# ICR TREATMENT STUDY ANALYSIS

## Base Analysis and Data Review Comments

**Treatment Study ID** 4005

**Study Protocol** Pilot-Scale Membrane Study

**Plant ICR Number** 685

**PWS Name** Fairfax County Water Authority

**City, State, Zip** Herndon, VA 20170

## General Comments:

1. This study was grandfathered into the ICR, and therefore does not meet all of the specific requirements listed in the ICR and rule-by-reference manuals. This pilot-scale study (study ID 4005) was conducted in conjunction with a single element study (study ID 4006). Both studies were conducted during the period of September 1995 through June 1996.

2. During this pilot-scale study, the FilmTec NF70 was evaluated over a two-month period for a total of 1200 hours.

3. Microfiltration, acid addition and scale control served as pretreatment to the nanofiltration system. The Summary Report contains additional performance data for the microfiltration system.

4. No cost information is provided in the Summary Report.

## Water Quality Comments:

1. Two water quality outliers were identified and removed prior to base analysis.

2. SDS conditions are summarized in Table 7 of the Summary Report. All SDS conditions remained constant over the course of the pilot-scale study: the target free chlorine residual was 1.0 mg/L; the pH was 7.5; the incubation time was 72 hours; and the incubation temperature was 19$^{o}$C.

3. The following parameters were not measured during this study: calcium hardness, ammonia, bromide, and TOX. Feed water bromide was measured during the single element study (4006) and the average concentration was 30 μg/L.

## Productivity Comments:

1. The nanofiltration membrane was cleaned using a 0.5% NaOH solution heated to 40$^{o}$C. Cleanings were performed after a 20% decline in the temperature-normalized specific flux.

2. During the study, the rate of fouling was observed to vary inversely with the flux rate, i.e., lower fluxes resulted in longer cleaning intervals.

3. During EPA data analysis the sustained specific flux and flux was calculated as 0.273 $\pm$ 0.036 gfd/psi and 16.42 $\pm$ 1.49 gfd, respectively. The corresponding projected cleaning interval for this study was 21 days, which compares well to that projected by the consultant, of 28 days.

**Fairfax County Water Authority** | **Pilot-Scale Membrane Treatment Study Summary** | **Session:** 1

**ICR Information**

**ID / ICR#:** VA6059501 / 685
**ICR Contact:** Ms. Jeanne Bailey
**Phone No.:** 703-404-5048
**Period:** 4/7/92 - 5/31/92 (54 days)

**Membrane Information**

| | |
|---|---|
| **Manufacturer:** | FilmTec Corp. |
| **Trade Name:** | FilmTec NF70 |
| **Membrane Model:** | NF70-4040 |
| **MWCO:** | 200 Daltons |
| **Element Size:** | 4" x 40" |
| **Element Area:** | 72.2 $ft^2$ |
| **Design Flux:** | 25.0 gfd |
| **Mfr. NDP:** | 70.0 psi |
| **Mfr. $MTC_w$:** | 0.357 (gfd/psi) |
| **Mfr. Temp:** | 25.0 °C |
| **Maximum Flow:** | 16.0 gpm |
| **Minimum Flow:** | 4.0 gpm |
| **Total Width :** | 12.0 ft |
| **Feed Spacer Thickness:** | 0.0028 ft |
| **840 Element Area** | 400.0 $ft^2$ |
| **840 Purchase Price:** | $600 |

**Design Parameters**

| | |
|---|---|
| **Norm Temp:** | 17.9 °C |
| **Temp Norm MTC-w:** | 0.290 TavgC |
| **Design Recovery:** | 0.85 |
| **Avg Sys Flux $F_w$:** | 18.0 gfd |
| **# of Elem in P.V.:** | 6 |
| **# Pres Ves in Stg 1:** | 2 |
| **# Pres Ves in Stg 2:** | 1 |
| **Pres Ves in Stg 3:** | NA |
| **Design Flux:** | 18.0 gfd |
| **Recycle Ratio:** | 0.00 |
| **Osmotic P Stage 1:** | 1.4 psi |
| **Osmotic P Stage 2:** | 3.0 psi |
| **Osmotic P Stage 3:** | NA |

**Water Quality Summary**

| | Feed (System) | | | | Permeate (System) | | | | Concentrate (System) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Summary** | **Mean** | **SD** | **Count** | **Min/Max** | **Mean** | **SD** | **Count** | **Min/Max** | **Mean** | **SD** | **Count** | **Min/Max** |
| pH | 6.1 | 0.2 | 5 | 5.9 - 6.4 | 5.6 | 0.2 | 5 | 5.4 - 6.0 | 6.3 | 0.2 | 5 | 6.0 - 6.5 |
| Temp | 14.4 | 3.1 | 6 | 10.0 - 17.1 | 15.5 | 3.0 | 6 | 11.2 - 18.1 | 14.1 | 4.2 | 6 | 7.6 - 18.4 |
| Alk | 14 | 3 | 6 | 9 - 18 | 3 | 2 | 6 | 1 - 6 | 62 | 18 | 6 | 31 - 81 |
| **TDS** | **87** | **6** | **6** | **82 - 98** | **12** | **2** | **6** | **10 - 16** | **390** | **76** | **6** | **270 - 501** |
| TotHard | 65 | 15 | 6 | 49 - 83 | 22 | 15 | 6 | 1 - 46 | 248 | 58 | 6 | 145 - 308 |
| CaHard | NA | NA | 0 | 0 - 0 | NA | NA | 0 | 0 - 0 | NA | NA | 0 | 0 - 0 |
| Turb | 0.09 | 0.0 | 5 | 0.08 - 0.10 | 0.07 | 0.0 | 4 | 0.05 - 0.09 | 0.20 | 0.1 | 4 | 0.16 - 0.28 |
| Amm | NA | NA | 0 | NA | NA | NA | 0.00 | NA | NA | NA | 0 | 0.0 - 0.0 |
| **TOC** | **5.5** | **0.5** | **6** | **4.8 - 6.1** | **0.3** | **0.0** | **6** | **0.3 - 0.3** | **28.8** | **5.0** | **6** | **23.0 - 34.9** |
| UV254 | 0.166 | 0.0 | 6 | 0.111 - 0.190 | 0.005 | 0.0 | 6 | 0.005 - 0.005 | 0.928 | 0.2 | 6 | 0.684 - 1.124 |
| SUVA | 3.04 | 0.37 | 6 | 2.31 - 3.40 | 1.80 | 0.00 | 6 | 1.80 - 1.80 | 3.29 | 0.80 | 6 | 2.72 - 4.89 |
| **Bromide** | **NA** | **NA** | **0** | **0 - 0** | **NA** | **NA** | **0** | **0 - 0** | | | | |
| **TOX** | **NA** | **NA** | **0** | **0 - 0** | **NA** | **NA** | **0** | **0 - 0** | | | | |
| CHCl3 | 94.2 | 21.4 | 3 | 81.9 - 118.9 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| BDCM | 12.4 | 3.5 | 3 | 8.3 - 14.4 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| DBCM | 0.0 | 0.0 | 3 | 0.0 - 0.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| CHBr3 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| **THM4** | **106.6** | **17.8** | **3** | **96.3 - 127.2** | **0.0** | **0.0** | **3** | **0.0 - 0.0** | | | | |
| MCAA | 3.0 | 0.0 | 3 | 3.0 - 3.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| DCAA | 49.0 | 12.1 | 3 | 42.0 - 63.0 | 1.0 | 0.0 | 3 | 1.0 - 1.0 | | | | |
| TCAA | 66.0 | 5.2 | 3 | 63.0 - 72.0 | 0.7 | 0.6 | 3 | 0.0 - 1.0 | | | | |
| MBAA | 0.0 | 0.0 | 3 | 0.0 - 0.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| DBAA | 5.3 | 4.6 | 3 | 0.0 - 8.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| BCAA | 4.0 | 1.7 | 3 | 2.0 - 5.0 | 0.0 | 0.0 | 3 | 0.0 - 0.0 | | | | |
| TBAA | NA | NA | 0 | NA | NA | NA | 0 | NA | | | | |
| CDBAA | NA | NA | 0 | NA | NA | NA | 0 | NA | | | | |
| DCBAA | NA | NA | 0 | NA | NA | NA | 0 | NA | | | | |
| **HAA5** | **123.3** | **12.7** | **3** | **116.0 - 138.0** | **1.7** | **0.6** | **3** | **1.0 - 2.0** | | | | |
| **HAA6** | **127.3** | **11.0** | **3** | **121.0 - 140.0** | **1.7** | **0.6** | **3** | **1.0 - 2.0** | | | | |
| **HAA9** | **NA** | **NA** | **0** | **NA** | **NA** | **NA** | **0** | **NA** | | | | |

**Mass Balance Closure Errors (%)**

| WQP | Count | Avg | SD/RD |
|---|---|---|---|
| Alk | 6 | -10 | 12 |
| TDS | 6 | -16 | 12 |
| TotHard | 6 | -10 | 15 |
| CaHard | 0 | n/a | n/a |
| Turb | 4 | -5 | 52 |
| Amm | 0 | n/a | n/a |
| TOC | 0 | n/a | n/a |
| UV254 | 5 | -4 | 9 |
| TDSt | 48 | -13 | 12 |

**Comments:**

**SDS Conditions**

| **WQP** | **Avg** | **SD** | **Count** | **Min - Max** |
|---|---|---|---|---|
| Res (1) | 0.68 | 0.34 | 6 | 0.04 - 1.03 |
| Temp (°C) | 19.0 | 0.0 | 6 | 19.0 - 19.0 |
| pH (unit) | 7.5 | 0.0 | 6 | 7.5 - 7.5 |
| Time (hr) | 72.0 | 0.0 | 6 | 72.0 - 72.0 |

**Pretreatment Information**

| **Process** | **Description** | **Scale** |
|---|---|---|
| Microfiltration | 0.2 micron nominal pore size | pilot-scale |
| Sulfuric acid addition | pH = 6.0 | Pilot-scale |
| Cartridge filtration | 5 um nominal pore size | pilot-scale |

**Mass Balance Errors**

| **Pressure** | **RPD** | **SD** | **Flow** | **RPD** | **SD** | **TDS** | **RPD** | **SD** |
|---|---|---|---|---|---|---|---|---|
| System Inf - Stg 1 Inf | 0.0% | 0.0% | System Inf - Stg 1 Inf | 0.0% | 0.0% | System Inf - Stg 1 Inf | 0.0% | 0.0% |
| Sys Conc - Stg 2 Conc | 0.0% | 0.0% | Sys Conc - Stg 2 Conc | 0.0% | 0.0% | Sys Conc - Stg 2 Conc | 0.0% | 0.0% |
| Stg 1 Conc - Stg 2 Inf | 0.0% | 0.0% | Stg 1 Conc - Stg 2 Inf | 0.0% | 0.0% | Stg 1 Conc - Stg 2 Inf | 0.0% | 0.0% |
| Sys Perm - Avg Stg Perm | -14.7% | 40.2% | Sys Perm - Sum Stg Pei | 0.0% | 0.0% | Sys Perm - Avg Stg Perm | -17.1% | 6.4% |

**Stage Summary**

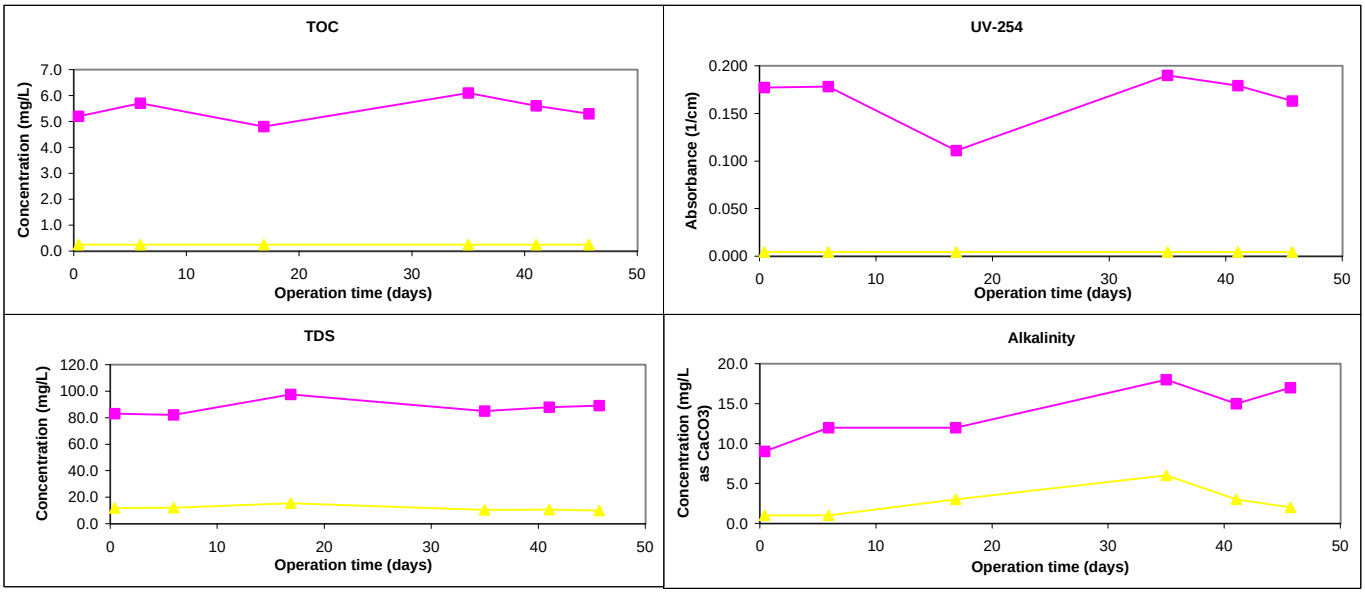
| | Stage 1 Influent | | | | | | Stage 1 Permeate | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WQP** | **Sys Feed** | **Sys Conc** | **Mean** | **SD** | **Count** | **Min/Max** | **Sys Perm** | **Mean** | **SD** | **Count** | **Min/Max** |
| **Recovery** | | | **0.59** | **0.02** | **6** | **0.56 - 0.62** | | | | | |
| pH | 6.1 | 6.3 | 6.0 | 0.3 | 5 | 5.7 - 6.4 | 5.6 | NA | NA | 0 | 0.0 - 0.0 |
| Temp | 14.4 | 14.1 | 14.6 | 3.2 | 6 | 10.0 - 17.1 | 15.5 | NA | NA | 0 | 0.0 - 0.0 |
| Alk | 14 | 62 | 14 | 3 | 6 | **9 - 18** | 3 | NA | NA | 0 | 0 - 0 |
| **TDS** | **87** | **390** | 87 | **6** | **6** | **82 - 98** | **12** | **9** | **1** | **6** | **8 - 12** |
| TotHard | 65 | 248 | 67 | 18 | 5 | 49 - 86 | 22 | NA | NA | 0 | 0 - 0 |
| CaHard | NA | NA | NA | NA | 0 | 0 - 0 | NA | NA | NA | 0 | 0 - 0 |
| Turb | 0.09 | 0.20 | 0.10 | 0 | 5 | 0.08 - 0.12 | 0.07 | NA | NA | 0 | 0 - 0 |
| **TOC** | **5.5** | **28.8** | 5.5 | **0.5** | **6** | **4.8 - 6.1** | **0.3** | **NA** | **NA** | **0** | **0.0 - 0.0** |
| UV254 | 0.166 | **0.928** | 0.166 | 0.028 | 6 | 0.111 - 0.190 | 0.005 | 0.005 | 0.000 | 6 | 0.005 - 0.005 |
| SUVA | 3.04 | **3.29** | 3.04 | 0.37 | 6 | 2.31 - 3.40 | 1.80 | NA | NA | 0 | NA |

| | Stage 2 Influent | | | | | | Stage 2 Permeate | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WQP** | **Sys Feed** | **Sys Conc** | **Mean** | **SD** | **Count** | **Min/Max** | **Sys Perm** | **Mean** | **SD** | **Count** | **Min/Max** |
| **Recovery** | | | **0.56** | **0.04** | **6** | **0.49 - 0.60** | | | | | |
| pH | 6.1 | 6.3 | 6.3 | 0.1 | 5 | 6.1 - 6.4 | 5.6 | NA | NA | 0 | 0.0 - 0.0 |
| Temp | 14.4 | 14.1 | 15.6 | 3.0 | 6 | 11.4 - 18.2 | 15.5 | NA | NA | 0 | 0.0 - 0.0 |
| Alk | 14 | 62 | 30 | 7 | 6 | 20 - 37 | 3 | NA | NA | 0 | 0 - 0 |
| **TDS** | **87** | **390** | 189 | **18** | **6** | **164 - 219** | **12** | **19** | **4** | **6** | **15 - 26** |
| TotHard | 65 | 248 | 143 | 24 | 6 | 116 - 173 | 22 | NA | NA | 0 | 0 - 0 |
| CaHard | NA | NA | NA | NA | 0 | 0 - 0 | NA | NA | NA | 0 | 0 - 0 |
| Turb | 0.09 | 0.20 | 0.14 | 0 | 5 | 0.12 - 0.17 | 0.07 | NA | NA | 0 | 0 - 0 |
| **TOC** | **5.5** | **28.8** | 12.1 | **2.2** | **6** | **9.5 - 14.6** | **0.3** | **0.3** | **NA** | **1** | **0.3 - 0.3** |
| UV254 | 0.166 | **0.928** | 0.403 | 0.066 | 6 | 0.284 - 0.471 | 0.005 | 0.005 | 0.000 | 6 | 0.005 - 0.005 |
| SUVA | 3.04 | **3.29** | **3.36** | 0.43 | 6.00 | 2.99 - 4.02 | 1.80 | NA | NA | 1.00 | NA |

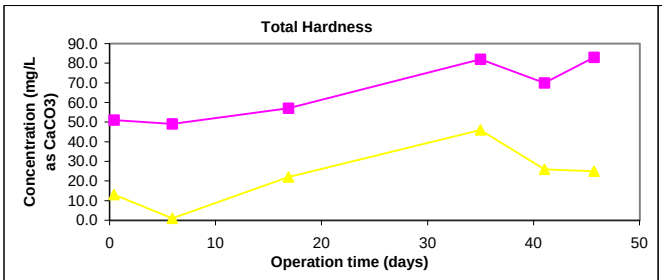
| | Stage 3 Influent | | | | | | Stage 3 Permeate | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WQP** | **Sys Feed** | **Sys Conc** | **Mean** | **SD** | **Count** | **Min/Max** | **Sys Perm** | **Mean** | **SD** | **Count** | **Min/Max** |
| **Recovery** | | | | | | | | | | | |
| pH | | | | | | | | | | | |
| Temp | | | | | | | | | | | |
| Alk | This | was | **only** | a | two | stage | study. | | | | |
| **TDS** | | | | | | | | | | | |
| TotHard | | | | | | | | | | | |
| CaHard | | | | | | | | | | | |
| Turb | | | | | | | | | | | |
| **TOC** | | | | | | | | | | | |
| UV254 | | | | | | | | | | | |
| SUVA | | | | | | | | | | | |

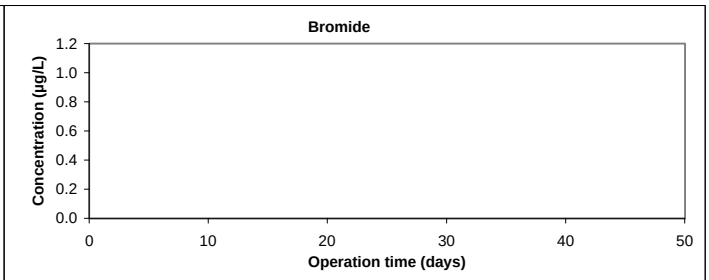
**Water Quality Parameter Graphs**

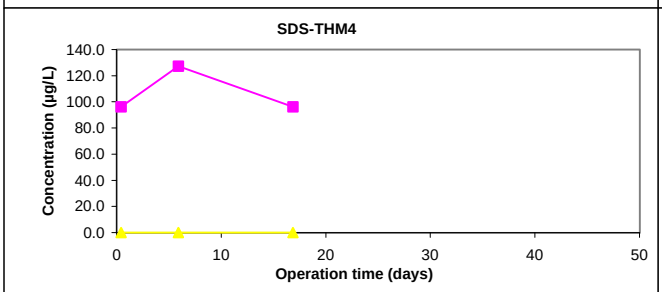
**Chart Legend:**
Feed (System)
Permeate (System)

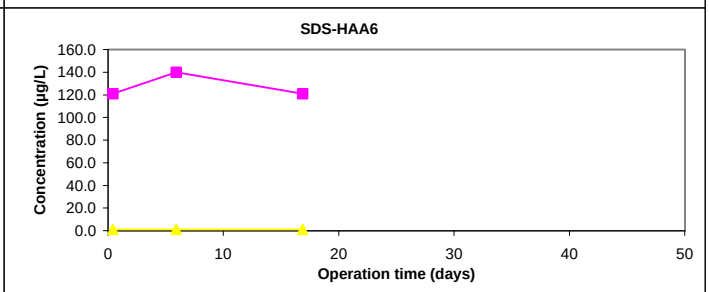


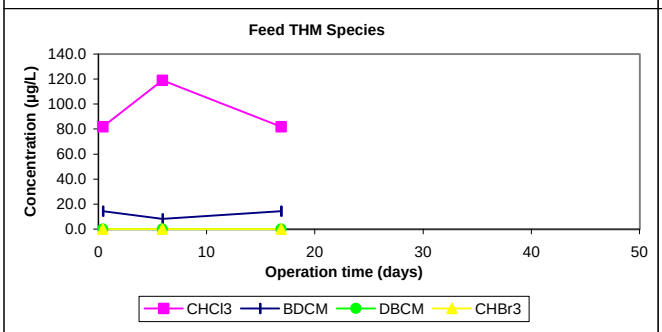
**Water Quality Graphs (Continued)**

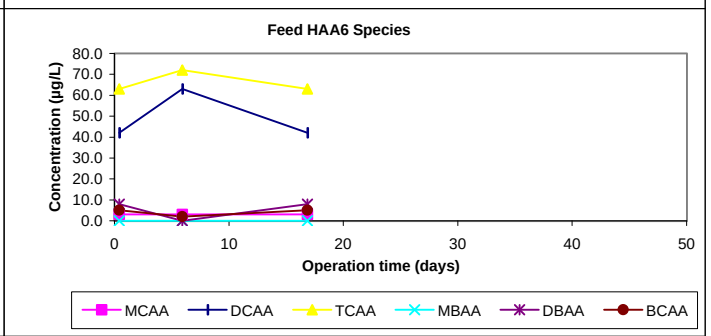


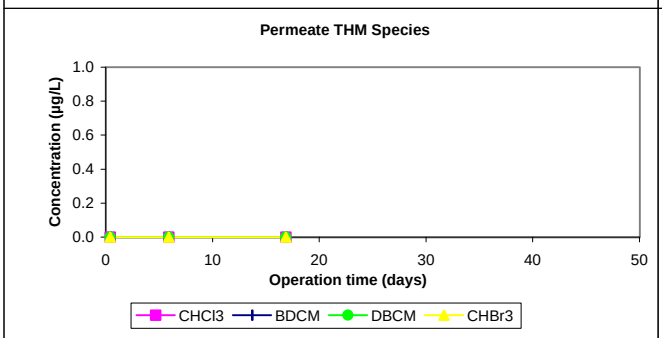



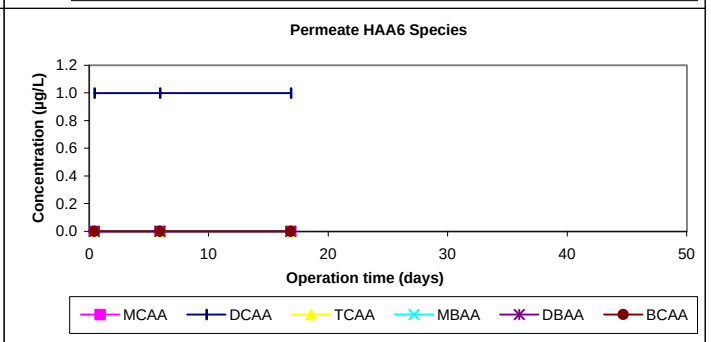



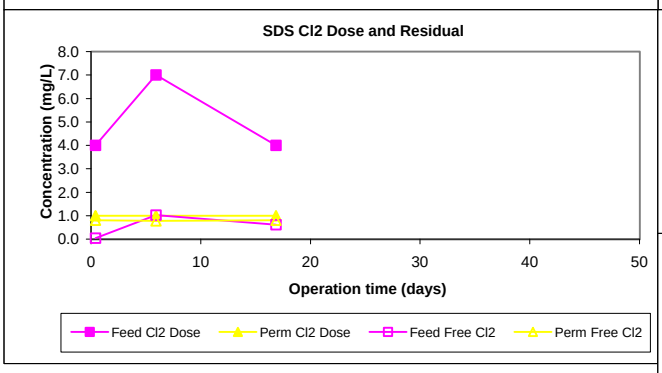



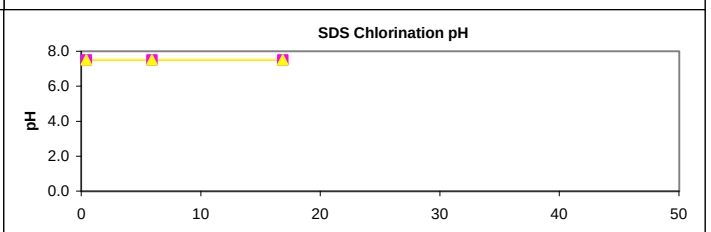



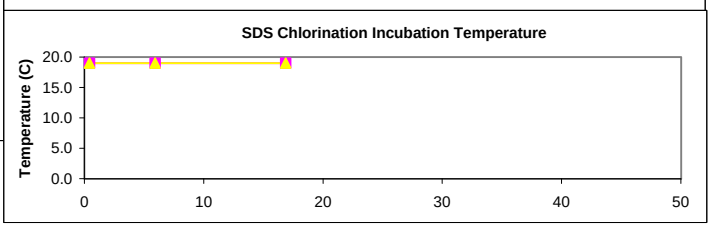



**Productivity Graphs**