hrs restarted feed pump (unit in operation). | At 0800 hrs no flow to unit - primary influent pump tripped out. Checked alarms ummary - last biofilter feed tank low level alarm at 0322 hrs. Unit in idle since that time. Alarm summary also showed that unit has been cycling between "filtration in progress" to "biofilter feed pump low level" since 10/30. Screen reservoir is emptying overtime. Clogged lower 1 inch ball valve on screen (low drain on screen reservoir) to minimize cycling. At 0847 hrs unit restarted following rest of primary influent feed pump. Note that BAF2 is now operational on BAF1 effluent from storage tank 1. Current flow to BAF2 is 10 gpm. With hydraulic configuration of BAF1 - storage tank 1 - clean water tank 1, need to be careful with wash cycles on BAF1. At 1000 hrs cleaned effluent turbidimeter. | |
| 11/03/01 | | No comments. | |
| 11/04/01 | At 0145 hrs reset primary effluent pump and restarted. Tripped on overload. Aslo running in manual at local station. | No comments. | |
| 11/05/01 | Alarm summary: 0750 filter 1B aborted; filter backwash required (filter run time 30 hrs), unit in semi-auto-idle. Initiated backwash at 0904 hrs. At 0941 hrs backwas aborted, clean water tank level low (stopped at final rinse). Put in service at 1015 hrs. At 1110 hrs cleaned turbidimeter. | Noted on Sunday morning that primary effluent feed pump tripped out at approximately 0845 hrs. Reset pump and started at 0945 hrs. Unit operated throughout Sunday in semi-auto mode. Unit switched back to AUTO mode. | |
| 11/06/01 | Acknowledged CW tank low level alarm received at 0120 hrs. | Backwash aborted at 1954 hrs due to low CW tank level. Unit in IDLE since that time. | |
| 11/07/01 | At 0754 hrs backwash aborted, low tank level. Returned to service at 1107 hrs. At 1114 hrs cleaned turbidimeter, S6 overflow bucket with bleach. Put in backwash at 1115 hrs. Restarted unit at 1350 hrs. | At 0754 hrs filling BAF1 CW tank with C2 water and will initiate backwash after full. At 1115 hrs initiated backwash in SEMI AUTO mode. No feed after backwash - switched to AUTO-FILTRATION with no luck. At 1645 hrs BAF1 back online with FP1 in MANUAL. Problem with facility PLC. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
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| 11/08/01 | | S6 Sampler not started yesterday after BAF1 back online - Bob "miss." At 1515 hrs effluent turbidimeter back online. Flow set at 0.7 L/min and current turbidimeter is reading 20.68 NTU. | |
| 11/09/01 | Setpoint changes: Flowrate from 19 to 21 gpm; backwash interval from 24 to 18 hrs; air flow from 6 to 7 scfm. | Bleached S6 overflow bucket and sample lines. Bleached turbidimeter lines; cleaned turbidimeter; rotometer adjusted flow. Cleaned skid screen. At 1525 hrs control set point changes from Ondeo/HDR/KC conference call: Feed flow from 19 to 21 gpm; aeration from 6 to 7 scfm; backwash frequency timer from 24 to 18 hr. Secured and restarted unit to 0 backwash timer (was at 21 hrs). Therefore, next backwash will occur after 39 hrs or 70 inch differential pressure (currently at 63 inches). | |
| 11/10/01 | At 0840 energetic backwash initiated. | Decided to run energetic backwash cycle (last energetic backwash on 10/12). Initiated at 0840 hrs and completed. From 0915 hrs to 1030 hrs turbidimeter out-of-service for cleaning. After energetic backwash, put unit back in AUTO-FILTRATION. Ran OK, but noted lots of debris in effluent, decided to run NORMAL backwash. Prior to starting backwash, noted flow over the top of the reactor. Reset drain and effluent valves on screen. STopped troubleshooting and initiated backwash at 0925 hrs. | |
| 11/11/01 | | No comments. | |
| 11/12/01 | At 0030 hrs adjusted turbidimeter flow rate from 0 to 0.7 lpm. | No comments. | |
| 11/13/01 | | No comments. | |
| 11/14/01 | At 0855 hrs adjusted effluent turbidity flow to 0.7 Lpm. | Cleaned turbidimeter; adjusted flow. Cleaned skid fine screen.Noted unit backwashed mid-morning under following conditions: filter run time of 9 hours and filter differential pressure of 58 inches. Why did it backwash? Need to monitor. | |
| 11/15/01 | At 0905 hrs adjusted effluent turbidity flow from 0 to 0.4 Lpm. Turbidity dropped from 20.5 to 6.5 after 10 minutes. | No comments. | |
| 11/16/01 | At 0930 hrs backwash required message. At 2300 hrs couldn't get the turbidimeter flow going. | Baf 1 showing "backwash required" - the backwash wasn't initiated at 18 hrs due to low water level in clean water tank. The time lapse since last backwash was 24.8 hours. Apparently there wasn't enough flow to fill CW tank. Adjusted overflow on BAF2 feed and wait to see if tank will fill up. At 1530 hrs initiated backwash following "top-off" of CW1 tank with C2 water. At 2300 hrs can't get the turbidity flow to open, after opening the valve 100% still very little flow. | |
| 11/17/01 | At 1400 hrs adjusted turbidimeter flow down to 0.4 Lpm. | No comments. | |
| 11/18/01 | At 0900 hrs no flow, backwash aborted. At 0945 hrs started nozzle cleaning pump. At 1000 hrs finished nozzle cleaning. | At 0135 hrs effluent turbidity flow still no flow, tried to open valve to 100% to push obstacle, no luck. At 0845 hrs discovered unit secured with flashing note "filter run aborted" and "backwash required." Following alrms on alarm summary page: 11.16 1726 hrs filter backwash completed; 11/17 0706 hrs filtration in progress; 11/17 0706 hrs filter backwash in progress; 11/17 0803 hrs filtration in progress; 11/17 0803 hrs filter backwash in progress; 11/17 1051 hrs filtration in progress; 11/17 1051 hrs filter backwash in progress; 11/17 1147 hrs filtration in progress; 11/17 1147 hrs filter backwash in progress; 11/17 1159 hrs filter backwash required; 11/18 0323 hrs filtration in progress, 11/18 0323 hrs filter 1B filtration aborted; 11/18 0323 hrs filter idle in progress; 11/18 0323 hrs filter backwash required; 11/18 1037 hrs EVT system. Not sure why system was tripping to backwash. At 0900 hrs filling CW1 tank with C2 water (arppoximately 1000 gal.) At 0945 hrs performed :overdue" nozzle cleaning procedure from 0945 to 1000 hrs. From | |
| 11/19/01 | At 0130 hrs unit in backwash. | At 1825 hrs troubleshooting "lack of fill" of CW1 tank. Last backwash of BAF1 was in early AM (0130 hrs). Checked flow balance. Disocvered that high point bleed on feed line to MF had been left open by Bob. FP2 discharge flow (prebleed close) or 10.6 gpm. FP2 discharge flow (postbleed close) of 9.1 gpm. In flow of 21 gpm, and now out flow of 19.1 gpm. From 1830 to 1900 hrs filled CW1 tank with C2 water to prepare for backwash in next 1.5 hours. | |
| 11/20/01 | At 0920 hrs after adjusting flow on turbidimeter, flow spiked to 50+ NTU after 10 minutes went down to 2.86 NTU. | No comments. | |
| 11/21/01 | Cleaned turbidimeter; overflow bucket and sample lines, skid fine screen. | At 0530 hrs added approximately 500 gallons of C2 water to CW1 tank. Plan to secure MF unit at end of shift to eliminate potential for BAF shutdown on lack of backwash water. | |
| 11/22/01 | | No comments. | |
| 11/23/01 | At 1415 hrs calve supply for turbidimeter was closed, opened valve and established flow. | No comments. | |
| 11/24/01 | At 1315 hrs system in backwash when data was taken. | No comments. | |
| 11/25/01 | At 0859 hrs adjusted flow to turbidimeter to 1. | No comments. | |
| 11/26/01 | At 0934 hrs cleaned turbdimeter and rotometerl reestablished flow to meter. | No comments. | |
| 11/27/01 | Unit restarted at 0923 hrs. Unit was in idle, filter run aborted at 0718 hrs. Feed tank low alarm cycling again. At 0955 hrs didn't get S6 sample - sample tube broke. | At 0955 hrs feed tank low alarm cycle - didn't get enough flow due to scum building up on the screen, causing unit to stop filtration, once the feed level increased the filtration started again - the cycle was repeated unti the air blower tripped and the unit went into idle mode. Clean the screen, clear alarm, and restarted the unit. | |
| 11/28/01 | At 0230 hrs no flow to turbidimeter, couldn't fix. Alarm at 0411 hrs, filter aborted system in idle. Filter runtime of 13.3 hours; in semi-auto backwash required. Filter differential pressure of 85 - system indicates backwash required but is not going into backwash. | System in idle - backwash required, filter differential pressure of 85 with a filter runtime at 13.3 hrs. The system didn't go into abckwash due to low water level in CW1 tank - since last started-up didn't have time to fill CW1 before backwash was required - perhaps storage tank was low also. The actual total filter run time since last abckwash (on 26th) is close to 30 hrs - that could be the reason why the unit went into idle. The system registered 13.3 hrs lapse time because the clock was reset when the unit was restarted on 11/27. From 1125 to 1140 hrs cleaned the turbidimeter and re-established flow. | |
| 11/29/01 | At 1320 hrs changed flow from 21 to 23 gpm, air flow from 7 to 8 scfm. | At 1420 hrs changed flow from 21 to 23 gpm. Changed air flow from 7 to 8 scfm. From 1530 to 1600 hrs filled BAF1 CW1 tank with C2 water. Has not been filling throughout the day. Need to work on storage tank hydraulics. | |
| 11/30/01 | | No comments. | |
| 12/01/01 | | No comments. | |
| 12/02/01 | At 0426 hrs unit had been restarted after 7 hours of runtime. | Unit shutdown at 2117 hrs on 12/1 on process air blower failure. Noted from alarm log that unit is cycling again based on low feed level alarms. Cleaned feed screen and fully closed facility valve DV14 to route all WS2 tank flow to BAF1. At approximately 0430 hrs cleaned turbidimeter. | |
| 12/03/01 | A 0826 hrs adjusted flow. At 1040 hrs adjusted turbidimeter flow. At 1650 hrs no data recorded due to unit being in backwash. | At 0900 hrs cleaned turbidimeter and rotometer. Cleaned skid fine screen. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 12/04/01 | Flow to turbidimeter reestablished at 0850 hrs. | No comments. | |
| 12/05/01 | At 0451 hrs filter backwash required; clean tank is not full, added H2O. DO meter reading compared to lab DO meter. Field meter reading high by 1-1.5 mg/L. TSK will change membrane. | At 4:51 hrs, filter backwash required; level of clean water tank low; added water and the unit went into bw. | |
| 12/06/01 | At 0919 hrs adjusted flow to turbidimeter. Sampler for S6 for 12/5 grab, sampler indicated full but no sample. | No comments. | |
| 12/07/01 | S6 grab taken. Backwash required at 2218 hours (12/6). Added water to clean water tank at 0744 hrs. No flow at 0935 hrs to turbidimeter, adjust flow and clean turbidimeter at 1032 hrs. | No comments. | |
| 12/08/01 | At 0130 hrs unable to read screen, locked up. Clean water tank level low; to ensure sufficient backwash water for 12/9, fill tank with water. At 0945 hrs bleached turbidimeter lines; cleaned meter and rotometer, reestablished flow. At 2230 hrs backwash in progress completed. | No comments. | |
| 12/09/01 | At 0510 hrs adjusted turbidity flow to 0.4 lpm. Started sampler at 0900 hrs. At 1840 hrs backwash required at 1733 hrs, started filling tank. | No comments. | |
| 12/10/01 | At 050 hrs, no flow to turbidimeter, adjusted flow to 0.2 lpm. | At 9:45 hrs, the unit shutdown on process air blower failure. Feed flow cycling. Restarted unit after adjusting feed flow using DV-14. Filter runtime = 13 hrs. | |
| 12/11/01 | | At 9:25 hrs, cleaned turbidimeter | |
| 12/12/01 | | No comments. | |
| 12/13/01 | | At 9:50 hrs, cleaned turbidimeter and skid fine screen | |
| 12/14/01 | | Process shutdown last evening at 22:56. Sequence of events 19:46 hrs- backwash completed, 22:56 hrs filtration aborted, idled, process air blower failure. AT 9:20 hrs restarted unit after resetting process air blower on OIS. At 15:00 hrs- re-established turbidimeter flow and cleaned turbidity meter. At 15:30 hrs- closed facility valve DV 14 to eliminate cycling of pilot on low feed flow. At 16:15 hrs- topped off CW1 tank with C3 2water (approx 500 gal). Storage tank is still catching up after BAF 1 shutdown last night. | |
| 12/15/01 | | No comments. | |
| 12/16/01 | | No comments. | |
| 12/17/01 | cleaned S6 overflow bucket, cleaned turbidimeter | No comments. | |
| 12/18/01 | At 10:00-10:15 hrs, cleaned turbidimeter. At 14:40 hrs, performed energetic backwash. Flow was established at 14:50 hrs. | At 14:11 hrs, performed energetic BW | |
| 12/19/01 | Closed HV 14 valve | At 9:57 hrs (10:59 screen time), filter process air blower failure; restarted | |
| 12/20/01 | SCADA alarm- high eff turbidity alarm | At 5:10 hrs, alarm; filter bw required. Biofilter feed tank low level since 12/19. At 8:30 hrs, added water to clean water tank, bewnt into backwash. Bleached turbidimeter line. Clean screen, rotometer. Flow resumed at 10:07 hrs. Cleaned S6 overflow bucket. | |
| 12/21/01 | | Bleached S6 overflow bucket. Cleaned turbidimeter rotometer, lines, etc. Had difficult time re-establishing flow 13:30 hrs. At 8:30 hrs, backwash required alarm. Low level in clean water tank. Added water; backwash sequence initiated. | |
| 12/22/01 | | No comments. | |
| 12/23/01 | At 17:15 hrs, backwash required- started filling tank (only 3/4 of tank) | No comments. | |
| 12/24/01 | | No comments. | |
| 12/25/01 | At 4:30 hrs, cleaned rotometer. Isolated flow to sampler bucket and cleaned with brush and water. | No comments. | |
| 12/26/01 | | No comments. | |
| 12/27/01 | | At 8:30 to 9:30 hrs, cleaned effluent turbidimeter and sampler overflow bucket. Also cleaned overflow weir with broom. Cleaned feed screen. | |
| 12/28/01 | | At 9:30 to 9:45 hrs, cleaned effluent sampler and feed screen. | |
| 12/29/01 | | No comments. | |
| 12/30/01 | | No comments. | |
| 12/31/01 | | No comments. | |
| 01/01/02 | | No comments. | |
| 01/02/02 | | No comments. | |
| 01/03/02 | | No comments. | |
| 01/04/02 | | No comments. | |
| 01/05/02 | | No comments. | |
| 01/06/02 | | No comments. | |
| 01/07/02 | | No comments. | |
| 01/08/02 | | At 9:15 hrs, cleaned turbidimeter. | |
| 01/09/02 | | No comments. | |
| 01/10/02 | | At 12:45 hrs, changed BW interval to 12 hrs. Filled cw tank with C3 water. This will be the case through the weekend. | |
| 01/11/02 | | Continue to fill CW tank with C3 water for backwash. Free chlorine testing found 8 mg/L in C3 water (expected only around 1m g/L) | |
| 01/12/02 | | No comments. | |
| 01/13/02 | | No comments. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 01/14/02 | | At 16:50 hrs, adjusted turbidimeter flow to 0.6 Lpm. Unit tripped process air blower failure- cycling on low feed water level. Reset air blower and re-started unit. Free chlorine in C3 = 2.6 mg/L | |
| 01/15/02 | | At 9:15 hrs, cleaned turbidimeter (eff). | |
| 01/16/02 | Plant power outage from 12:45 to 13:37 hrs. Put unit back in semi auto-idle from 12:53 to 13:40 hrs. | No comments. | |
| 01/17/02 | | No comments. | |
| 01/18/02 | | No comments. | |
| 01/19/02 | | No comments. | |
| 01/20/02 | | At 3:20 hrs, filter run aborted- bachwash required. At 10:00 hrs, acknowledged backwash required alam. (Alarm summary: Last backwash 1/18/02 at 18:16. On 1/18/01 at 21:30 hrs, filtration abort- unit in idle. On 1/19/02 at 9:26 hrs, filter backwash required. On 1/20/02 at 3:26 hrs, filtration in progress, filter filtration abort, filter idle in progress). At 10:26 hrs, initiated backwash in semi-auto mode. At 11:38 hrs, unit back in auto-filtration mode. Checked storage tank 1 level. Currently at 4 ft. At 11:53 hrs, cleaned effluent turbidimeter. At 11:45 hrs, after restart of unit in auto-filtration, effluent overflowing top of reactor. Effluent valve V5 failed to open. Restarted after draining excess water in maunal mode and resetting V5. | |
| 01/21/02 | | No comments. | |
| 01/22/02 | | At 15:45 hrs, cleaned effluent turbidimeter and started S6 sampler | |
| 01/23/02 | At 10:28 hrs, cleaned turbidimeter | From 14:30 to 18:45 hrs, collected samples for special test. | |
| 01/24/02 | At 9:30 hrs, cleaned rotometer, rewstablished flow, cleaned skid screen. | At 15:30 hrs, secured C2 water supply to CW tank. BAF1 should be able to provide for its own backwash. MF offline. | |
| 01/25/02 | | At 7:15 hrs, noted BAF1 flashing "backwash required" with 12.1 hr on timer. CW tank did not fill. Re initiated C2 water to CW1 tank. Will continue with C2 water hose on. At 7:20 hrs, backwash started. | |
| 01/26/02 | AT 18:50 hrs, rebooted operator interface- PC frozen. At 18:50 cleaned turbidimeter. | No comments. | |
| 01/27/02 | At 1:18 hrs, the display was blank. At 3:13 hrs, the display still blank, pused buttons and it finally responded. | No comments. | |
| 01/28/02 | At 8:40 hrs, bleached and cleaned screen, sample overflow bucket and sample line | At 10:30 hrs, noticed that the screen was out. AT 14:20 hrs, rebooted PC (pulled pwer cable). Also changed filter to waste step in normal backwash from 20 to 30 minutes. | |
| 01/29/02 | | No comments. | |
| 01/30/02 | | No comments. | |
| 01/31/02 | | No comments. | |
| 02/01/02 | At 13:35 hrs, initiated energetic BW. Cleaned screen & turbidimeter, bleached overflow bucket | At 13:35 hrs, initiated energetic backwash. Last backwash was 12/18/01. Ondeo wants to reduce post-was diff pressure to less than 50 in. At 17:25 hrs, initiated nozzle clean. Last nozzle clean was 11/18/02. AT 14:15 -14:45 hrs, effluent turbidity off line for cleaning and removal of rotometer. Flow will be checked visually at overflow. Tired of cleaning rotometer. At 15:30 hrs, initated second energetic backwash. Discovered unit overflowing after putting back in auto-filtrattion following the second energetic backwash. Selected OFF and restarted. Effluent valve had not opened. | |
| 02/02/02 | | No comments. | |
| 02/03/02 | AT 9:30 hrs, resured C2 water to CW1 tank. At 16:30 hrs, adjusted flow on trubidimeter. | At 11:00 to 12:30 hrs, cleaned effluent turbidimeter and feed screen. At 9:30 hrs, secured C2 water to CW1 tank. Want to attempt to use BAF1 effluent for the backwash. | |
| 02/04/02 | | No comments. | |
| 02/05/02 | At 8:30 hrs, backwash required flashing- still need 1.5 ft in CW1 tak to initiate bw. Turned on C2 water source to supplement. | ST1 low level- fill CW1 with C2 water. At 11:40 hrs, measured the over flow from BAF2 = 6 gpm. This indicated that only 3 gpm is going to ST1. At this rate, it will take 11 hrs to fill the ST1 tank. At 15:20 hrs, reduced the BAF2 overflow from BAF 2 to 1.5 gpm, this should allow the ST1 tank to fill up in about 6 hours instead of 11 hrs. Filled up the ST1 with C2 water and secured the C2 water. | |
| 02/06/02 | | No comments. | |
| 02/07/02 | Bleached overflow buckets and replace sampleline. Cleaned skid screen. Bleached S2 sample line. | No comments. | |
| 02/08/02 | | At 15:45 hrs, disconvered turbidimeter had not been receiving flow (dry well). Cleaned turbidimeter and cleared fed line- will adjust after backwash completed. | |
| 02/09/02 | At 7:37 hrs, turned on C2 water to CW tank (BAF2 over flow was readjusted on Friday and the actual overflow rate had not yet been measure) | | |
| 02/10/02 | At 13:07 hrs, C2 water was turned off. | From 12:45 to 15:00 hrs, cleaned turbidimeter and sample overflow bucket. | |
| 02/11/02 | | No comments. | |
| 02/12/02 | | No comments. | |
| 02/13/02 | | No comments. | |
| 02/14/02 | | At 8:45 hrs, discovered unit shutdown on process air blower fialure at 6:32 hrs. At 9:26 hrs, restarted unit after resetting process air blower. Filling CW1 tank with C2 to verify enough water for next BW. Will secure when tank full. At 12:00, increased feed to 27 gpm | |
| 02/15/02 | | No comments. | |
| 02/16/02 | | No comments. | |
| 02/17/02 | | No comments. | |
| 02/18/02 | | No comments. | |
| 02/19/02 | | From 15:15 to 15:45 hrs, cleaned effluent turbidimeter and overflow bucket. | |
| 02/20/02 | | From 18:10 to 18:25 hrs, cleaned effluent turbidimeter. | |
| 02/21/02 | | No comments. | |
| 02/22/02 | | No comments. | |
| 02/23/02 | | No comments. | |

| Date | Comment 1 | Comment 2 | Comment 3 |
|---|---|---|---|
| 02/24/02 | | Shift operator reset process air blower failure @ 8:40 hrs. From alarm summary, looks like the unit was trying to wash yesterday afternoon starting @ 15:51 hrs. From 2/23, 15:51 hrs to 16:57 hrs, unit was cycling between wash and filtration. Shutdown @ 16:57 with process air blower failure. Therefore, the unit was off from 2/23, 17:00 to 2/24, 8:00. From 15:15 to 15:45 hrs, cleaned effluent turbidimeter. | |
| 25-Feb-02 | | No comments. | |
| 26-Feb-02 | | No comments. | |
| 27-Feb-02 | | At 13:30 hrs, initiated backwash and put the unit in idle. | |
| 28-Feb-02 | | Around 15:00 hrs, started the unit back up and started intensive sampling. | |
| 1-Mar-02 | | Around 16:00 hrs, put the unit in idle. | |
| 2-Mar-02 | | Unit in idle | |
| 3-Mar-02 | | Unit in idle | |
| 4-Mar-02 | | At 14:00 hrs, attempted to start the unit back up, but had trouble getting feed water. Suspected the pump was air-lock. Was able to started up the pump after leaving the DV 14 opened for a while. However, didn't have time to complete the test by then. Postponed the test to the next day. | |
| 5-Mar-02 | | Started unit back up around 10:20. When first started, drained was very slow. Had to stop the unit and re-started. The unit shut down by itself briefly due to low feed level. Adjusted the feed valve and re-started. At 12:30, the test was completed and the unit was backwashed 3 times as Ondeo requested. | |
| 6-Mar-02 | | The unit was drained and the screen chamber was rinsed. | |
| 7-Mar-02 | | The media was removed to prepare for shipping. | |

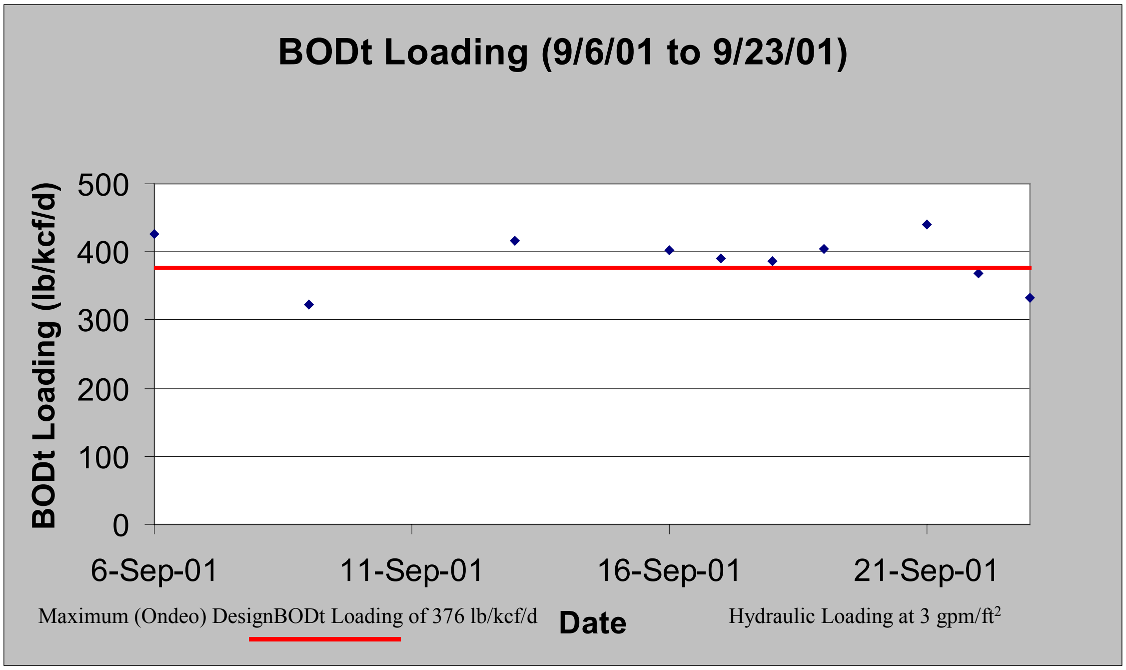


*Figure 1. BODt Loading in Phase IA*

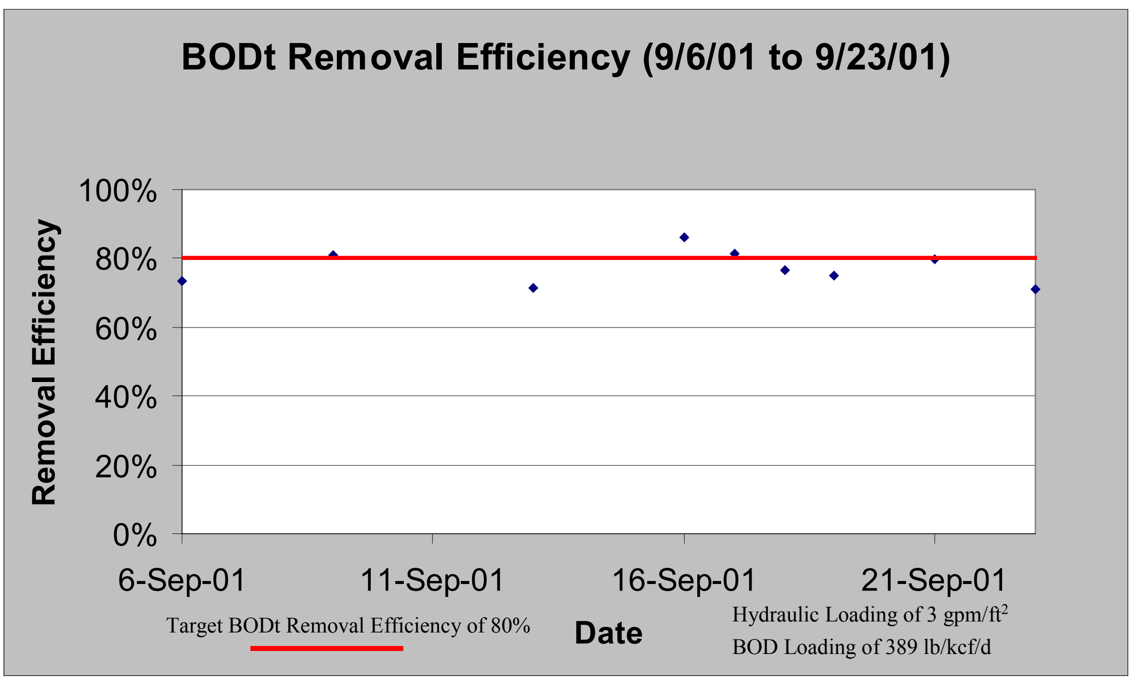


*Figure 2. BODt Removal Efficiency in Phase IA*

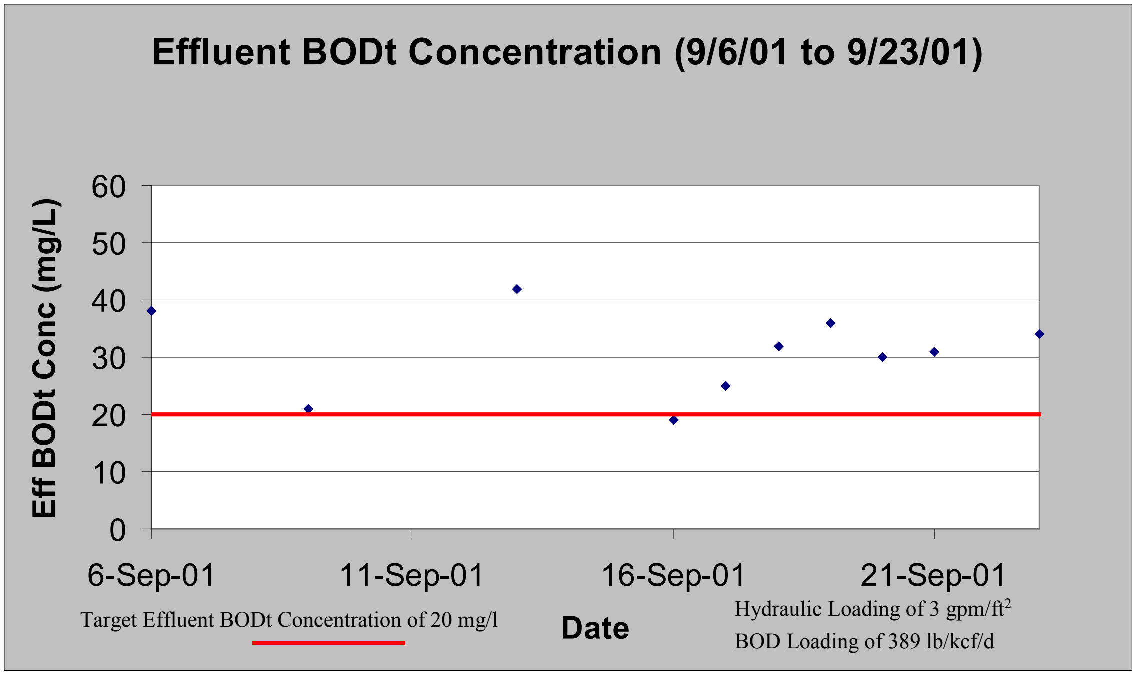


*Figure 3. Effluent BODt Concentration in Phase IA*

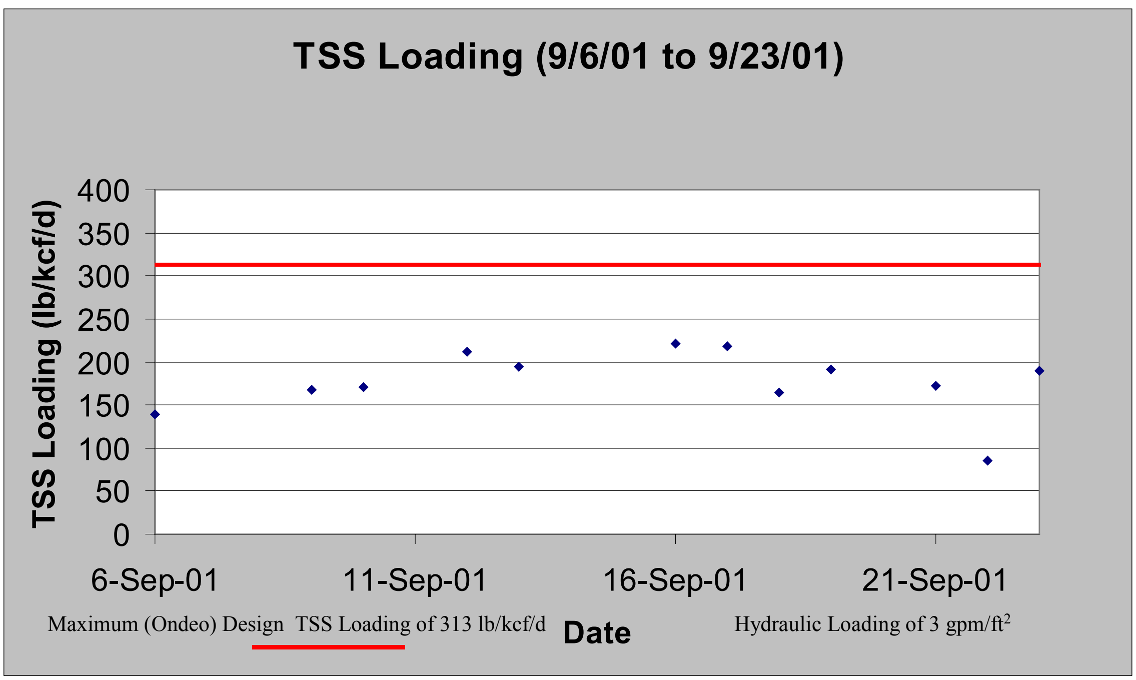


*Figure 4. TSS Loading in Phase IA*

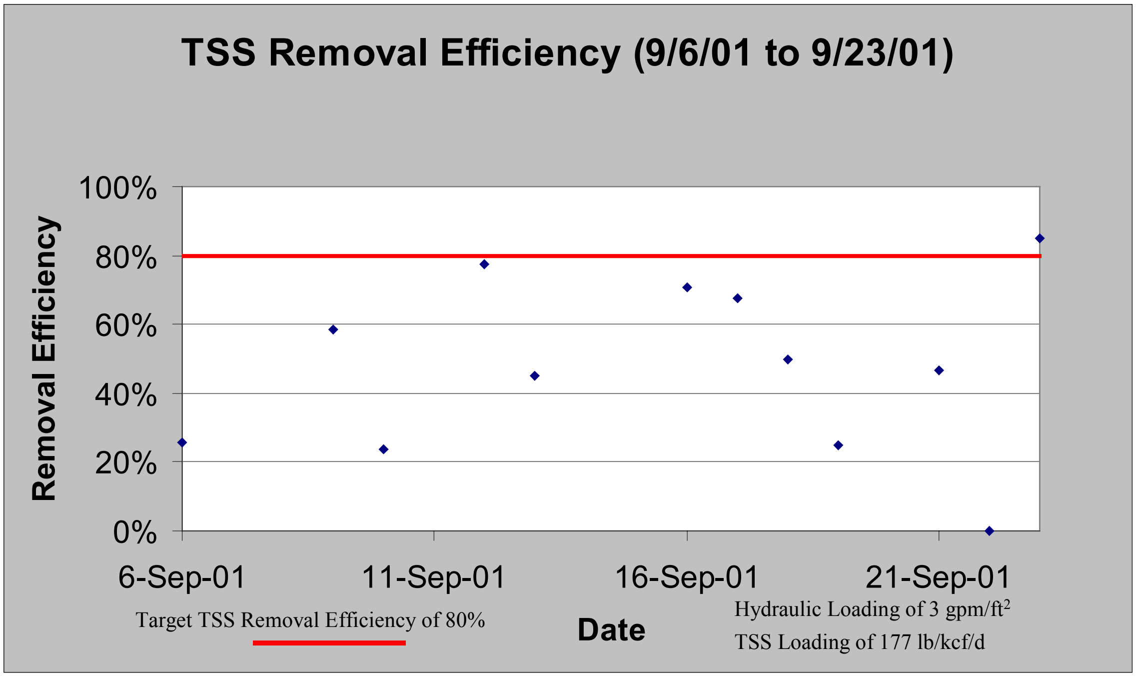


*Figure 5. TSS Removal Efficiency in Phase IA*

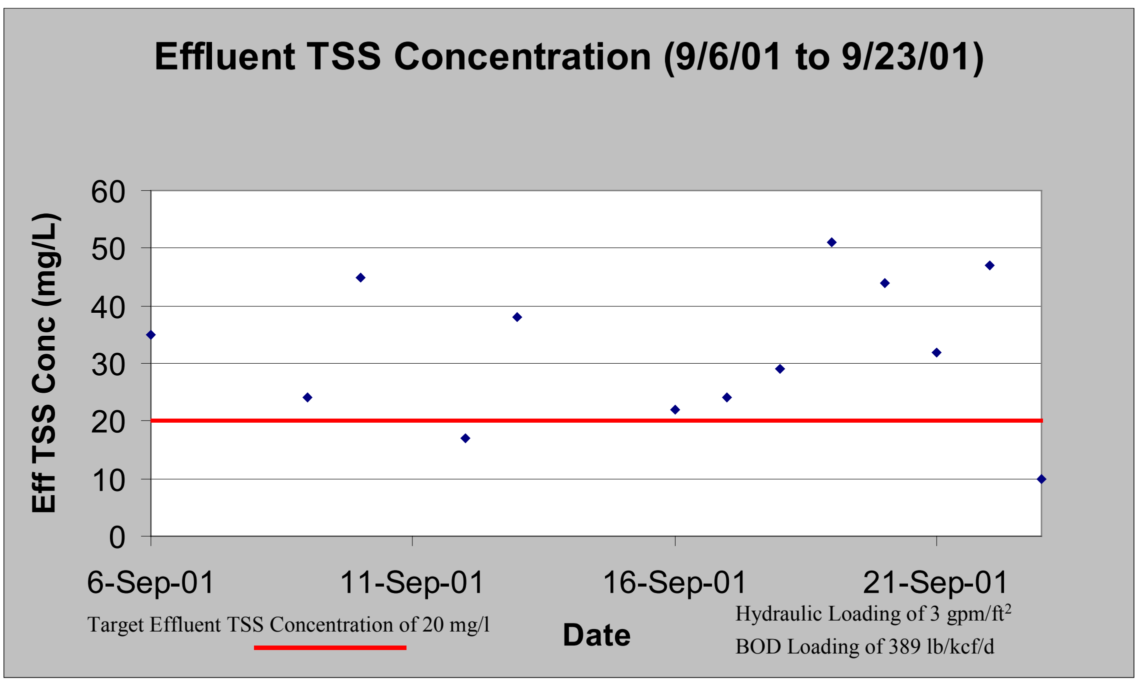


*Figure 6. Effluent TSS Concentration in Phase IA*

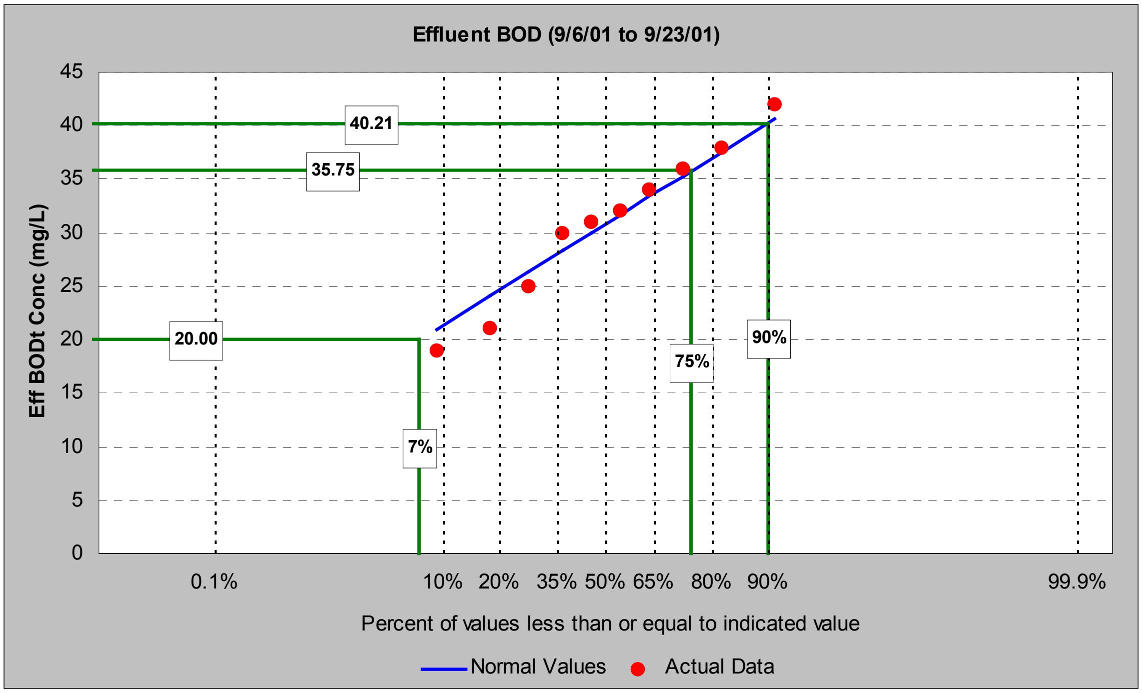


*Figure 7. Effluent BODt Percentile Plot in Phase IA*

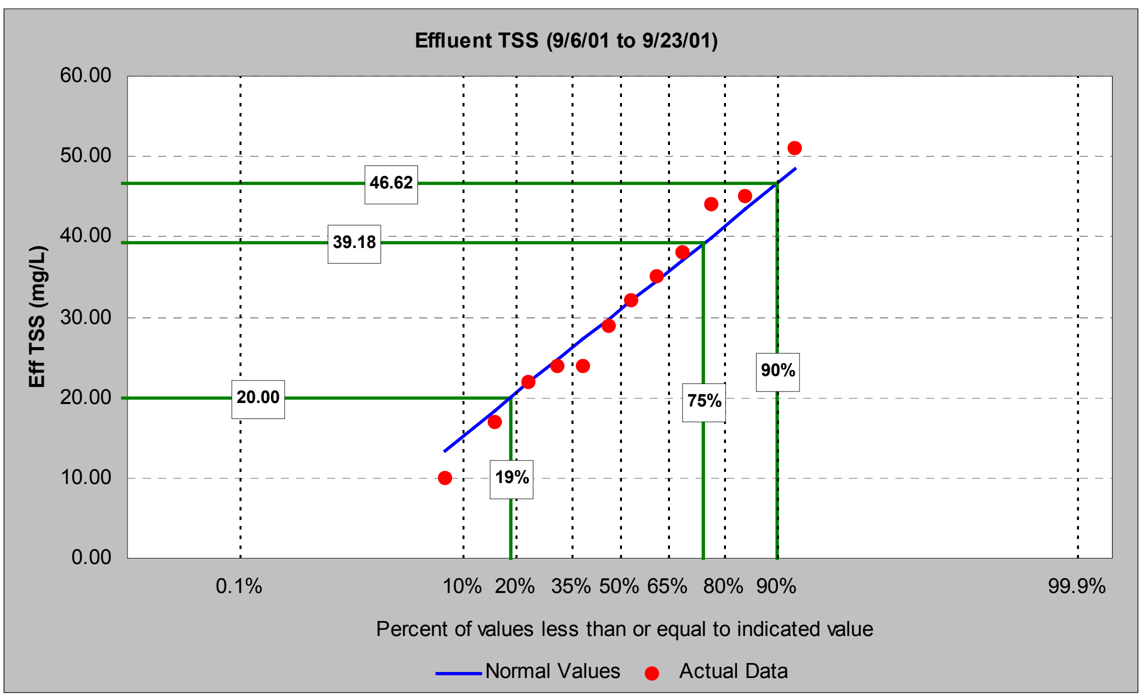


*Figure 8. Effluent TSS Percentile Plot in Phase IA*

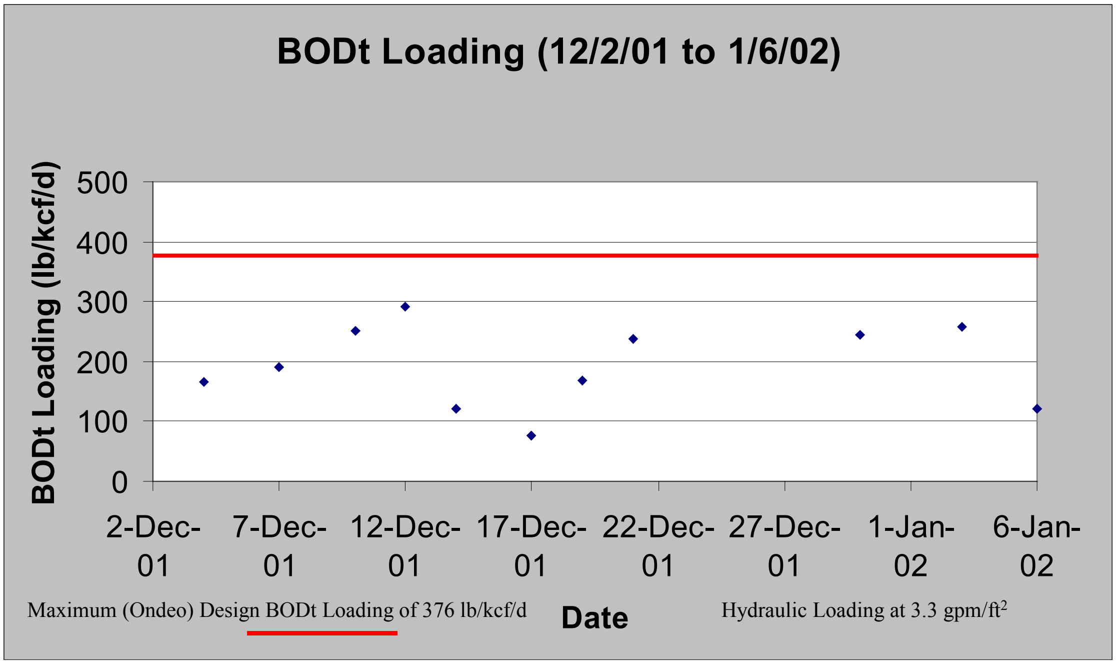


*Figure 1. BODt Loading in Phase IIB*

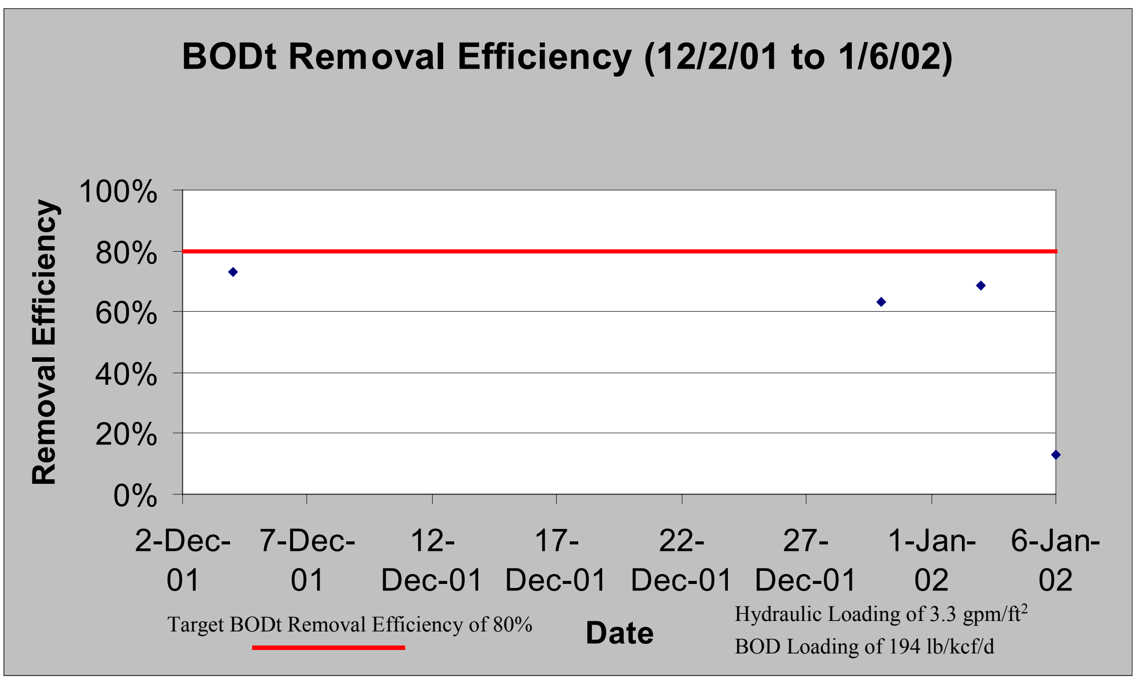


*Figure 2. BODt Removal Efficiency in Phase IIB*

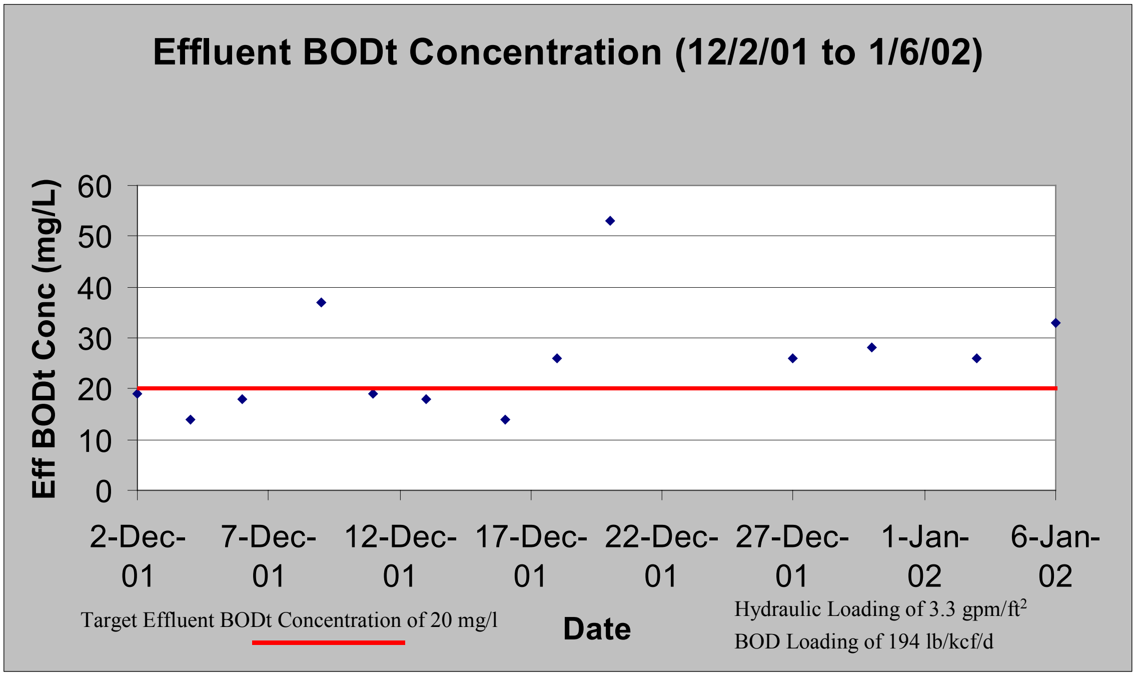


*Figure 3. Effluent BODt Concentration in Phase IIB*

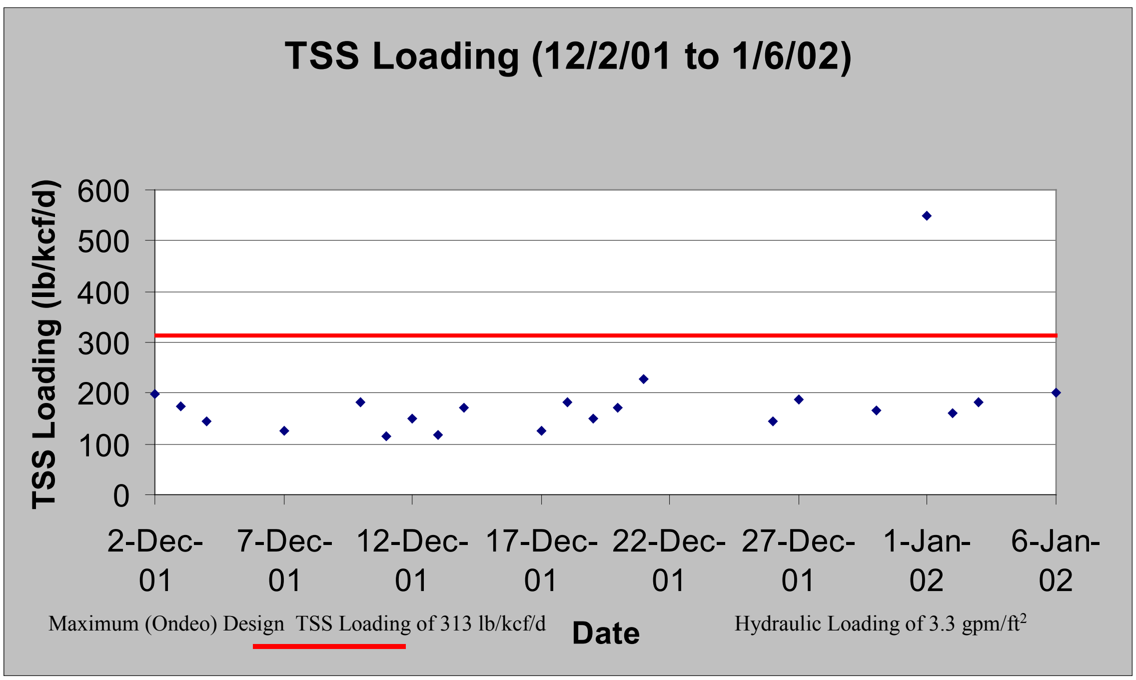


*Figure 4. TSS Loading in Phase IIB*

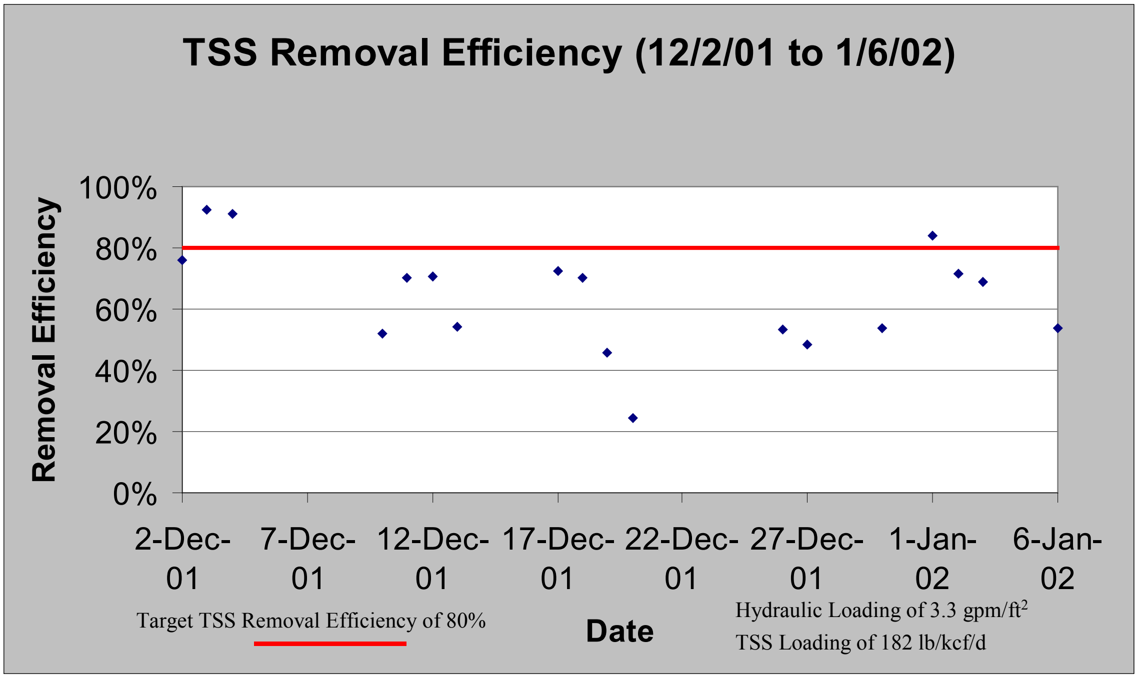


*Figure 5. TSS Removal Efficiency in Phase IIB*

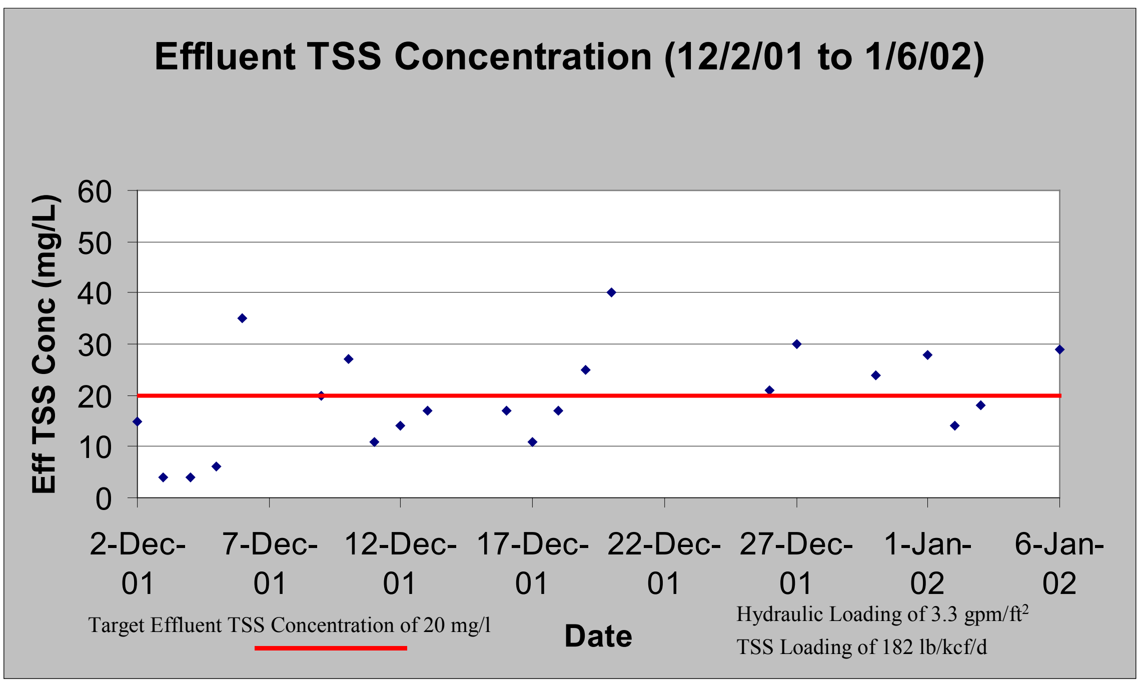


*Figure 6. Effluent TSS Concentration in Phase IIB*

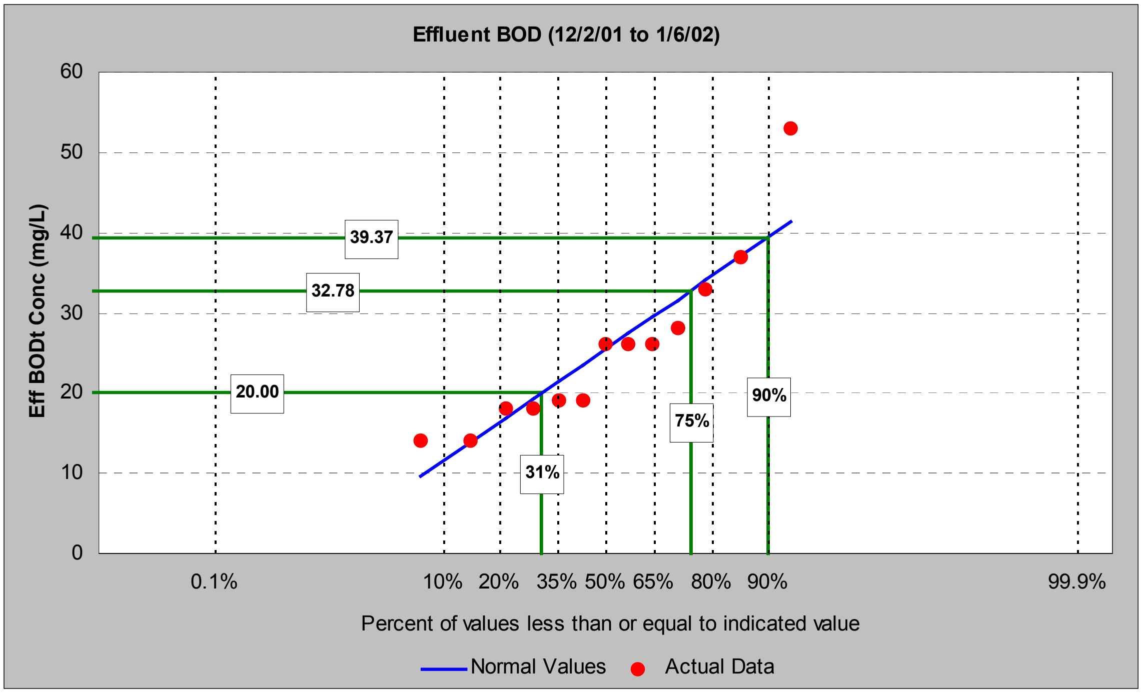


*Figure 7. Effluent BODt Percentile Plot in Phase IIB*

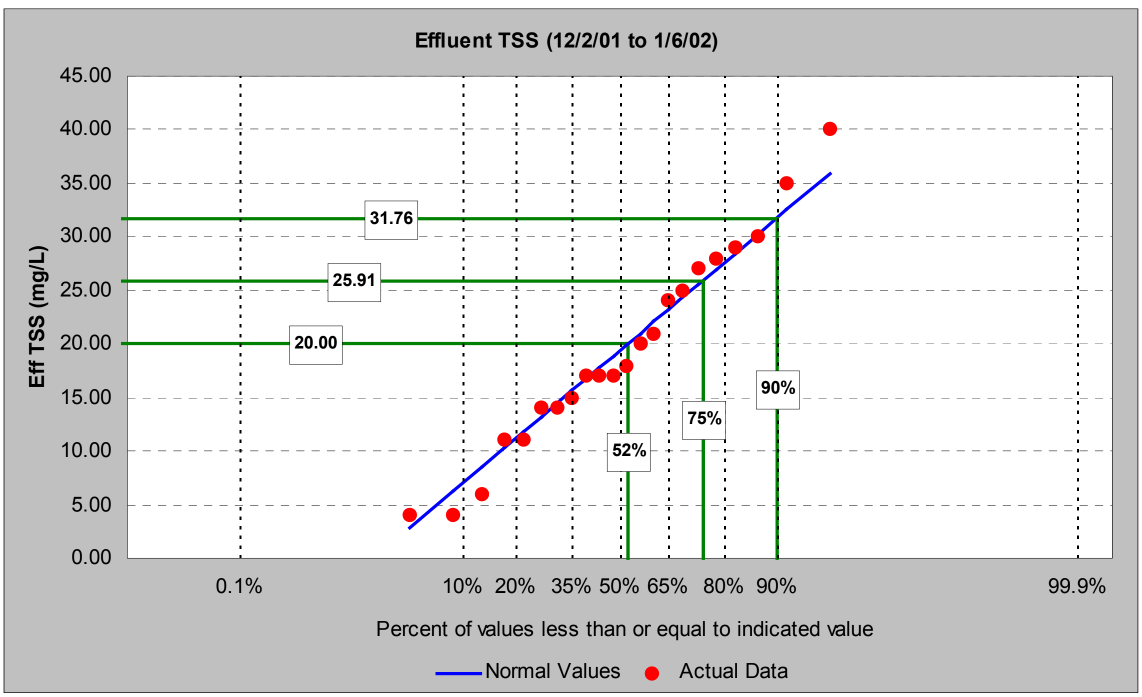


*Figure 8. Effluent TSS Percentile Plot in Phase IIB*

## Phase IIIA

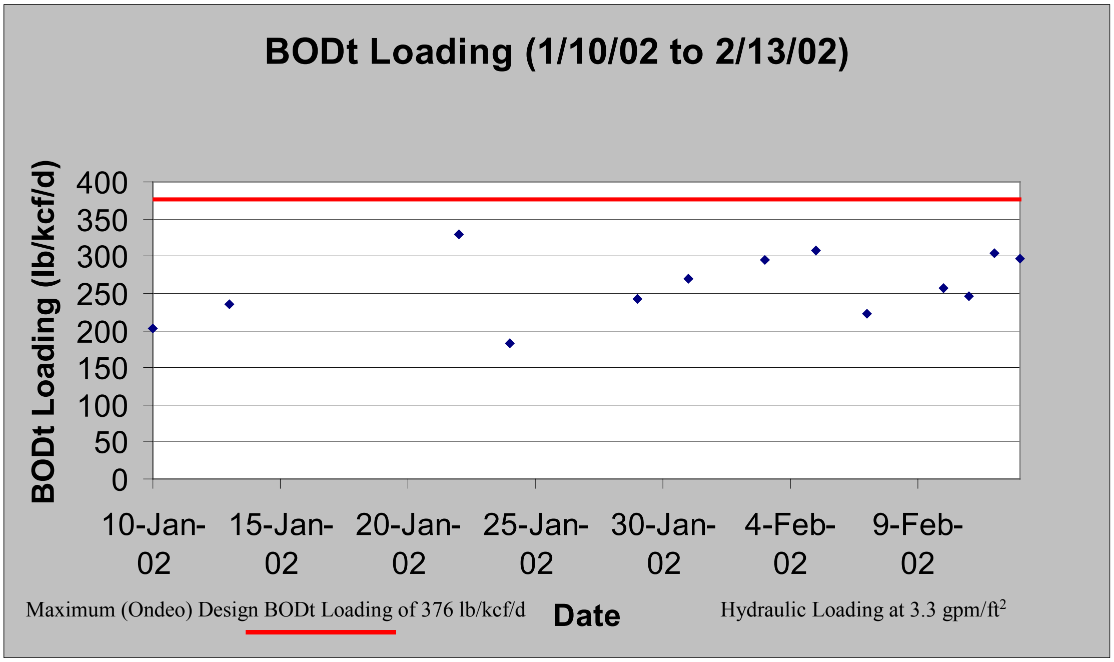


*Figure 1. BODt Loading in Phase IIIA*

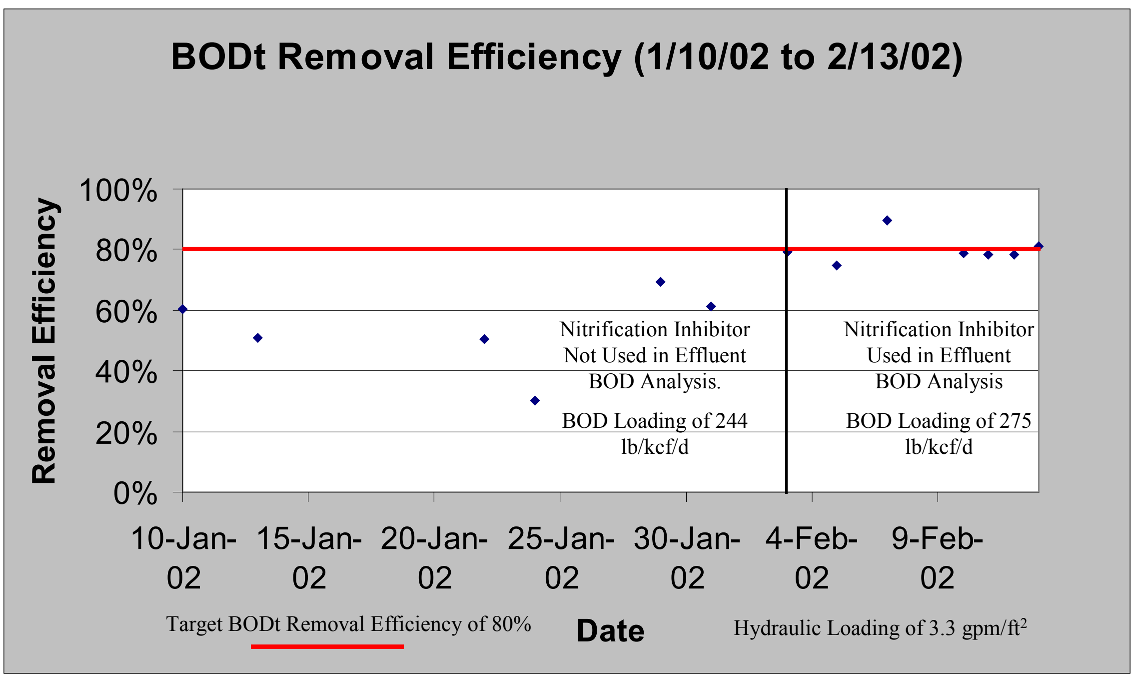


*Figure 2. BODt Removal Efficiency in Phase IIIA*

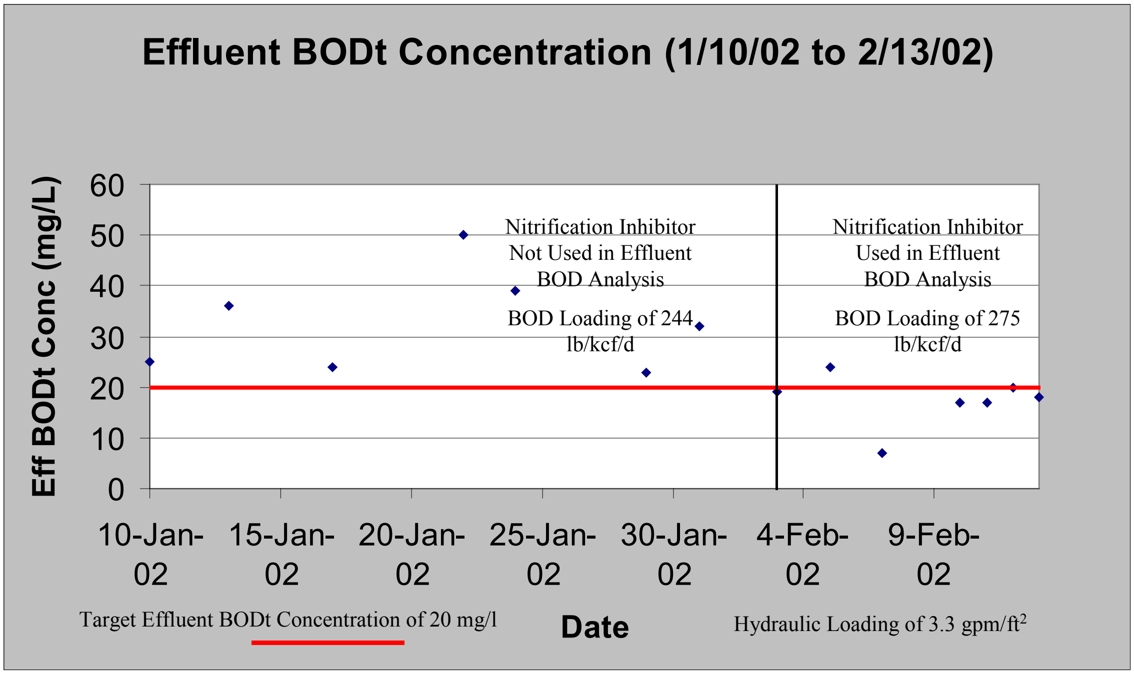


*Figure 3. Effluent BODt Concentration in Phase IIIA*

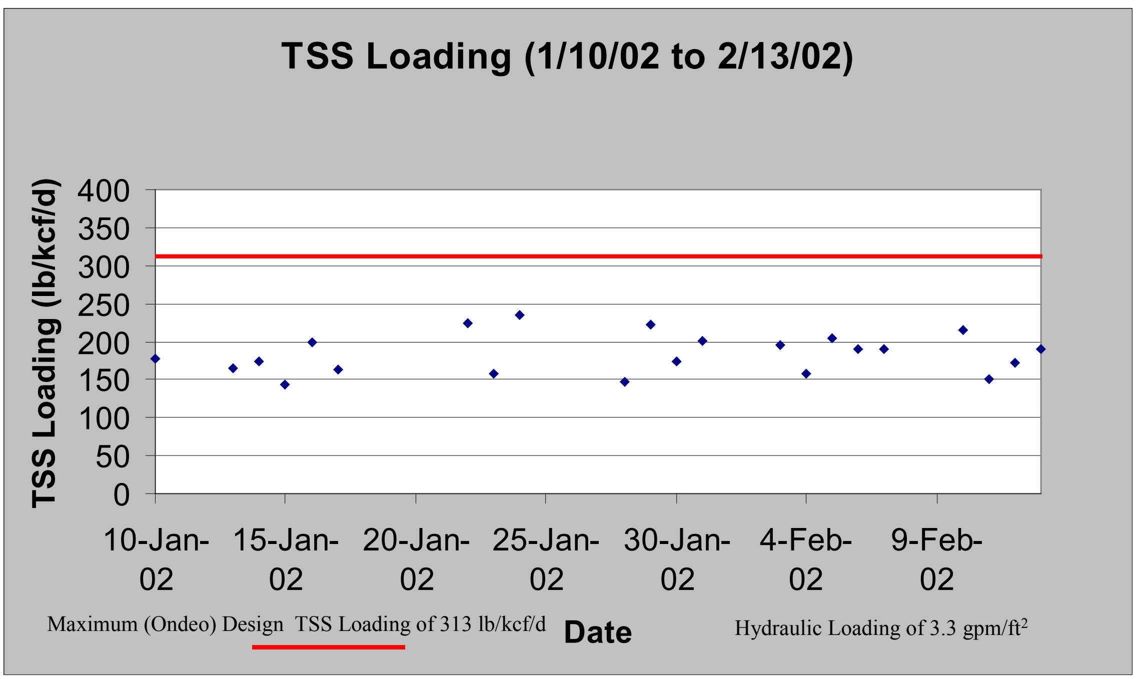


*Figure 4. TSS Loading in Phase IIIA*

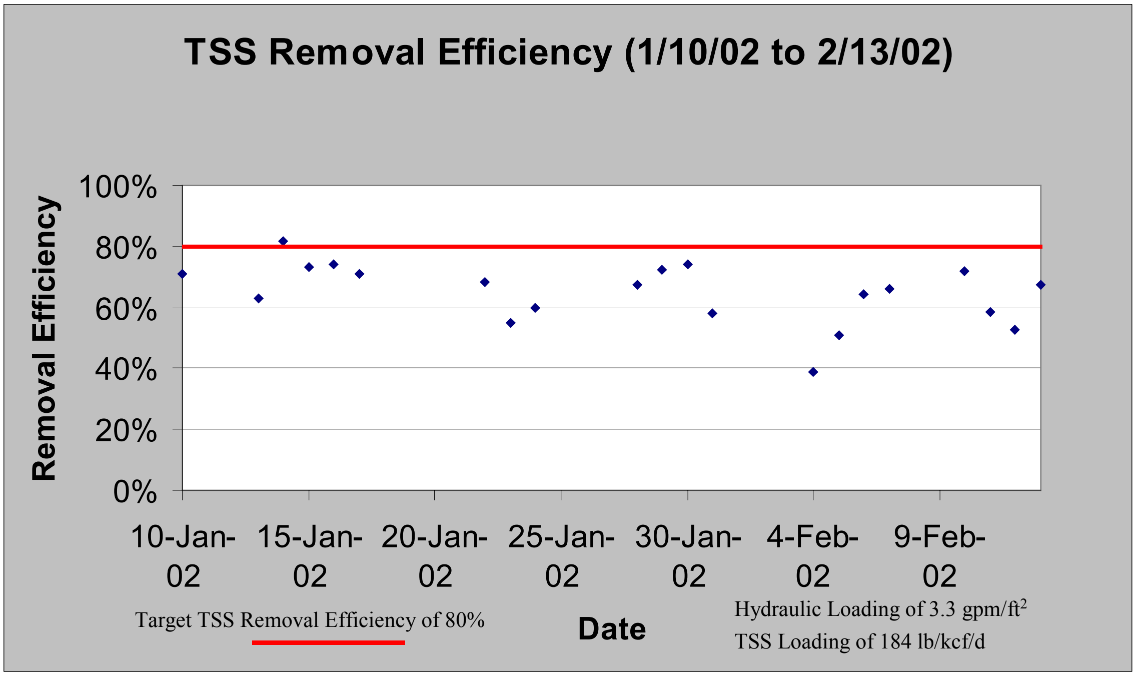


*Figure 5. TSS Removal Efficiency in Phase IIIA*

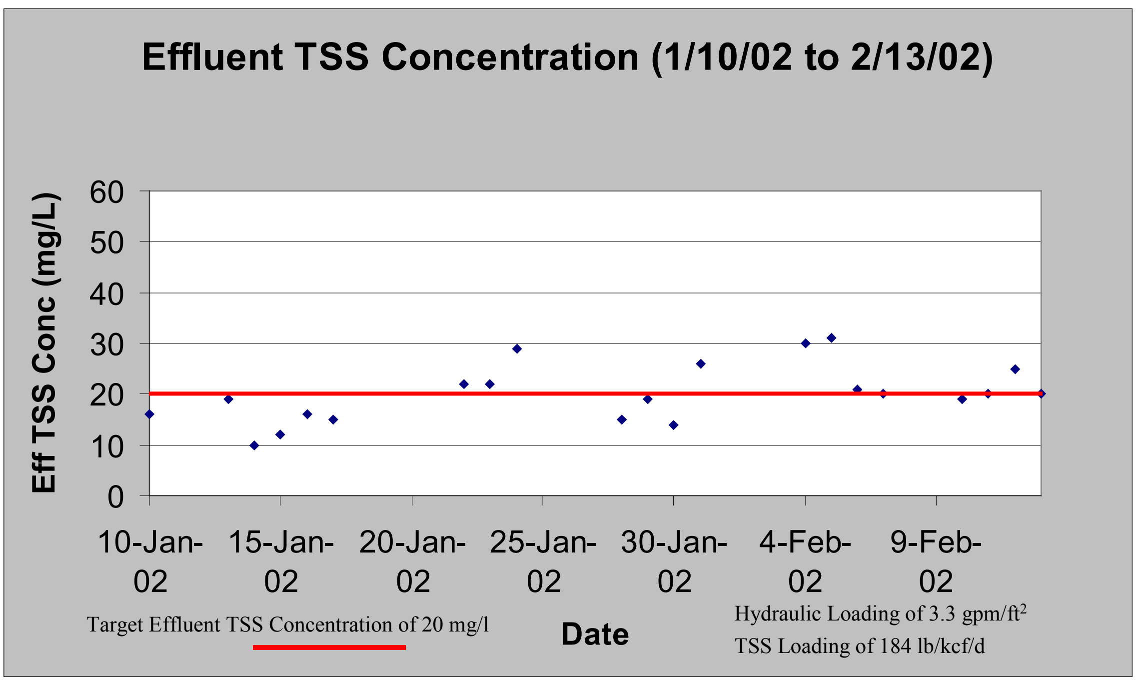


*Figure 6. Effluent TSS Concentration in Phase IIIA*

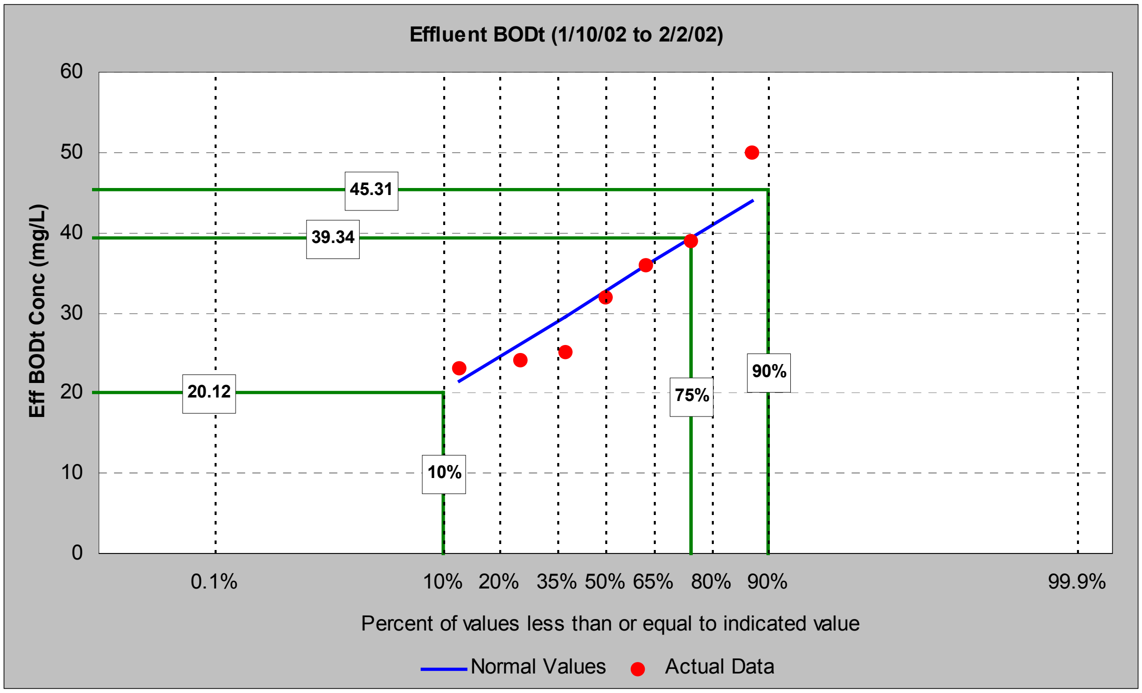


*Figure 7. Effluent BODt Percentile Plot in First Part of Phase IIIA (BODt Analyses without Nitrification Inhibitor)*

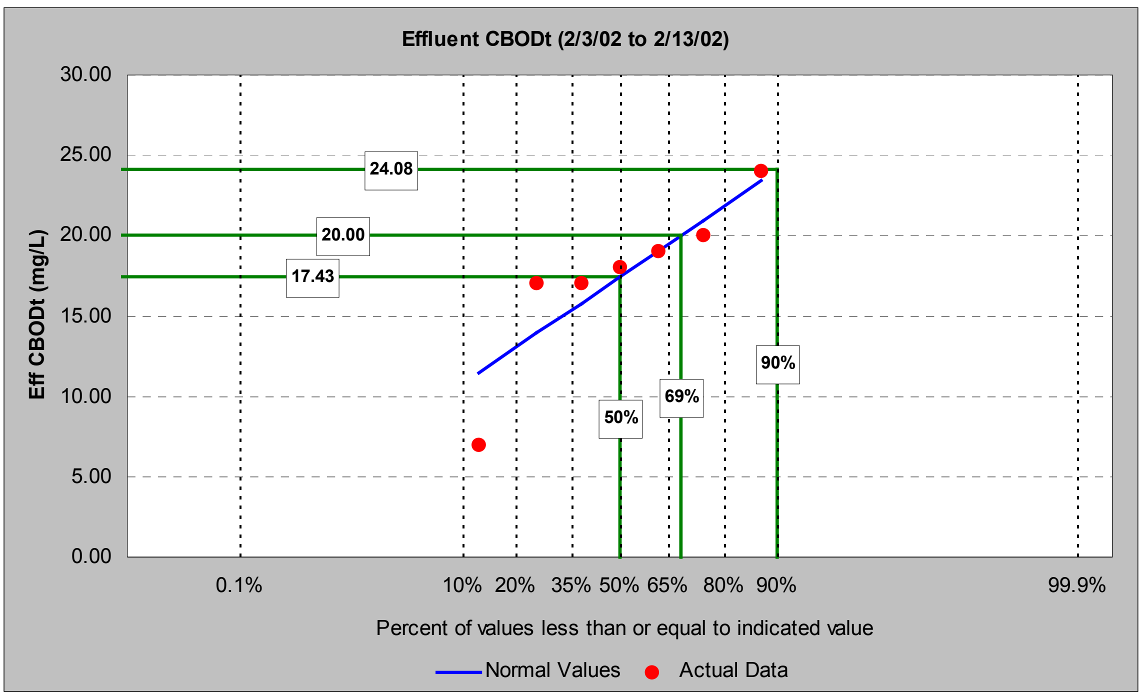


*Figure 8. Effluent BODt Percentile Plot in Second Part of Phase IIIA (BODt Analyses with Nitrification Inhibitor)*

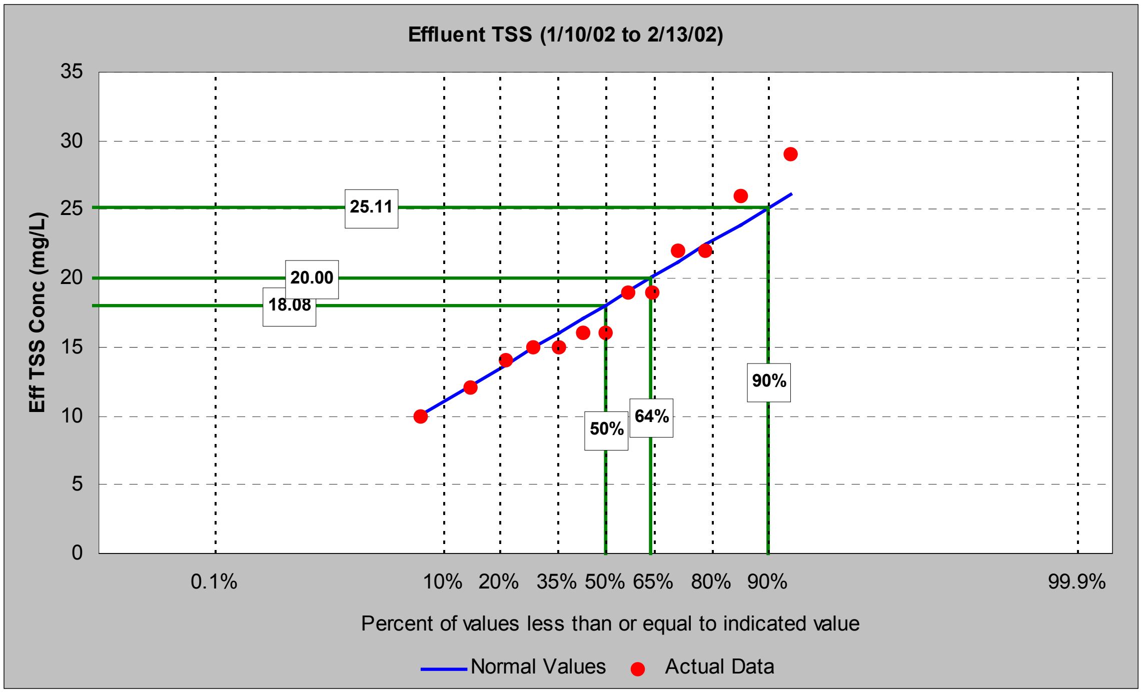


*Figure 9. Effluent TSS Percentile Plot in Phase IIIA*

## Phase IIIB

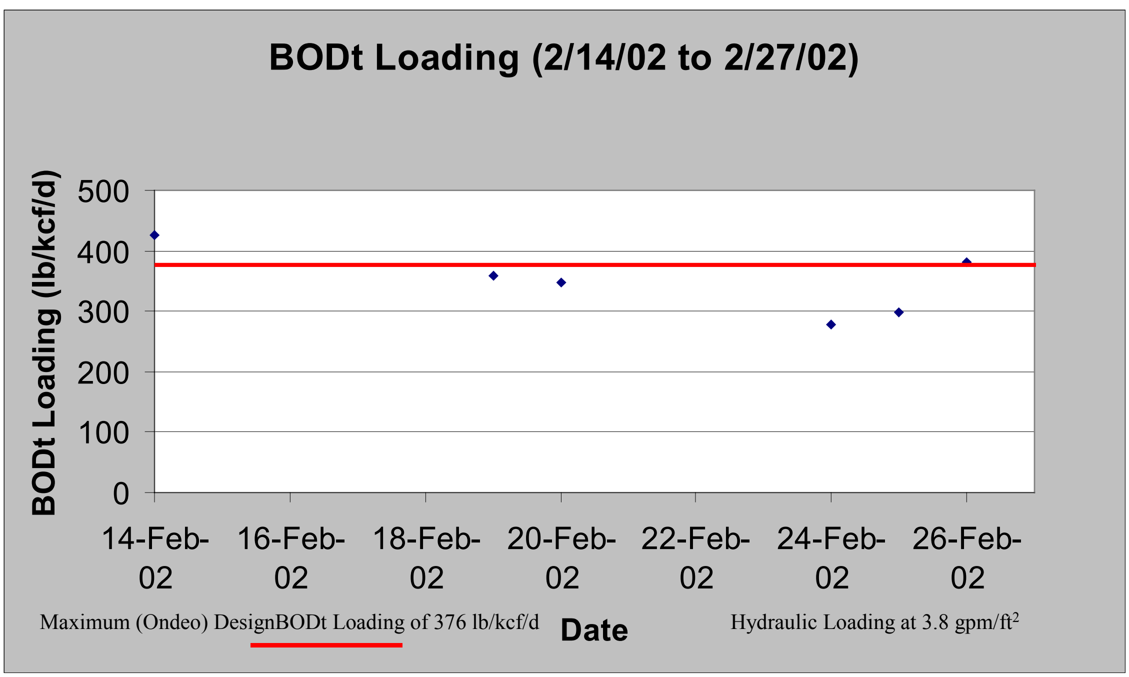


*Figure 10. BODt Loading in Phase IIIB*

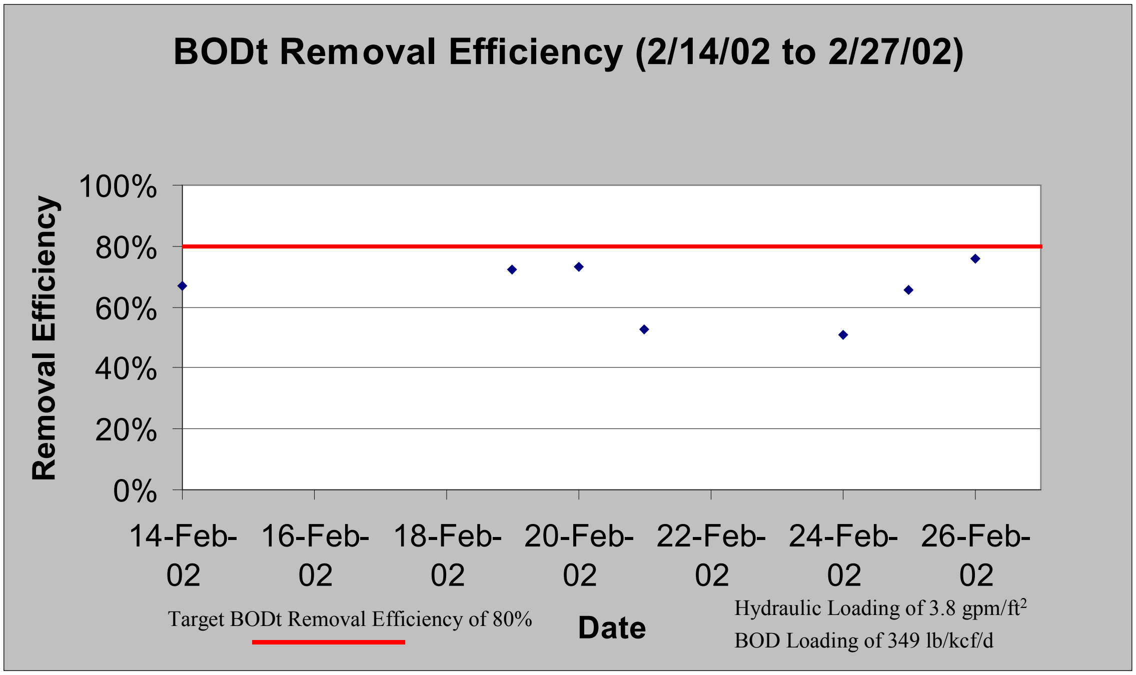


*Figure 11. BODt Removal Efficiency in Phase IIIB*

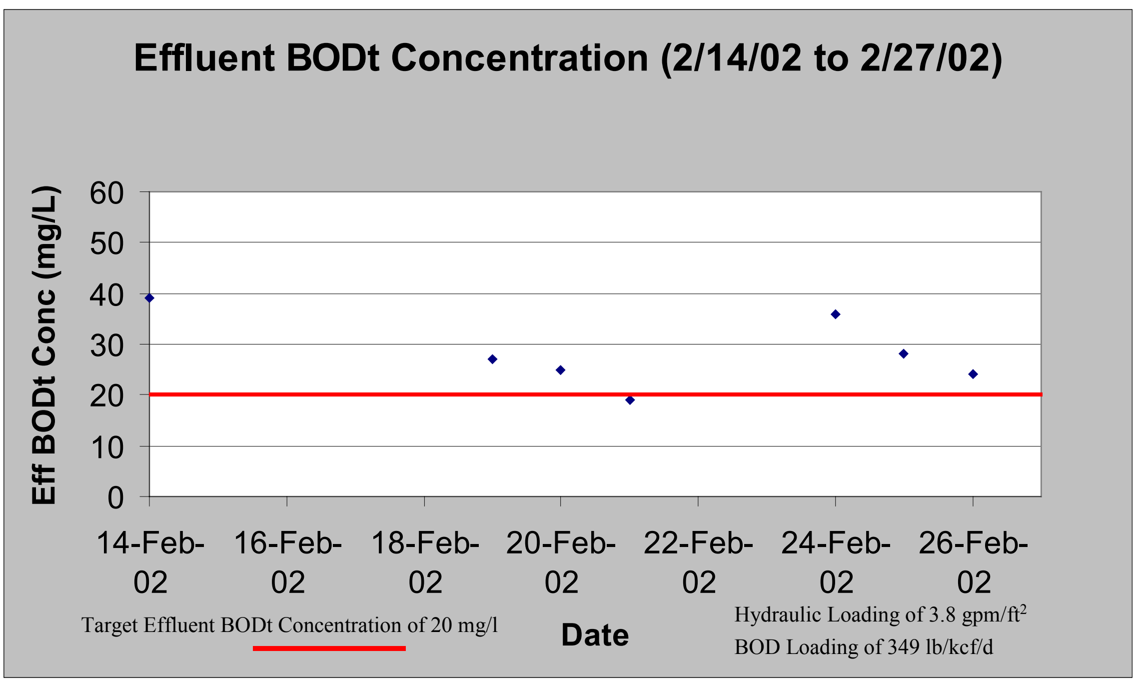


*Figure 12. Effluent BODt Concentration in Phase IIIB*

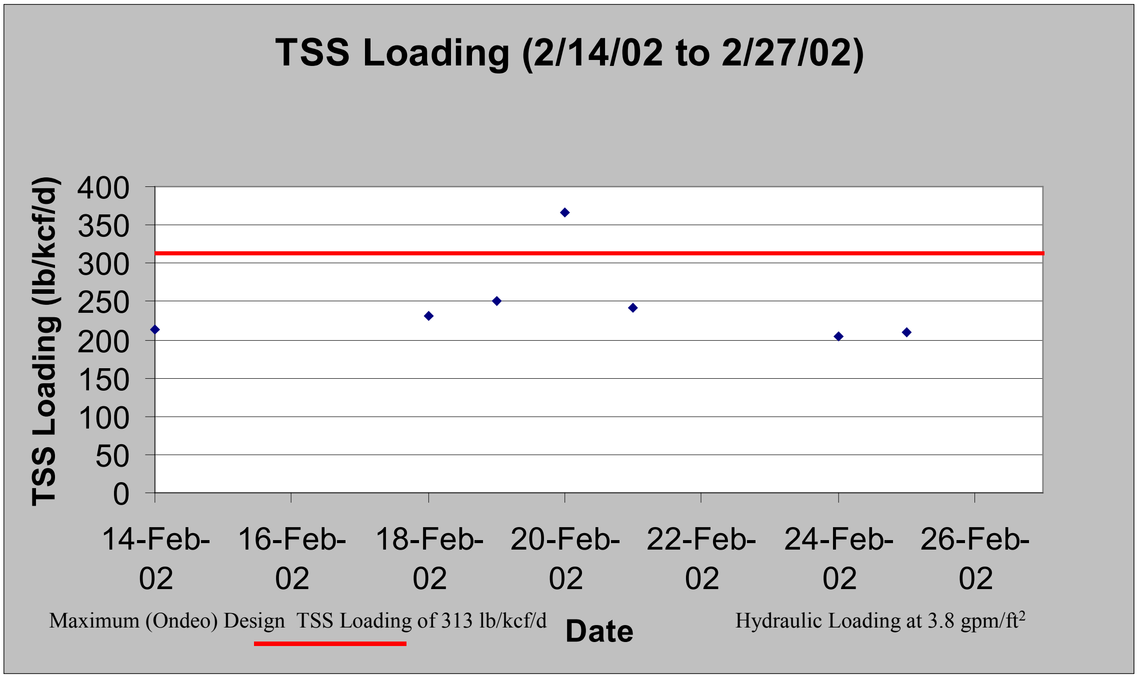


*Figure 13. TSS Loading in Phase IIIB*

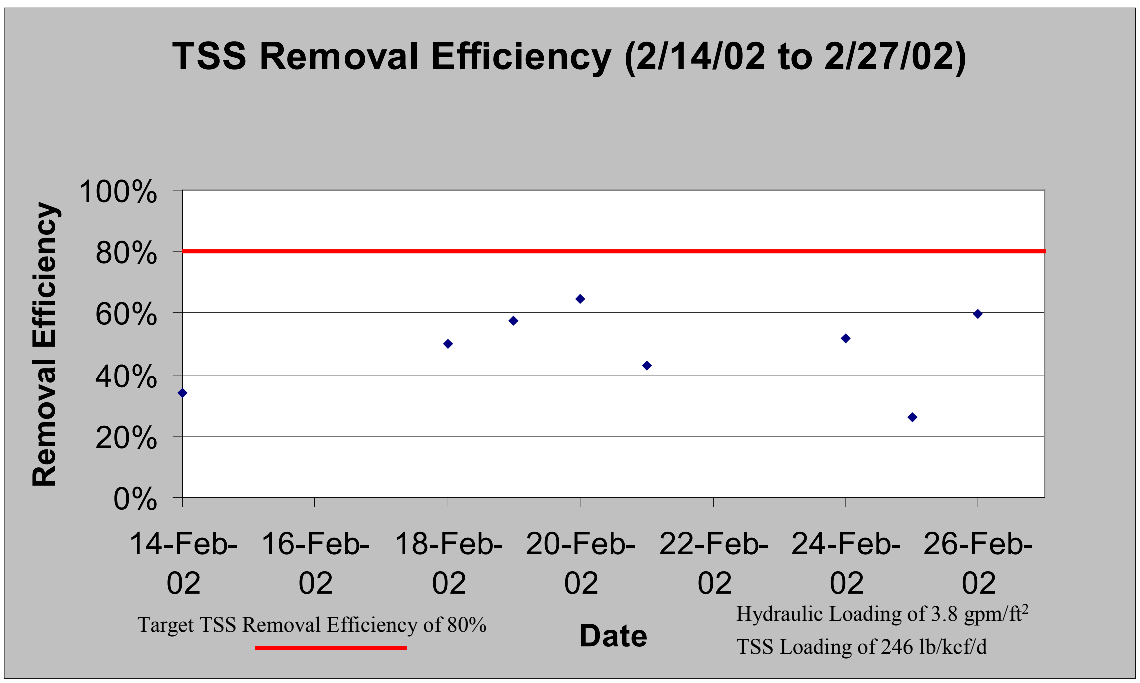


*Figure 14. TSS Removal Efficiency in Phase IIIB*

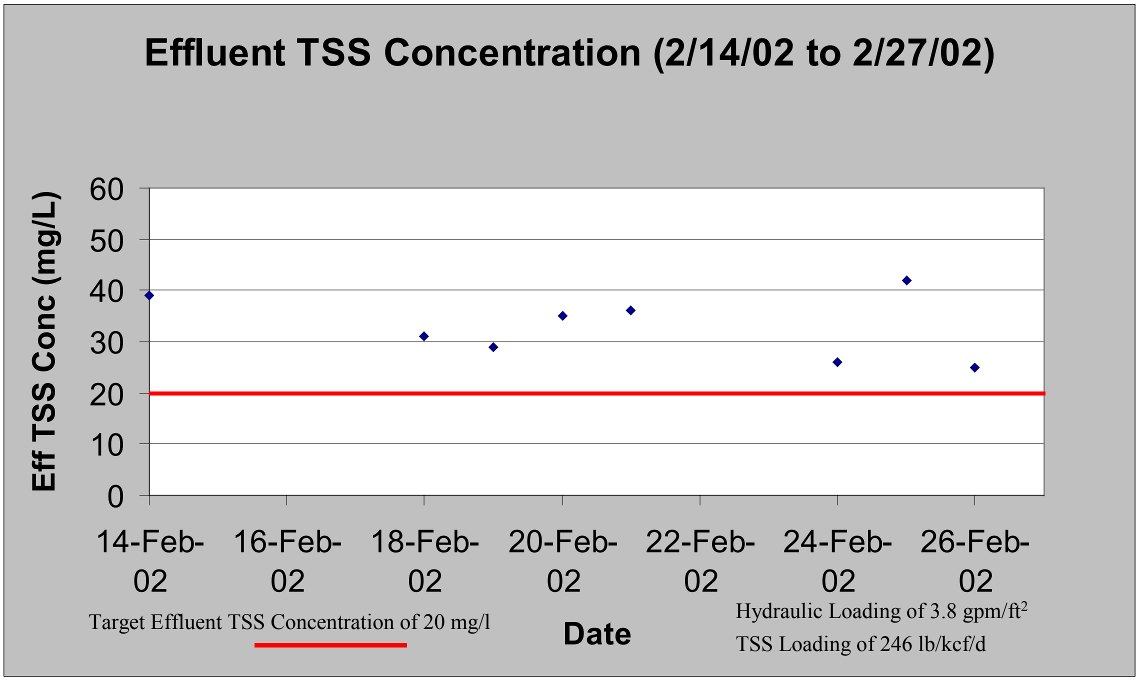


*Figure 15. Effluent TSS Concentration in Phase IIIB*

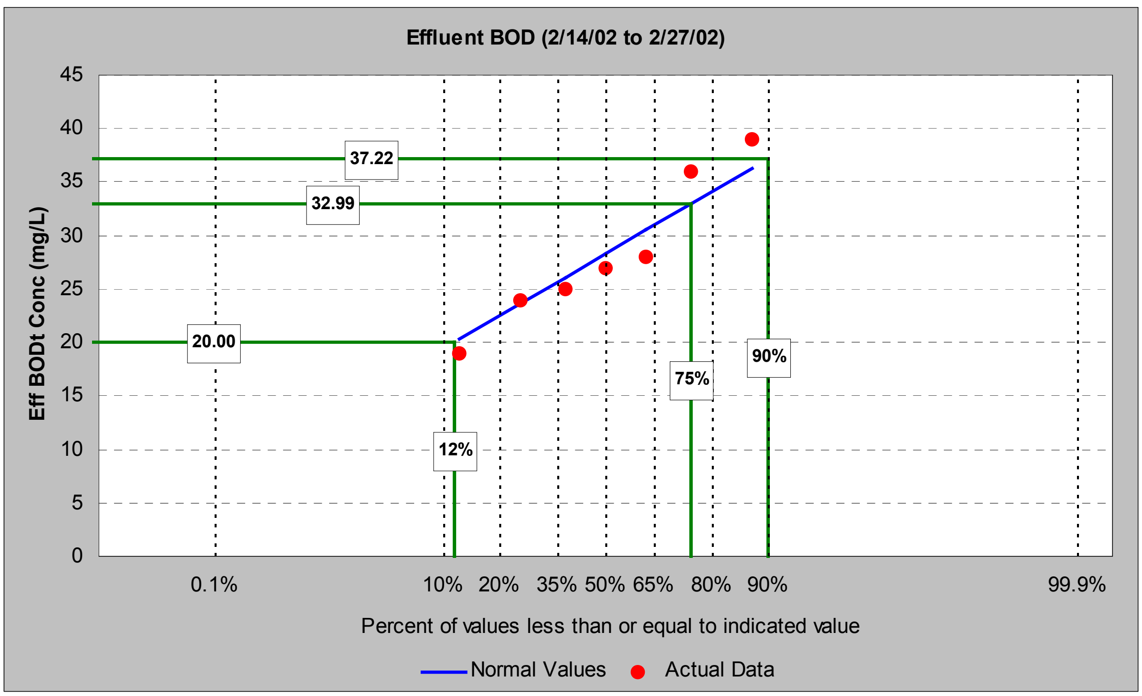


*Figure 16. Effluent BODt Percentile Plot in Phase IIIB*

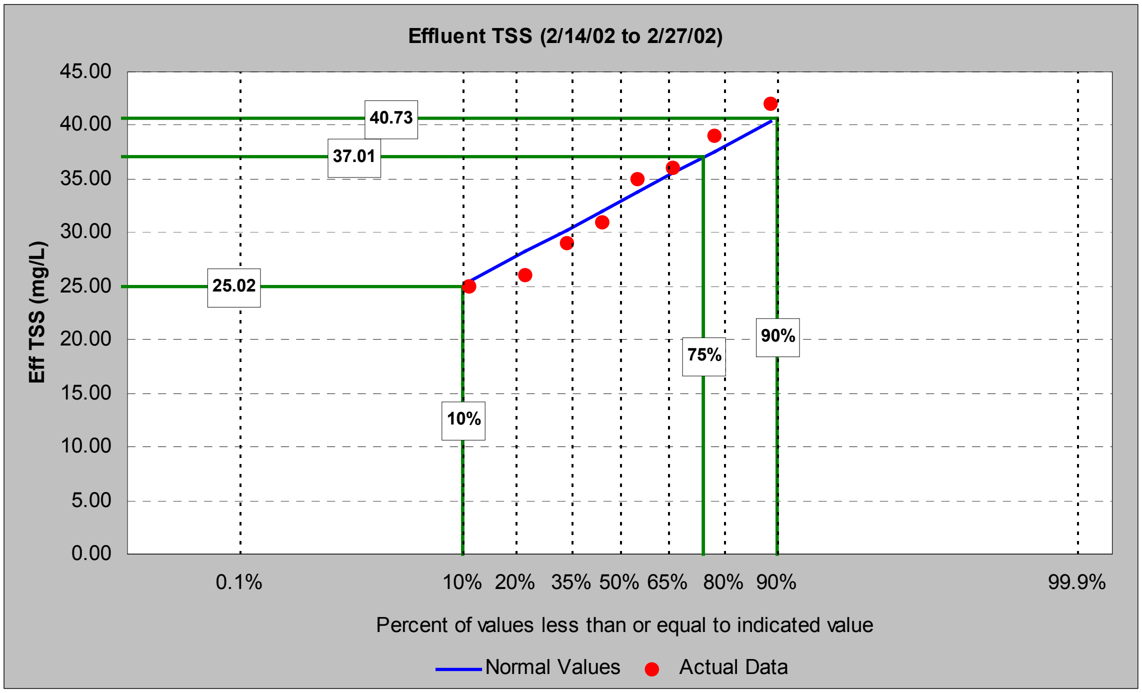

*Figure 17. Effluent TSS Percentile Plot in Phase IIIB*

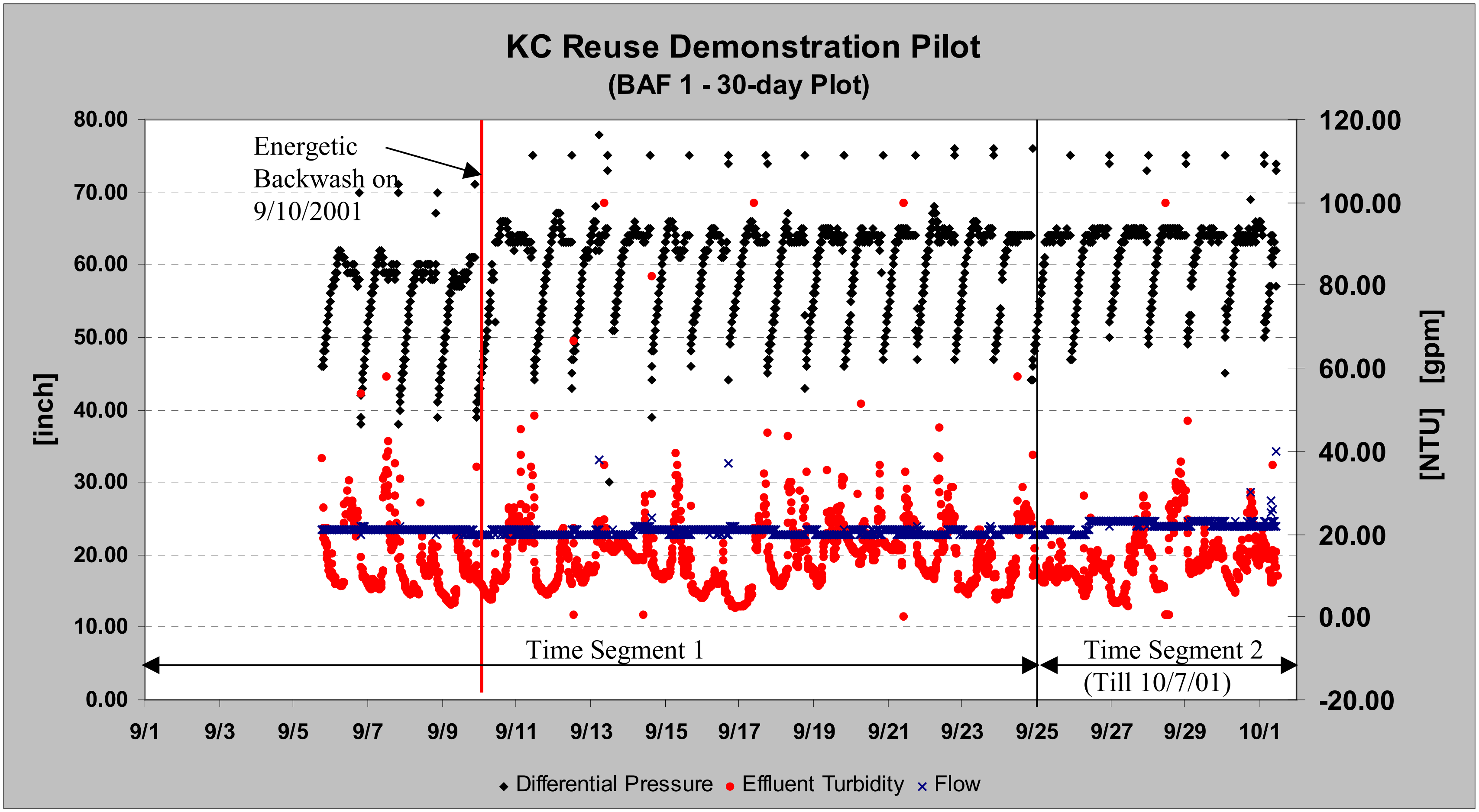


*Figure 1. Differential Pressure Buildup Pattern in September 2001*

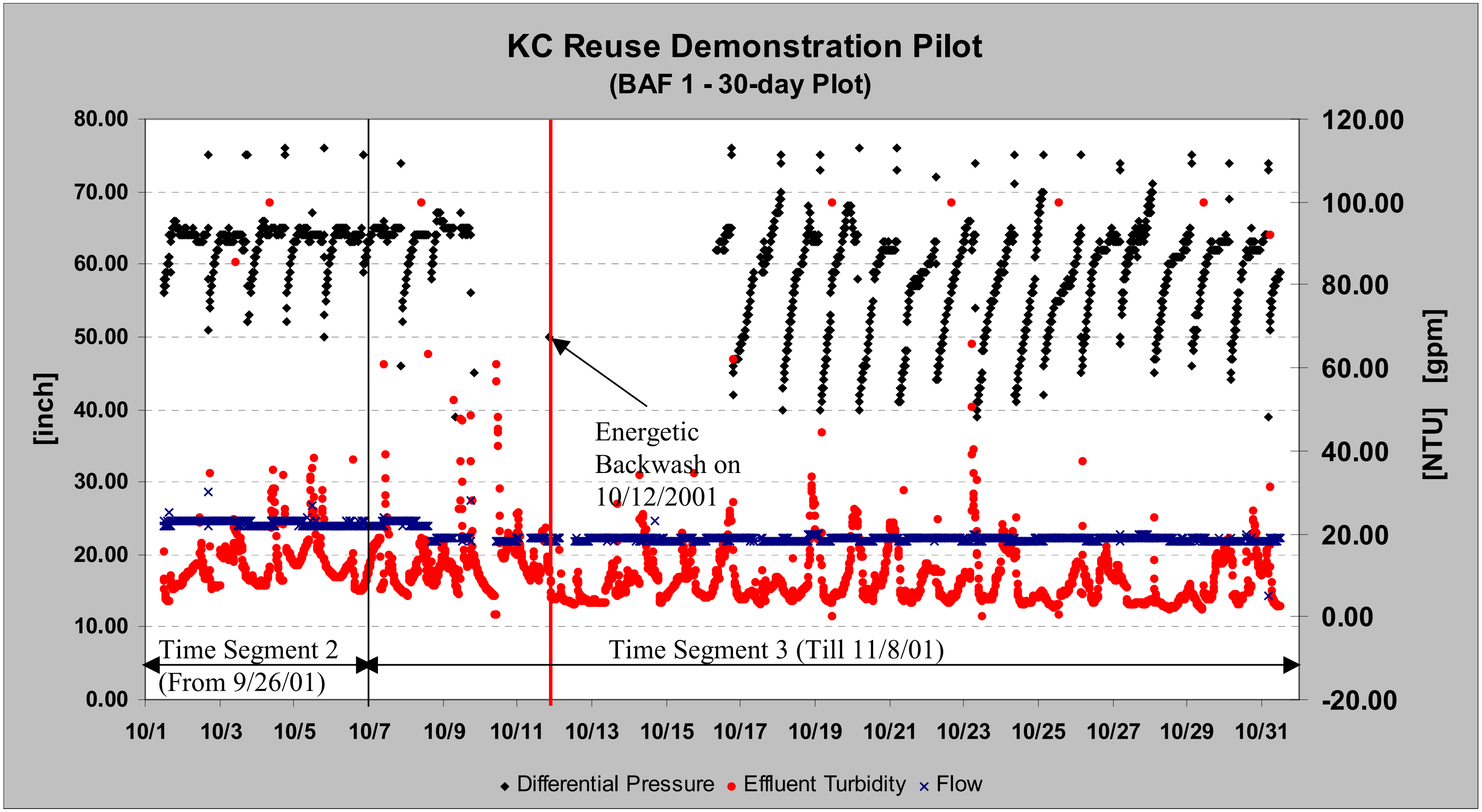


*Figure 2. Differential Pressure Buildup Pattern in October 2001*

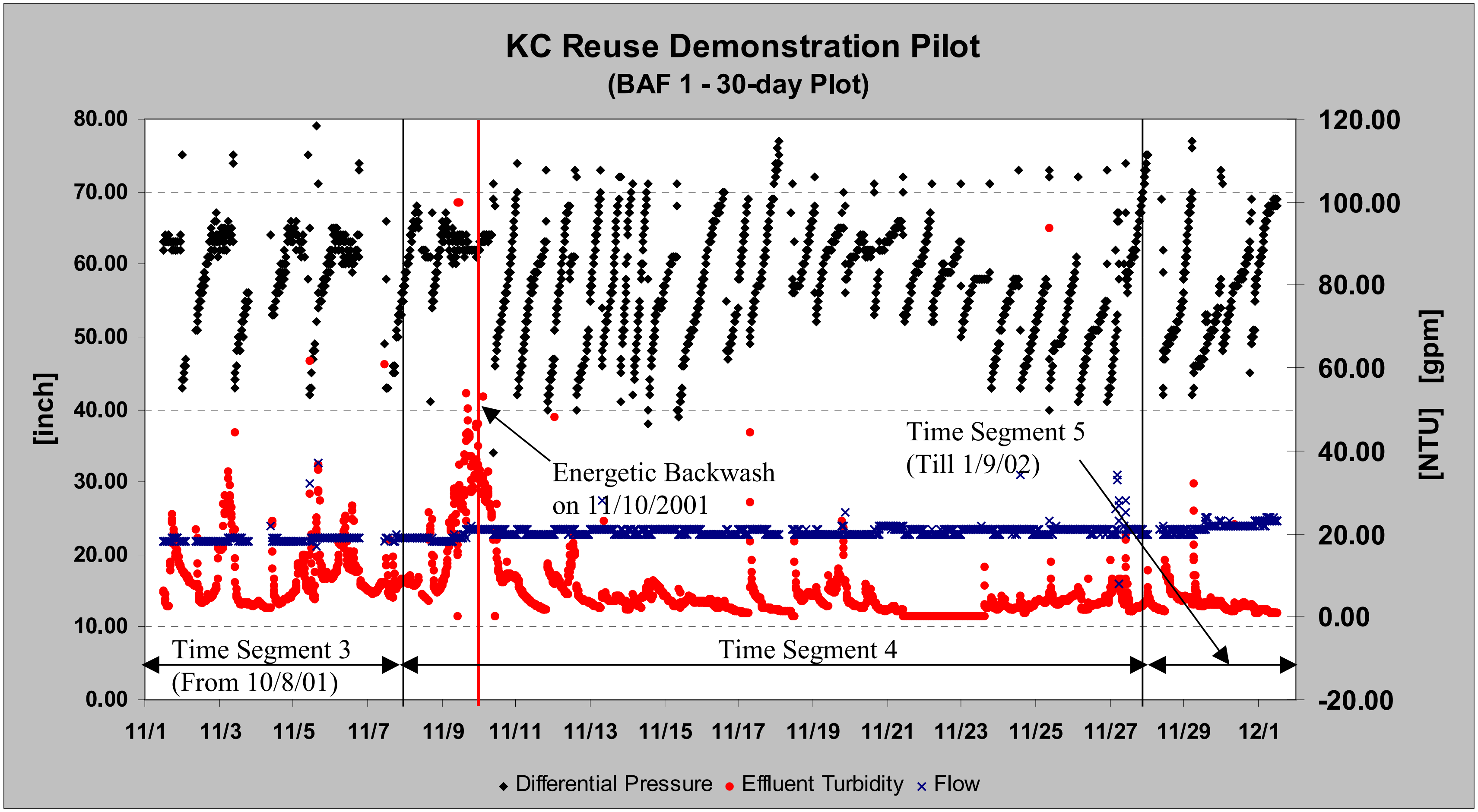


*Figure 3. Differential Pressure Buildup Pattern in November 2001*

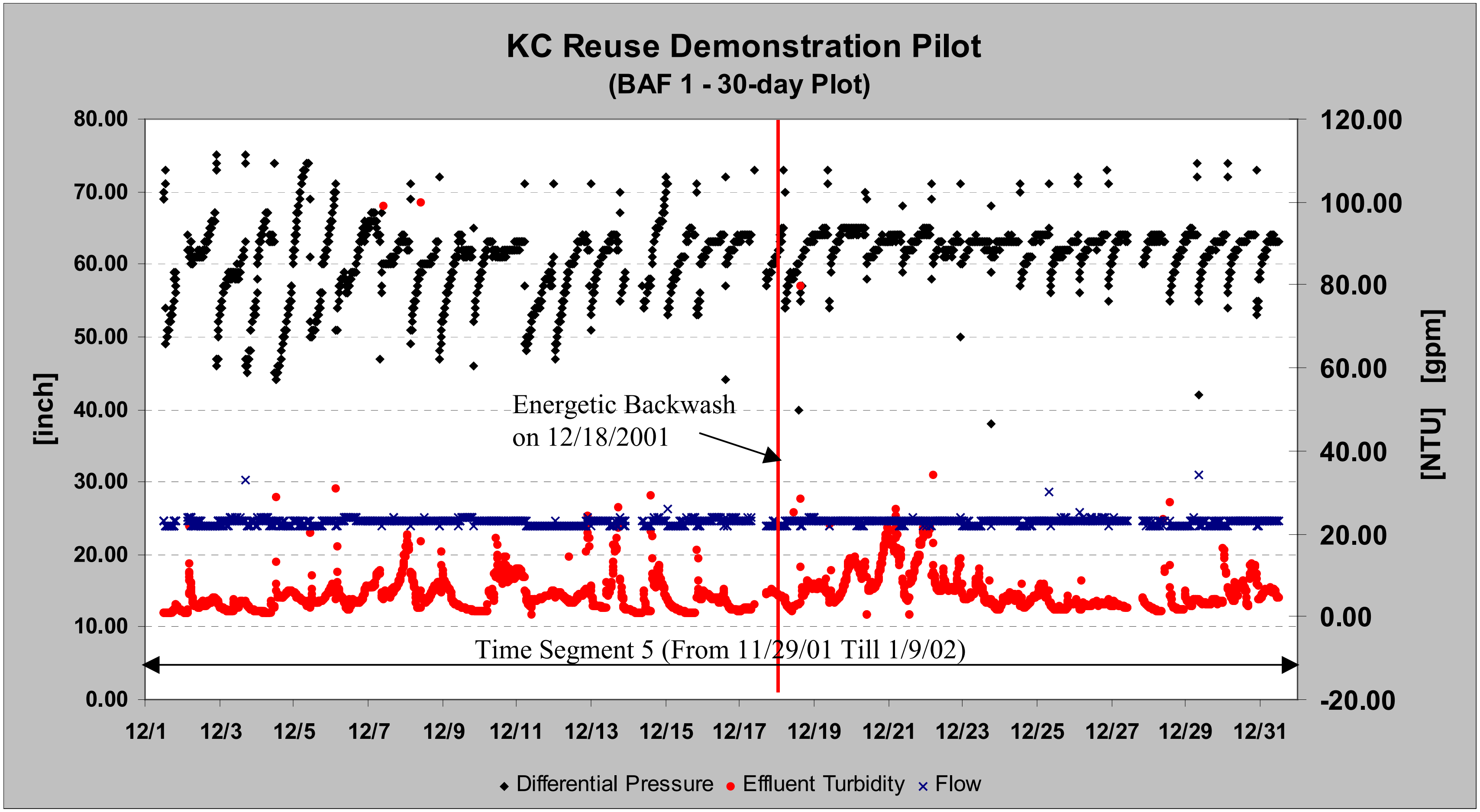


*Figure 4. Differential Pressure Buildup Pattern in December 2001*

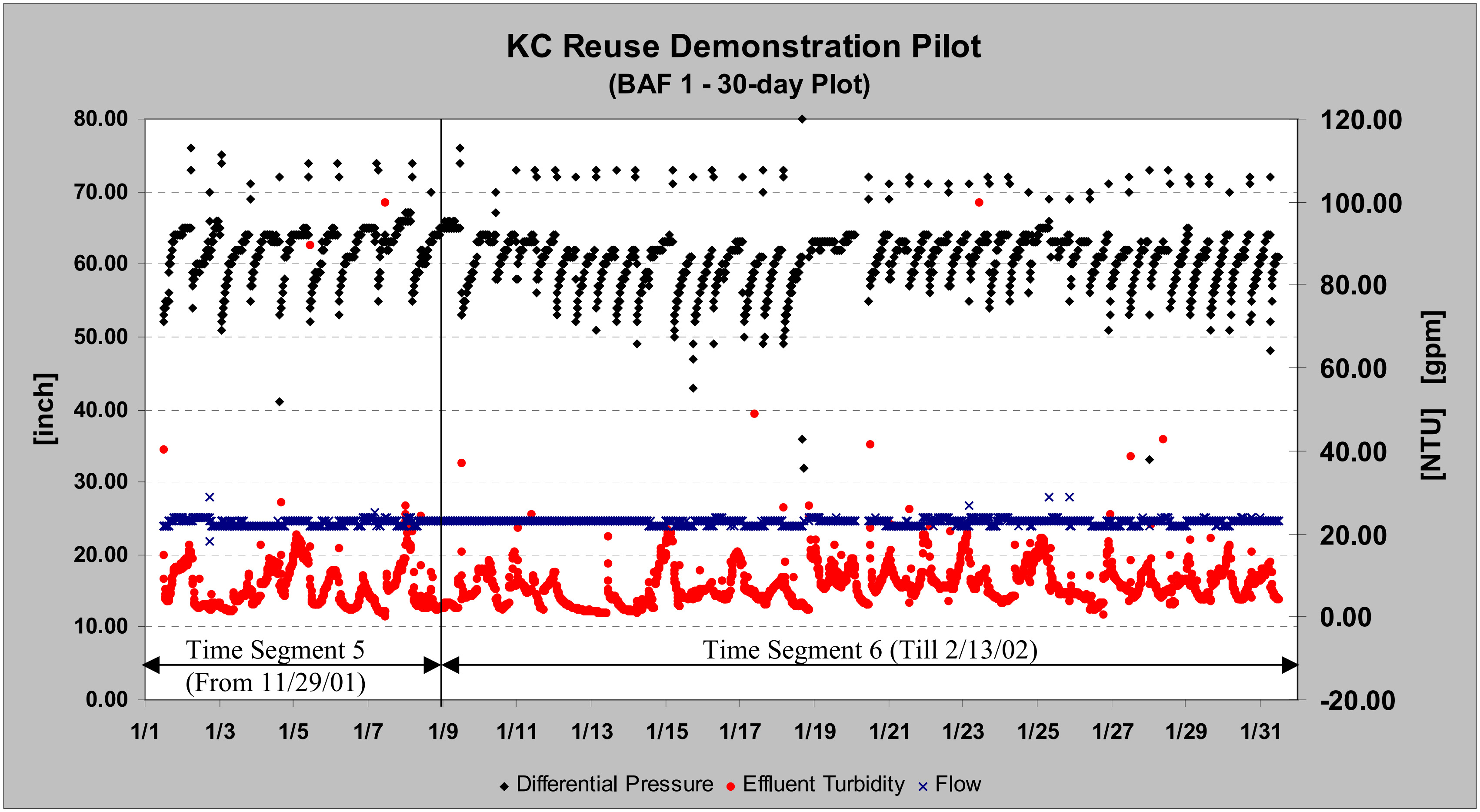


*Figure 5. Differential Pressure Buildup Pattern in January 2002*

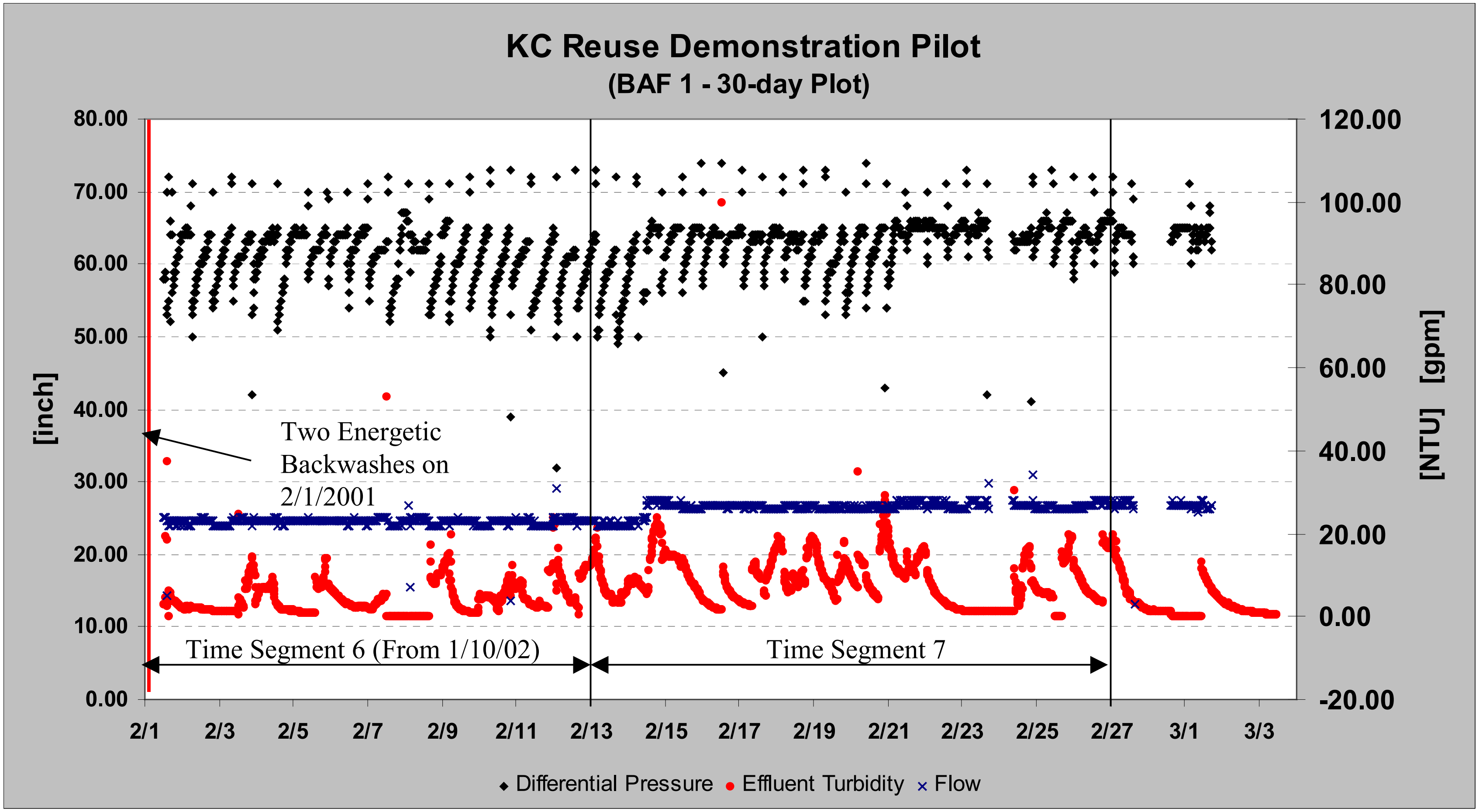


*Figure 6. Differential Pressure Buildup Pattern in February 2002*

# BAF #1 Pilot Unit Photos

## Introduction

The following is a series of photos of the Ondeo BIOFOR BOD removal biological aerated filter pilot unit (BAF #1) during the pilot testing. Each photo includes a caption and text boxes to point out key pieces of equipment.

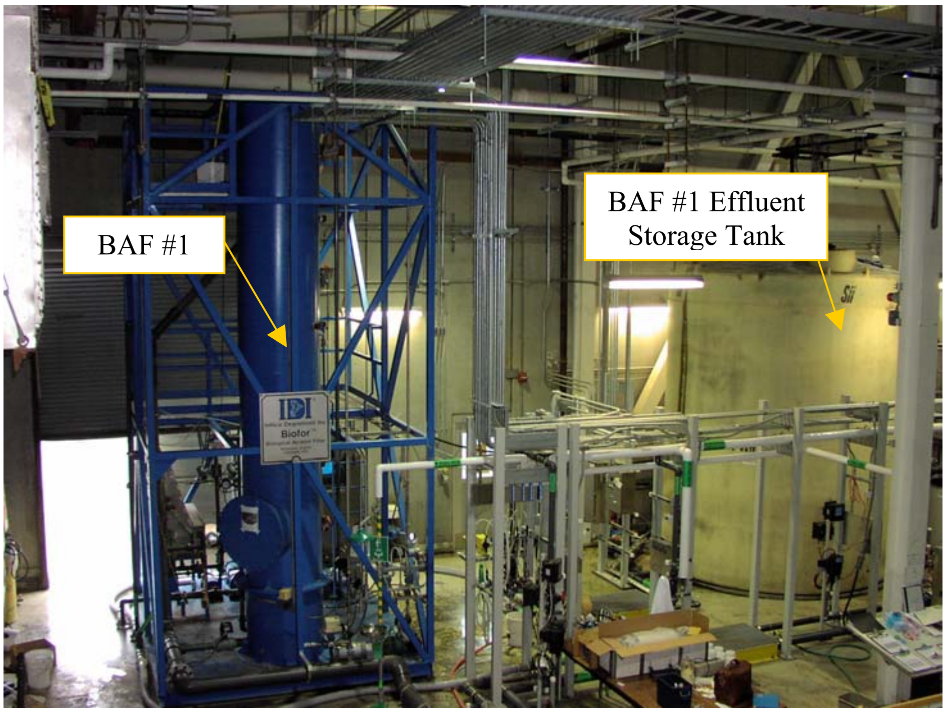


*Figure 1. BAF #1 and Effluent Storage Tank*

*Figure 2. BAF #1 Influent Fine Screen*


*Figure 3. Exterior Air Supply Manifold*

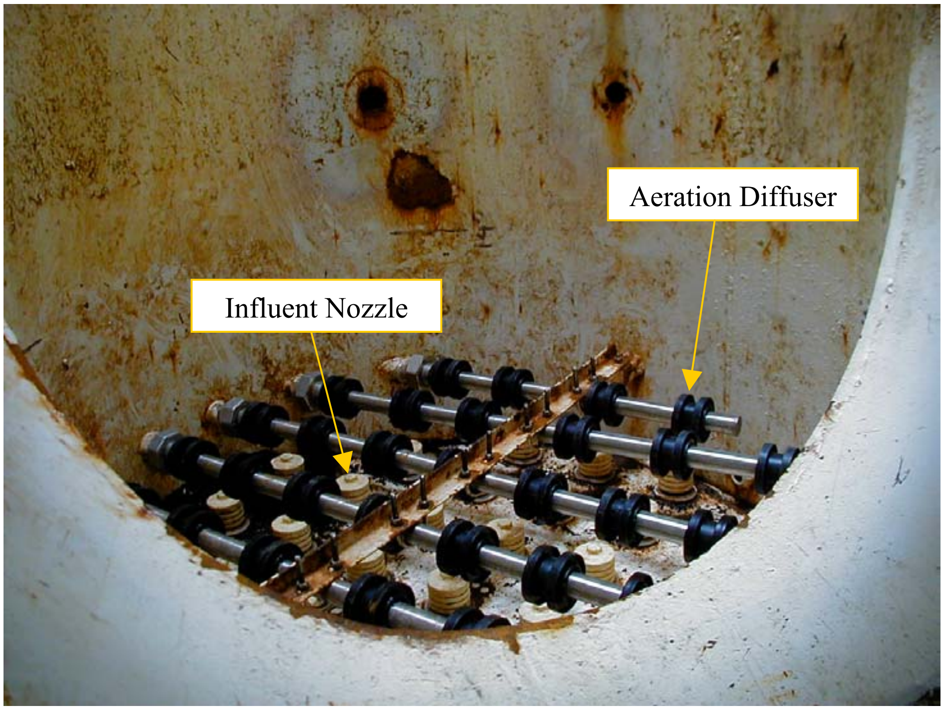


*Figure 4. Aeration Diffusers and Influent Nozzles*

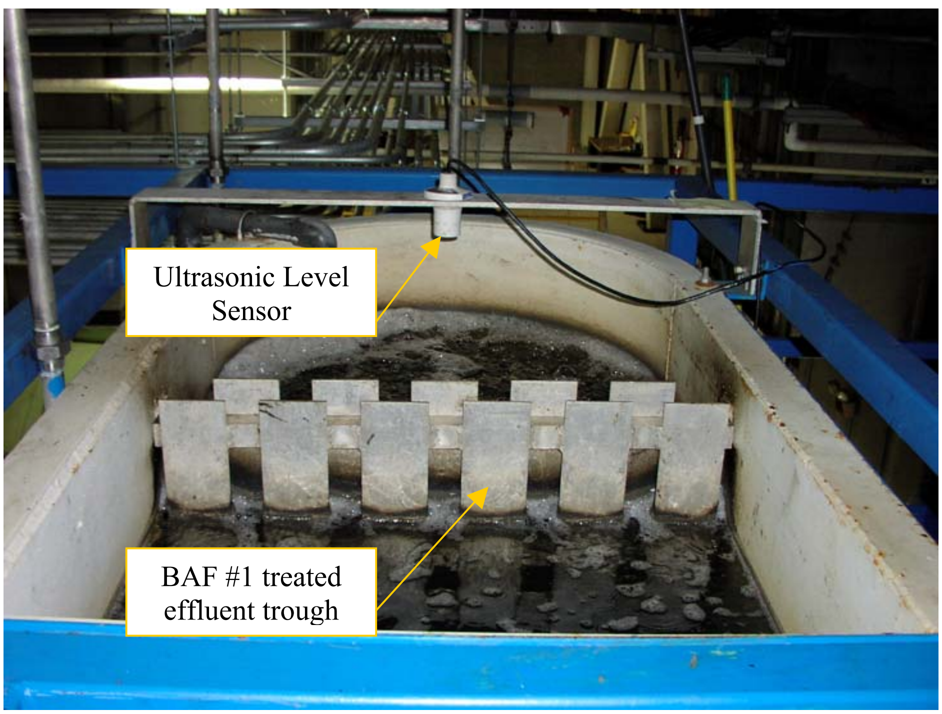


*Figure 5. Top of BAF #1*


*Figure 6. BAF #1 Panel PC (Control Interface)*