

# ICR TREATMENT STUDY ANALYSIS

## Base Analysis and Data Review Comments

|                           |  |
|---------------------------|--|
| <b>Treatment Study ID</b> | 1073   |
| <b>Study Protocol</b>     | Pilot-Scale Membrane Study                         |
| <b>Plant ICR Number</b>   | 1075   |
| <b>PWS Name</b>           | Florida Water Services, Deltona Lakes Water System |
| <b>City, State, Zip</b>   | Deltona, FL 32725                                  |

### General Comments:

1. This pilot-scale membrane study evaluated a single membrane type, the Fluid Systems TFC 4921S, over a one-year period. The system was operated at 75% recovery for the first 4632 hours, and the recovery was increased to 80% for the remaining 2118 hours.
2. A cost analysis is presented in the Results and Discussion section of the Summary Report. The total annual costs for a nanofiltration system were estimated at \$1.41 per 1000 gallons compared to \$0.45 per 1000 gallons for existing aeration and disinfection treatment. The costs for the membrane system do NOT include concentrate disposal costs.

### Water Quality Comments:

1. 223 water quality outliers were identified and removed prior to base analysis. 221 of these outliers were SDS conditions and DBP data for tests failing to achieve a free chlorine residual (all feed data Weeks 1-20, Week 36).
2. During the first two quarters of testing, feed SDS-chlorine doses were insufficient to meet the inorganic demand and achieve a free chlorine residual at the end of the test. Starting on December 15, 1998, the procedures were corrected to ensure that a free chlorine residual was obtained at the end of all SDS tests.
3. The target SDS conditions used after December 15, 1998 are: incubation time of 48 hours; pH of 8.1; temperature of 20°C; and free residual of 0.5 to 1.0 mg/L. The SDS incubation time was changed from 24 to 48 hours beginning with August 24, 1998.
4. During week 36, a very low chlorine dose was used for the feed sample (comparable to dosing conditions prior to 12/15/98), resulting in relatively low SDS-DBP concentrations. Due to the questionable SDS conditions, feed SDS-DBP data was not used during analysis.

## **Productivity Comments:**

1. 9 productivity outliers were identified and removed prior to base analysis.
2. During productivity analysis, small positive slopes were computed in the system and first stage (indicating a very slight increase in productivity over time), while a very small negative slope was computed for the third stage. This analysis indicates that no severe fouling was occurring in any stage of the system during this study. Since these slopes result in cleaning intervals in excess of one year, the minimum cleaning frequency of 365 days was used. The consultant computed a small negative rate of flux decline for the entire system and estimated the cleaning interval at 668 days.
3. During this study, the membrane system was not cleaned. Thus a cleaning efficiency could not be calculated.

## ICR Information

ID / ICR#: FL3640287 / 1075  
 ICR Contact: Craig J. Anderson  
 Phone No.: 407-574-6691 ext. 155  
 Period: 6/29/98 - 9/6/98 (69 days)

## Membrane Information

Manufacturer: Fluid Systems  
 Trade Name: Fluid Systems 4921S  
 Membrane Model: 4040-TFCS 4921S  
 MWCO: 200 Daltons  
 Element Size: 4-inch x 40-inch  
 Element Area: 78.0 ft<sup>2</sup>  
 Design Flux: 20.5 gfd  
 Mfr. NDP: 75.0 psi  
 Mfr. MTC<sub>w</sub>: 0.270 (gfd/psi)  
 Mfr. Temp: 25.0 °C  
 Maximum Flow: 10.0 gpm  
 Minimum Flow: 4.0 gpm  
 Total Width : 13.8 ft  
 Feed Spacer Thickness: 0.0027 ft  
 840 Element Area 330.0 ft<sup>2</sup>  
 840 Purchase Price: \$790

## Design Parameters

Norm Temp: 25.0 °C  
 Temp Norm MTC-w: 0.270 TavGC  
 Design Recovery: 0.75  
 Avg Sys Flux F<sub>w</sub>: 13.1 gfd  
 # of Elem in P.V.: 3  
 # Pres Ves in Stg 1: 2  
 # Pres Ves in Stg 2: 1  
 Pres Ves in Stg 3: NA  
 Design Flux: 13.1 gfd  
 Recycle Ratio: 0.59  
 Osmotic P Stage 1: 4.4 psi  
 Osmotic P Stage 2: 4.8 psi  
 Osmotic P Stage 3: NA

## Water Quality Summary

| Summary        | Feed (System) |      |       |               | Permeate (System)        |      |                                     |               | Concentrate (System)               |       |       |               |
|----------------|---------------|------|-------|---------------|--------------------------|------|-------------------------------------|---------------|------------------------------------|-------|-------|---------------|
|                | Mean          | SD   | Count | Min/Max       | Mean                     | SD   | Count                               | Min/Max       | Mean                               | SD    | Count | Min/Max       |
| pH             | 6.5           | 0.1  | 5     | 6.4 - 6.6     | 5.9                      | 0.1  | 5                                   | 5.8 - 6.0     | 6.9                                | 0.1   | 4     | 6.9 - 7.0     |
| Temp           | 25.0          | 0.5  | 5     | 24.1 - 25.4   | 25.0                     | 0.5  | 5                                   | 24.1 - 25.4   | 25.0                               | 0.5   | 5     | 24.1 - 25.4   |
| Alk            | 87            | 3    | 5     | 82 - 90       | 18                       | 4    | 5                                   | 16 - 25       | 273                                | 15    | 4     | 250 - 280     |
| TDS            | 255           | 7    | 5     | 250 - 265     | 34                       | 5    | 5                                   | 30 - 39       | 908                                | 51    | 4     | 860 - 980     |
| TotHard        | 170           | 0    | 5     | 170 - 170     | 22                       | 2    | 5                                   | 21 - 25       | 633                                | 26    | 4     | 610 - 670     |
| CaHard         | 146           | 5    | 5     | 140 - 150     | 19                       | 2    | 5                                   | 18 - 22       | 533                                | 10    | 4     | 520 - 540     |
| Turb           | 0.24          | 0.5  | 5     | 0.00 - 1.20   | 0.00                     | 0.0  | 5                                   | 0.00 - 0.00   | 0.99                               | 1.9   | 4     | 0.00 - 3.80   |
| Amm            | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | NA                                 | NA    | 0     | 0.0 - 0.0     |
| TOC            | 2.1           | 0.2  | 5     | 1.9 - 2.4     | 0.3                      | 0.0  | 5                                   | 0.3 - 0.3     | 8.0                                | 0.2   | 5     | 7.7 - 8.3     |
| UV254          | 0.087         | 0.0  | 5     | 0.085 - 0.087 | 0.006                    | 0.0  | 5                                   | 0.005 - 0.010 | 0.326                              | 0.0   | 5     | 0.310 - 0.340 |
| SUVA           | 4.17          | 0.36 | 5     | 3.63 - 4.58   | 2.24                     | 0.98 | 5                                   | 1.80 - 4.00   | 4.06                               | 0.07  | 5     | 4.00 - 4.18   |
| Bromide        | 47            | 12   | 5     | 33 - 64       | 10                       | 0    | 5                                   | 10 - 10       |                                    |       |       |               |
| TOX            | NA            | NA   | 0     | 0 - 0         | 30                       | 11   | 5                                   | 13 - 43       |                                    |       |       |               |
| CHCl3          | NA            | NA   | 0     | NA            | 6.0                      | 1.5  | 5                                   | 3.9 - 7.5     | Mass Balance<br>Closure Errors (%) |       |       |               |
| BDCM           | NA            | NA   | 0     | NA            | 2.5                      | 0.3  | 5                                   | 2.0 - 2.7     |                                    |       |       |               |
| DBCM           | NA            | NA   | 0     | NA            | 0.3                      | 0.6  | 5                                   | 0.0 - 1.4     | WQP                                | Count | Avg   | SD/RD         |
| CHBr3          | NA            | NA   | 0     | NA            | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Alk                                | 4     | -8    | 4             |
| THM4           | NA            | NA   | 0     | NA            | 8.7                      | 1.3  | 5                                   | 7.2 - 10.2    | TDS                                | 4     | -5    | 13            |
| MCAA           | NA            | NA   | 0     | NA            | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | TotHard                            | 4     | 2     | 3             |
| DCAA           | NA            | NA   | 0     | NA            | 0.8                      | 1.1  | 5                                   | 0.0 - 2.1     | CaHard                             | 4     | 1     | 3             |
| TCAA           | NA            | NA   | 0     | NA            | 0.5                      | 0.7  | 5                                   | 0.0 - 1.6     | Turb                               | 0     | n/a   | n/a           |
| MBAA           | NA            | NA   | 0     | NA            | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Amm                                | 0     | n/a   | n/a           |
| DBAA           | NA            | NA   | 0     | NA            | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | TOC                                | 0     | n/a   | n/a           |
| BCAA           | NA            | NA   | 0     | NA            | 0.3                      | 0.7  | 5                                   | 0.0 - 1.6     | UV254                              | 1     | -3    | n/a           |
| TBAA           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | TDS <sub>t</sub> 57 -11 10         |       |       |               |
| CDBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                                    |       |       |               |
| DCBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | Comments:                          |       |       |               |
| HAA5           | NA            | NA   | 0     | NA            | 1.3                      | 1.8  | 5                                   | 0.0 - 3.7     |                                    |       |       |               |
| HAA6           | NA            | NA   | 0     | NA            | 1.6                      | 2.4  | 5                                   | 0.0 - 5.3     |                                    |       |       |               |
| HAA9           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                                    |       |       |               |
| SDS Conditions |               |      |       |               | Pretreatment Information |      |                                     |               |                                    |       |       |               |
| WQP            | Avg           | SD   | Count | Min - Max     | Process                  |      | Description                         |               | Scale                              |       |       |               |
| Res (0)        | 0.82          | 0.28 | 5     | 0.61 - 1.30   | Cartridge filtration     |      | 5 mm exclusion size                 |               | Pilot scale                        |       |       |               |
| Temp (°C)      | 25.0          | 0.0  | 5     | 25.0 - 25.0   | Sulfuric Acid addition   |      | pH=6.4(@ 75% rec.), 6.2(@ 80% rec.) |               | Pilot scale                        |       |       |               |
| pH (unit)      | 8.0           | 0.0  | 5     | 7.9 - 8.0     |                          |      |                                     |               |                                    |       |       |               |
| Time (hr)      | 33.6          | 13.1 | 5     | 24.0 - 48.0   |                          |      |                                     |               |                                    |       |       |               |

## 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  | -55.1%  | 9.1%    |
| Sys Conc - Stg 2 Conc   | 0.0% | 0.0% | Sys Conc - Stg 2 Conc  | #VALUE! | #VALUE! | 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 | #VALUE! | #VALUE! | Stg 1 Conc - Stg 2 Inf  | 0.0%    | 0.0%    |
| Sys Perm - Avg Stg Perm | 0.1% | 1.0% | Sys Perm - Sum Stg Per | 26.9%   | 66.0%   | Sys Perm - Avg Stg Perm | #DIV/0! | #DIV/0! |

# 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 |                  |          | 0.51  | 0.01  | 5     | 0.50 - 0.53   |                  |       |       |       |               |
| pH       | 6.5              | 6.9      | 6.7   | 0.1   | 5     | 6.6 - 6.8     | 5.9              | 5.9   | 0.2   | 5     | 5.7 - 6.2     |
| Temp     | 25.0             | 25.0     | 25.2  | 0.2   | 5     | 25.0 - 25.4   | 25.0             | 25.2  | 0.2   | 5     | 25.0 - 25.4   |
| Alk      | 87               | 273      | 134   | 5     | 5     | 130 - 140     | 18               | 19    | 11    | 5     | 14 - 39       |
| TDS      | 255              | 908      | 400   | 20    | 5     | 380 - 420     | 34               | 27    | 7     | 5     | 20 - 38       |
| TotHard  | 170              | 633      | 280   | 10    | 5     | 270 - 290     | 22               | 15    | 1     | 5     | 14 - 17       |
| CaHard   | 146              | 533      | 236   | 5     | 5     | 230 - 240     | 19               | 12    | 3     | 5     | 10 - 16       |
| Turb     | 0.24             | 0.99     | 0.38  | 1     | 5     | 0.00 - 1.90   | 0.00             | 0.00  | 0.00  | 5     | 0 - 0         |
| TOC      | 2.1              | 8.0      | 3.8   | 0.1   | 5     | 3.6 - 4.0     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.087            | 0.326    | 0.146 | 0.005 | 5     | 0.140 - 0.150 | 0.006            | 0.005 | 0.000 | 5     | 0.005 - 0.005 |
| SUVA     | 4.17             | 4.06     | 3.87  | 0.27  | 5     | 3.50 - 4.17   | 2.24             | 1.80  | 0.00  | 5     | 1.80 - 1.80   |

|          | Stage 2 Influent |          |       |       |       |               | Stage 2 Permeate |       |       |       |               |
|----------|------------------|----------|-------|-------|-------|---------------|------------------|-------|-------|-------|---------------|
| WQP      | Sys Feed         | Sys Conc | Mean  | SD    | Count | Min/Max       | Sys Perm         | Mean  | SD    | Count | Min/Max       |
| Recovery |                  |          | 0.49  | 0.01  | 5     | 0.48 - 0.50   |                  |       |       |       |               |
| pH       | 6.5              | 6.9      | 6.8   | 0.1   | 5     | 6.7 - 6.9     | 5.9              | 6.0   | 0.1   | 5     | 5.9 - 6.2     |
| Temp     | 25.0             | 25.0     | 25.2  | 0.2   | 5     | 25.0 - 25.4   | 25.0             | 25.2  | 0.2   | 5     | 25.0 - 25.4   |
| Alk      | 87               | 273      | 186   | 13    | 5     | 180 - 210     | 18               | 26    | 2     | 5     | 24 - 29       |
| TDS      | 255              | 908      | 598   | 31    | 5     | 570 - 650     | 34               | 53    | 6     | 5     | 46 - 59       |
| TotHard  | 170              | 633      | 386   | 34    | 5     | 330 - 420     | 22               | 36    | 3     | 5     | 34 - 40       |
| CaHard   | 146              | 533      | 338   | 15    | 5     | 320 - 360     | 19               | 30    | 1     | 5     | 29 - 31       |
| Turb     | 0.24             | 0.99     | 0.44  | 1     | 5     | 0.00 - 2.20   | 0.00             | 0.00  | 0.00  | 5     | 0 - 0         |
| TOC      | 2.1              | 8.0      | 5.4   | 0.3   | 5     | 5.1 - 5.7     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.087            | 0.326    | 0.208 | 0.008 | 5     | 0.200 - 0.220 | 0.006            | 0.012 | 0.004 | 5     | 0.005 - 0.015 |
| SUVA     | 4.17             | 4.06     | 3.88  | 0.13  | 5.00  | 3.68 - 4.04   | 2.24             | 4.60  | 1.74  | 5.00  | 1.80 - 6.00   |

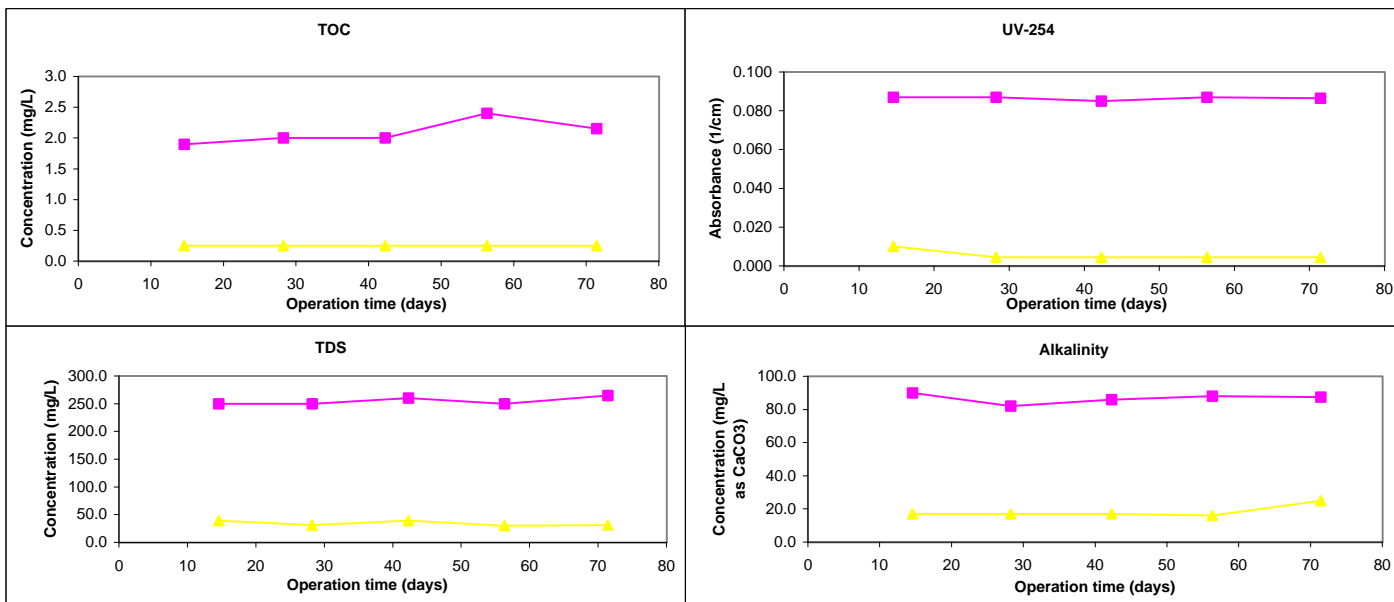
|          | Stage 3 Influent |          |      |    |       |         | Stage 3 Permeate |      |    |       |         |
|----------|------------------|----------|------|----|-------|---------|------------------|------|----|-------|---------|
| WQP      | Sys Feed         | Sys Conc | Mean | SD | Count | Min/Max | Sys Perm         | Mean | SD | Count | Min/Max |
| Recovery |                  |          |      |    |       |         |                  |      |    |       |         |
| pH       |                  |          |      |    |       |         |                  |      |    |       |         |
| Temp     |                  |          |      |    |       |         |                  |      |    |       |         |
| Alk      |                  |          |      |    |       |         |                  |      |    |       |         |
| TDS      |                  |          |      |    |       |         |                  |      |    |       |         |
| TotHard  |                  |          |      |    |       |         |                  |      |    |       |         |
| CaHard   |                  |          |      |    |       |         |                  |      |    |       |         |
| Turb     |                  |          |      |    |       |         |                  |      |    |       |         |
| TOC      |                  |          |      |    |       |         |                  |      |    |       |         |
| UV254    |                  |          |      |    |       |         |                  |      |    |       |         |
| SUVA     |                  |          |      |    |       |         |                  |      |    |       |         |

This was only a two stage study.

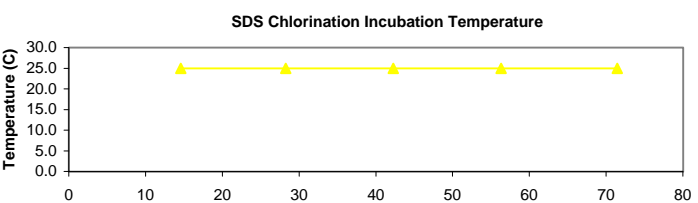
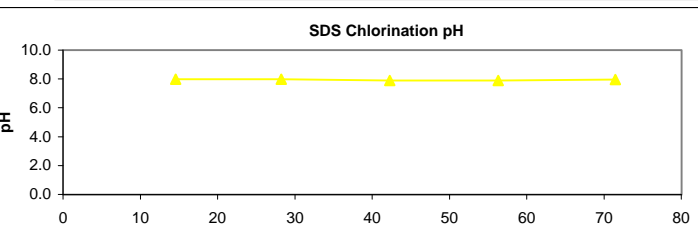
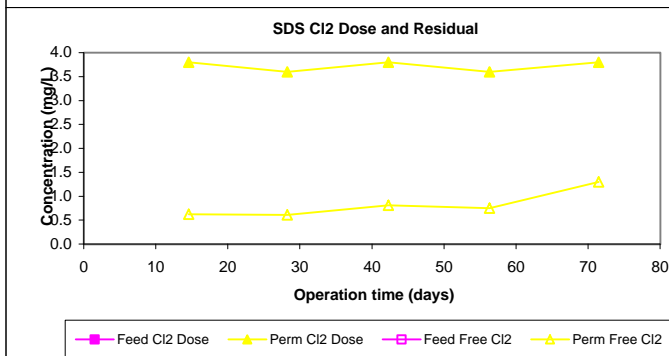
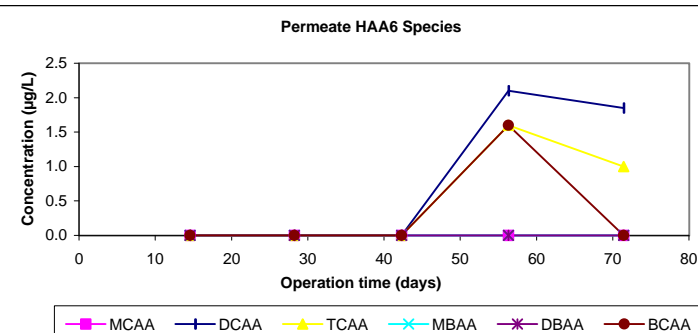
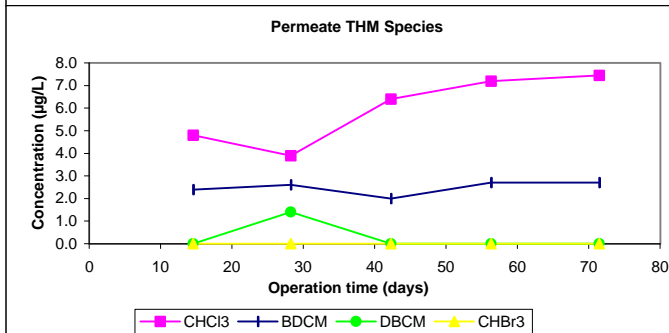
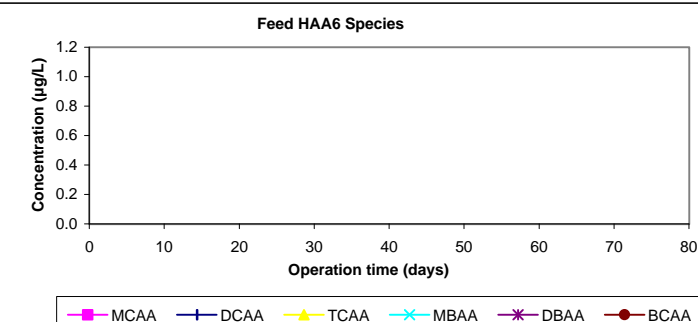
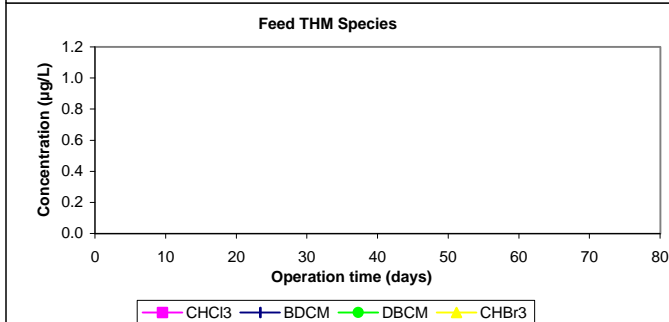
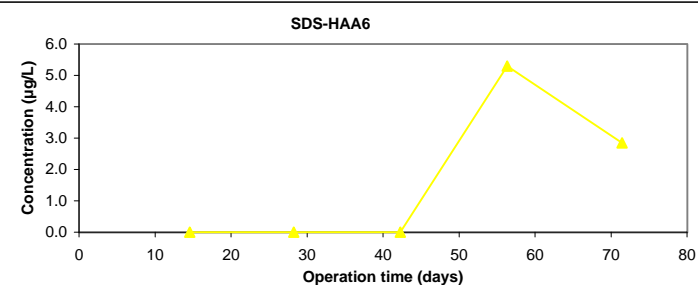
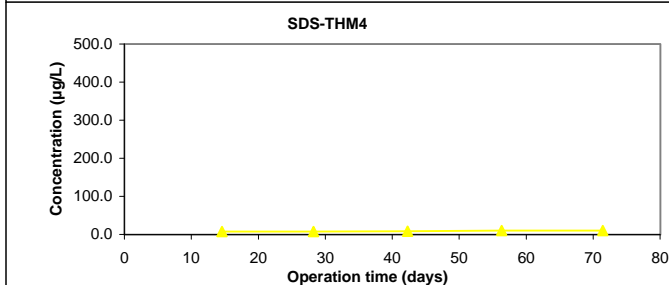
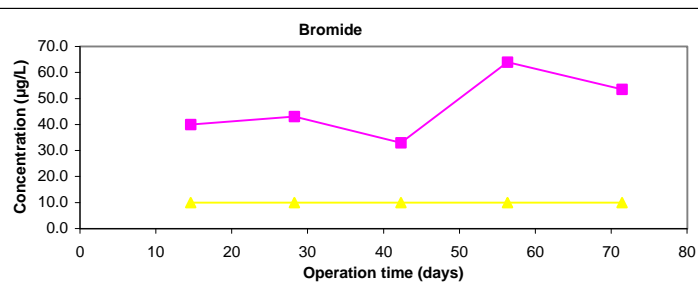
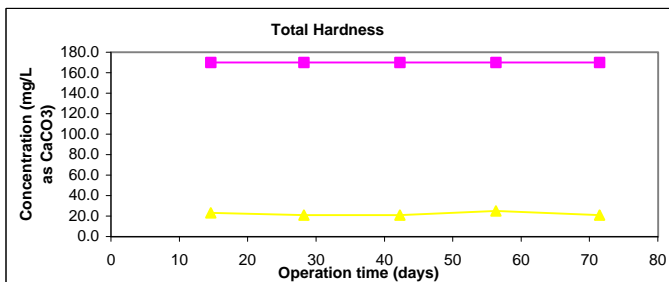
## Chart Legend:

- Feed (System)
- Permeate (System)

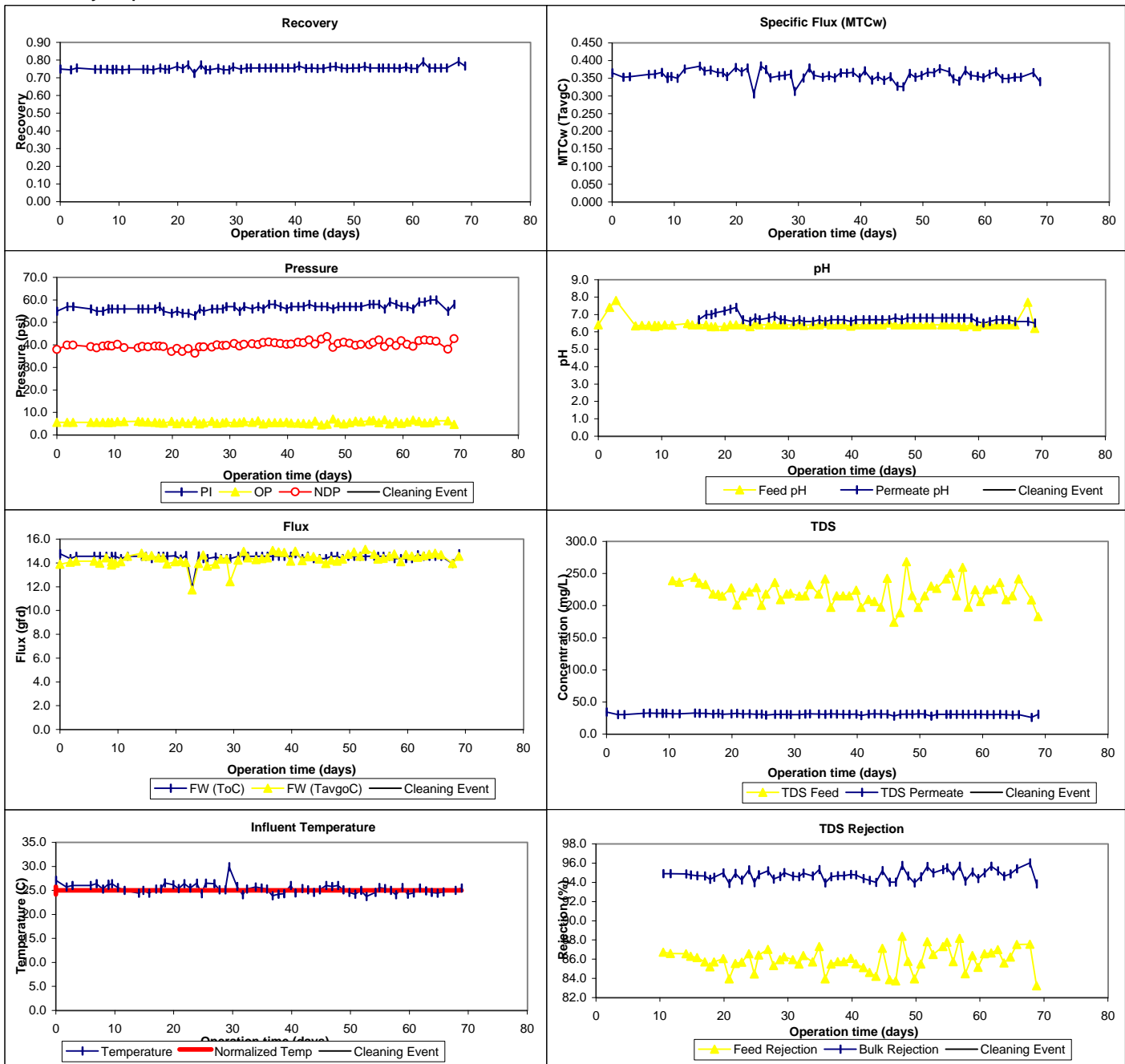
## Water Quality Parameter Graphs



## Water Quality Graphs (Continued)



Productivity Graphs



| ICR Information  | Membrane Information  | Design Parameters  |
|--|---|--|
| <b>ID / ICR#:</b> FL3640287 / 1075<br><b>ICR Contact:</b> Craig J. Anderson<br><b>Phone No.:</b> 407-574-6691 ext. 155<br><b>Period:</b> 9/7/98 - 11/15/98 (69 days) | <b>Manufacturer:</b> Fluid Systems<br><b>Trade Name:</b> Fluid Systems 4921S<br><b>Membrane Model:</b> 4040-TFCS 4921S<br><b>MWCO:</b> 200 Daltons<br><b>Element Size:</b> 4-inch x 40-inch<br><b>Element Area:</b> 78.0 ft <sup>2</sup><br><b>Design Flux:</b> 20.5 gfd<br><b>Mfr. NDP:</b> 75.0 psi<br><b>Mfr. MTC<sub>w</sub>:</b> 0.270 (gfd/psi)<br><b>Mfr. Temp:</b> 25.0 °C<br><b>Maximum Flow:</b> 10.0 gpm<br><b>Minimum Flow:</b> 4.0 gpm<br><b>Total Width :</b> 13.8 ft<br><b>Feed Spacer Thickness:</b> 0.0027 ft<br><b>840 Element Area</b> 330.0 ft <sup>2</sup><br><b>840 Purchase Price:</b> \$790 | <b>Norm Temp:</b> 25.0 °C<br><b>Temp Norm MTC-w:</b> 0.270 TavGC<br><b>Design Recovery:</b> 0.75<br><b>Avg Sys Flux F<sub>w</sub>:</b> 13.1 gfd<br><b># of Elem in P.V.:</b> 3<br><b># Pres Ves in Stg 1:</b> 2<br><b># Pres Ves in Stg 2:</b> 1<br><b>Pres Ves in Stg 3:</b> NA<br><b>Design Flux:</b> 13.1 gfd<br><b>Recycle Ratio:</b> 0.59<br><b>Osmotic P Stage 1:</b> 4.4 psi<br><b>Osmotic P Stage 2:</b> 4.8 psi<br><b>Osmotic P Stage 3:</b> NA |

## Water Quality Summary

| Summary               | Feed (System) |            |              |                  | Permeate (System)               |                                     |          |                  | Concentrate (System)      |            |              |                  |
|-----------------------|---------------|------------|--------------|------------------|---------------------------------|-------------------------------------|----------|------------------|---------------------------|------------|--------------|------------------|
|                       | Mean          | SD         | Count        | Min/Max          | Mean                            | SD                                  | Count    | Min/Max          | Mean                      | SD         | Count        | Min/Max          |
| pH                    | 6.6           | 0.2        | 5            | 6.5 - 6.8        | 5.9                             | 0.2                                 | 5        | 5.7 - 6.2        | 7.0                       | 0.1        | 5            | 6.9 - 7.1        |
| Temp                  | 24.0          | 0.7        | 5            | 23.0 - 24.6      | 24.0                            | 0.7                                 | 5        | 23.0 - 24.6      | 24.0                      | 0.7        | 5            | 23.0 - 24.6      |
| Alk                   | 90            | 3          | 5            | 87 - 95          | 17                              | 1                                   | 5        | 16 - 18          | 294                       | 18         | 5            | 270 - 310        |
| <b>TDS</b>            | <b>243</b>    | <b>7</b>   | <b>5</b>     | <b>235 - 250</b> | <b>29</b>                       | <b>2</b>                            | <b>5</b> | <b>26 - 32</b>   | <b>850</b>                | <b>34</b>  | <b>5</b>     | <b>800 - 890</b> |
| TotHard               | 176           | 5          | 5            | 170 - 180        | 20                              | 1                                   | 5        | 18 - 22          | 630                       | 16         | 5            | 610 - 650        |
| CaHard                | 149           | 5          | 5            | 140 - 155        | 16                              | 1                                   | 5        | 14 - 18          | 542                       | 15         | 5            | 520 - 560        |
| Turb                  | 0.00          | 0.0        | 5            | 0.00 - 0.00      | 0.00                            | 0.0                                 | 5        | 0.00 - 0.00      | 0.12                      | <b>0.1</b> | 5            | 0.00 - 0.31      |
| Amm                   | NA            | NA         | 0            | NA               | NA                              | NA                                  | 0        | NA               | NA                        | NA         | 0            | 0.0 - 0.0        |
| <b>TOC</b>            | <b>2.3</b>    | <b>0.3</b> | <b>5</b>     | <b>1.9 - 2.6</b> | <b>0.3</b>                      | <b>0.0</b>                          | <b>5</b> | <b>0.3 - 0.3</b> | <b>8.0</b>                | <b>0.4</b> | <b>5</b>     | <b>7.5 - 8.5</b> |
| UV254                 | 0.085         | 0.0        | 5            | 0.083 - 0.087    | 0.005                           | <b>0.0</b>                          | 5        | 0.005 - 0.009    | 0.328                     | 0.0        | 5            | 0.310 - 0.340    |
| SUVA                  | 3.83          | 0.45       | 5            | 3.19 - 4.47      | 2.16                            | <b>0.80</b>                         | 5        | 1.80 - 3.60      | 4.09                      | 0.29       | 5            | 3.78 - 4.53      |
| <b>Bromide</b>        | <b>54</b>     | <b>7</b>   | <b>5</b>     | <b>47 - 64</b>   | <b>10</b>                       | <b>0</b>                            | <b>5</b> | <b>10 - 10</b>   |                           |            |              |                  |
| <b>TOX</b>            | <b>NA</b>     | <b>NA</b>  | <b>0</b>     | <b>0 - 0</b>     | <b>23</b>                       | <b>15</b>                           | <b>5</b> | <b>13 - 44</b>   |                           |            |              |                  |
| CHCl3                 | NA            | NA         | 0            | NA               | 4.0                             | <b>2.4</b>                          | 5        | 1.6 - 8.0        | <b>Mass Balance</b>       |            |              |                  |
| BDCM                  | NA            | NA         | 0            | NA               | 0.9                             | <b>1.3</b>                          | 5        | 0.0 - 2.6        | <b>Closure Errors (%)</b> |            |              |                  |
| DBCM                  | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | WQP                       | Count      | Avg          | SD/RD            |
| CHBr3                 | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | Alk                       | 5          | -5           | 6                |
| <b>THM4</b>           | <b>NA</b>     | <b>NA</b>  | <b>0</b>     | <b>NA</b>        | <b>4.9</b>                      | <b>3.4</b>                          | <b>5</b> | <b>1.6 - 9.9</b> | TDS                       | 5          | -5           | 5                |
| MCAA                  | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | TotHard                   | 5          | -3           | 3                |
| DCAA                  | NA            | NA         | 0            | NA               | 1.2                             | <b>1.2</b>                          | 5        | 0.0 - 2.5        | CaHard                    | 5          | -1           | 3                |
| TCAA                  | NA            | NA         | 0            | NA               | 0.9                             | <b>1.3</b>                          | 5        | 0.0 - 2.8        | Turb                      | 0          | n/a          | n/a              |
| MBAA                  | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | Amm                       | 0          | n/a          | n/a              |
| DBAA                  | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | TOC                       | 0          | n/a          | n/a              |
| BCAA                  | NA            | NA         | 0            | NA               | 0.0                             | 0.0                                 | 5        | 0.0 - 0.0        | UV254                     | 1          | 8            | n/a              |
| TBAA                  | NA            | NA         | 0            | NA               | NA                              | NA                                  | 0        | NA               | TDS <sub>t</sub>          | 69         | -8           | 10               |
| CDBAA                 | NA            | NA         | 0            | NA               | NA                              | NA                                  | 0        | NA               | <b>Comments:</b>          |            |              |                  |
| DCBAA                 | NA            | NA         | 0            | NA               | NA                              | NA                                  | 0        | NA               |                           |            |              |                  |
| <b>HAA5</b>           | <b>NA</b>     | <b>NA</b>  | <b>0</b>     | <b>NA</b>        | <b>2.0</b>                      | <b>2.3</b>                          | <b>5</b> | <b>0.0 - 5.3</b> |                           |            |              |                  |
| <b>HAA6</b>           | <b>NA</b>     | <b>NA</b>  | <b>0</b>     | <b>NA</b>        | <b>2.0</b>                      | <b>2.3</b>                          | <b>5</b> | <b>0.0 - 5.3</b> |                           |            |              |                  |
| <b>HAA9</b>           | <b>NA</b>     | <b>NA</b>  | <b>0</b>     | <b>NA</b>        | <b>NA</b>                       | <b>NA</b>                           | <b>0</b> | <b>NA</b>        |                           |            |              |                  |
| <b>SDS Conditions</b> |               |            |              |                  | <b>Pretreatment Information</b> |                                     |          |                  |                           |            |              |                  |
| <b>WQP</b>            | <b>Avg</b>    | <b>SD</b>  | <b>Count</b> | <b>Min - Max</b> | <b>Process</b>                  | <b>Description</b>                  |          |                  |                           |            | <b>Scale</b> |                  |
| Res (0)               | 0.94          | 0.25       | 5            | 0.71 - 1.35      | Cartridge filtration            | 5 mm exclusion size                 |          |                  |                           |            | Pilot scale  |                  |
| Temp (°C)             | 25.0          | 0.0        | 5            | 25.0 - 25.0      | Sulfuric Acid addition          | pH=6.4(@ 75% rec.), 6.2(@ 80% rec.) |          |                  |                           |            | Pilot scale  |                  |
| pH (unit)             | 8.0           | 0.1        | 5            | 7.9 - 8.1        |                                 |                                     |          |                  |                           |            |              |                  |
| Time (hr)             | 48.0          | 0.0        | 5            | 48.0 - 48.0      |                                 |                                     |          |                  |                           |            |              |                  |

## 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  | <b>-59.7%</b> | 9.3% |
| Sys Conc - Stg 2 Conc   | 0.0% | 0.0% | Sys Conc - Stg 2 Conc  | 0.0% | 0.4% | Sys Conc - Stg 2 Conc   | 0.1%          | 1.7% |
| 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 Perr | 0.0% | 0.0% | Sys Perm - Sum Stg Per | 0.0% | 0.3% | Sys Perm - Avg Stg Perm | -6.7%         | 4.3% |

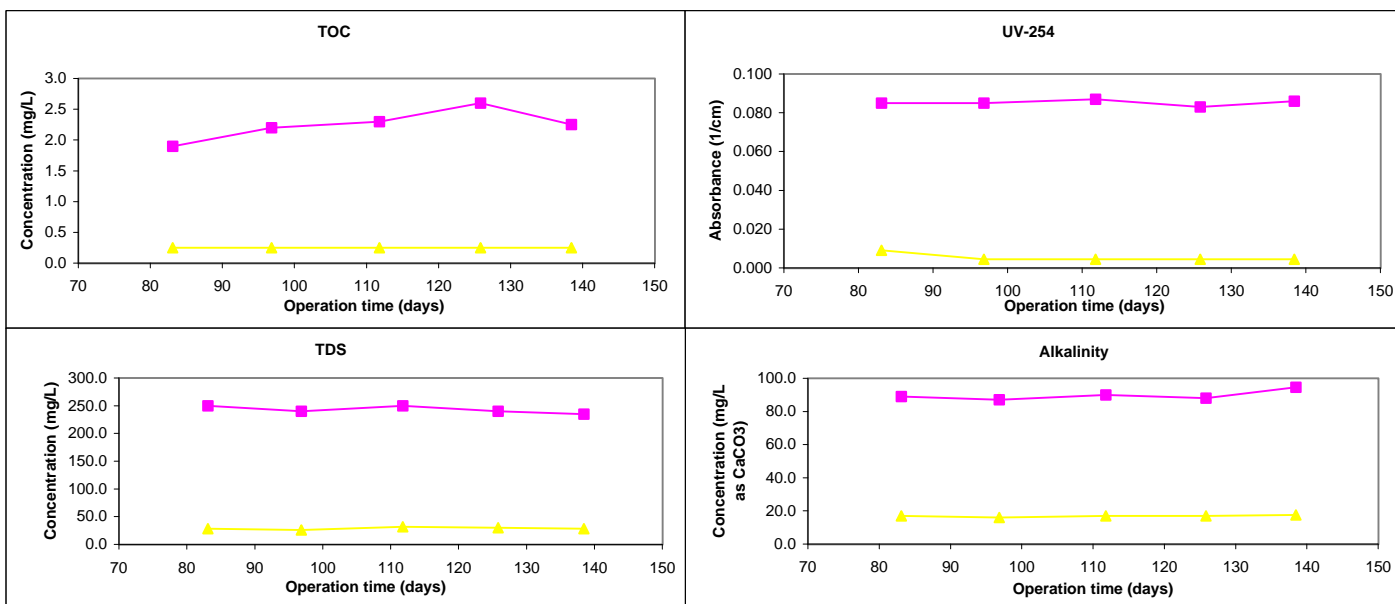
## Stage Summary

| WQP        | Stage 1 Influent |              |             |             |          |                    | Stage 1 Permeate |            |            |          |                  |
|------------|------------------|--------------|-------------|-------------|----------|--------------------|------------------|------------|------------|----------|------------------|
|            | Sys Feed         | Sys Conc     | Mean        | SD          | Count    | Min/Max            | Sys Perm         | Mean       | SD         | Count    | Min/Max          |
| Recovery   |                  |              | <b>0.52</b> | <b>0.01</b> | <b>5</b> | <b>0.50 - 0.53</b> |                  |            |            |          |                  |
| pH         | 6.6              | 7.0          | 6.8         | 0.2         | 4        | 6.6 - 7.1          | 5.9              | 6.2        | 0.5        | 5        | 5.7 - 6.9        |
| Temp       | 24.0             | 24.0         | 24.0        | 0.7         | 5        | 23.0 - 24.6        | 24.0             | 24.0       | 0.7        | 5        | 23.0 - 24.6      |
| Alk        | 90               | 294          | 138         | 5           | 4        | 130 - 140          | 17               | 13         | 1          | 5        | 12 - 14          |
| <b>TDS</b> | <b>243</b>       | <b>850</b>   | <b>378</b>  | <b>13</b>   | <b>4</b> | <b>360 - 390</b>   | <b>29</b>        | <b>18</b>  | <b>2</b>   | <b>5</b> | <b>16 - 20</b>   |
| TotHard    | 176              | 630          | 272         | 8           | 5        | 260 - 280          | 20               | 12         | 1          | 5        | 11 - 14          |
| CaHard     | 149              | 542          | 232         | 8           | 5        | 220 - 240          | 16               | 11         | 1          | 5        | 10 - 12          |
| Turb       | 0.00             | 0.12         | 0.07        | 0           | 4        | 0.00 - 0.27        | 0.00             | 0.01       | 0.03       | 5        | 0 - 0            |
| <b>TOC</b> | <b>2.3</b>       | <b>8.0</b>   | <b>3.7</b>  | <b>0.4</b>  | <b>5</b> | <b>3.2 - 4.2</b>   | <b>0.3</b>       | <b>0.3</b> | <b>0.0</b> | <b>5</b> | <b>0.3 - 0.3</b> |
| UV254      | 0.085            | <b>0.328</b> | 0.140       | 0.000       | 4        | 0.140 - 0.140      | 0.005            | 0.005      | 0.000      | 5        | 0.005 - 0.005    |
| SUVA       | 3.83             | <b>4.09</b>  | NA          | NA          | 4        | NA                 | 2.16             | 1.80       | 0.00       | 5        | 1.80 - 1.80      |
| WQP        | Stage 2 Influent |              |             |             |          |                    | Stage 2 Permeate |            |            |          |                  |
|            | Sys Feed         | Sys Conc     | Mean        | SD          | Count    | Min/Max            | Sys Perm         | Mean       | SD         | Count    | Min/Max          |
| Recovery   |                  |              | <b>0.48</b> | <b>0.01</b> | <b>5</b> | <b>0.47 - 0.50</b> |                  |            |            |          |                  |
| pH         | 6.6              | 7.0          | 6.9         | 0.1         | 5        | 6.8 - 7.0          | 5.9              | 6.0        | 0.1        | 5        | 5.9 - 6.2        |
| Temp       | 24.0             | 24.0         | 24.0        | 0.7         | 5        | 23.0 - 24.6        | 24.0             | 24.0       | 0.7        | 5        | 23.0 - 24.6      |
| Alk        | 90               | 294          | 194         | 11          | 5        | 180 - 210          | 17               | 24         | 1          | 5        | 22 - 25          |
| <b>TDS</b> | <b>243</b>       | <b>850</b>   | <b>548</b>  | <b>16</b>   | <b>5</b> | <b>530 - 570</b>   | <b>29</b>        | <b>46</b>  | <b>2</b>   | <b>5</b> | <b>44 - 48</b>   |
| TotHard    | 176              | 630          | 392         | 8           | 5        | 380 - 400          | 20               | 34         | 2          | 5        | 32 - 37          |
| CaHard     | 149              | 542          | 334         | 9           | 5        | 320 - 340          | 16               | 29         | 1          | 5        | 27 - 30          |
| Turb       | 0.00             | 0.12         | <b>0.26</b> | <b>1</b>    | <b>5</b> | <b>0.00 - 1.30</b> | 0.00             | 0.06       | 0.13       | 5        | 0 - 0            |
| <b>TOC</b> | <b>2.3</b>       | <b>8.0</b>   | <b>5.1</b>  | <b>0.3</b>  | <b>5</b> | <b>4.6 - 5.4</b>   | <b>0.3</b>       | <b>0.3</b> | <b>0.0</b> | <b>5</b> | <b>0.3 - 0.3</b> |
| UV254      | 0.085            | <b>0.328</b> | 0.202       | 0.004       | 5        | 0.200 - 0.210      | 0.005            | 0.011      | 0.002      | 5        | 0.009 - 0.013    |
| SUVA       | 3.83             | <b>4.09</b>  | 4.01        | 0.27        | 5.00     | 3.70 - 4.35        | 2.16             | 4.44       | 0.61       | 5.00     | 3.60 - 5.20      |
| WQP        | Stage 3 Influent |              |             |             |          |                    | Stage 3 Permeate |            |            |          |                  |
|            | Sys Feed         | Sys Conc     | Mean        | SD          | Count    | Min/Max            | Sys Perm         | Mean       | SD         | Count    | Min/Max          |
| Recovery   |                  |              |             |             |          |                    |                  |            |            |          |                  |
| pH         |                  |              |             |             |          |                    |                  |            |            |          |                  |
| Temp       |                  |              |             |             |          |                    |                  |            |            |          |                  |
| Alk        |                  |              |             |             |          |                    |                  |            |            |          |                  |
| <b>TDS</b> |                  |              |             |             |          |                    |                  |            |            |          |                  |
| TotHard    |                  |              |             |             |          |                    |                  |            |            |          |                  |
| CaHard     |                  |              |             |             |          |                    |                  |            |            |          |                  |
| Turb       |                  |              |             |             |          |                    |                  |            |            |          |                  |
| <b>TOC</b> |                  |              |             |             |          |                    |                  |            |            |          |                  |
| UV254      |                  |              |             |             |          |                    |                  |            |            |          |                  |
| SUVA       |                  |              |             |             |          |                    |                  |            |            |          |                  |

## Chart Legend:

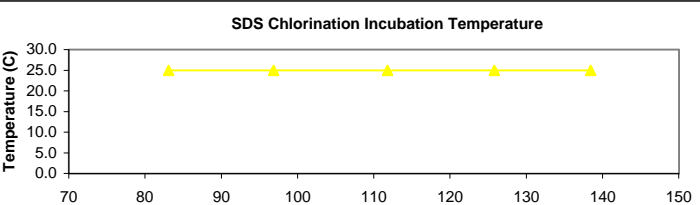
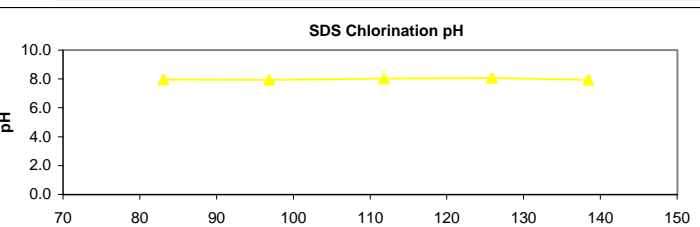
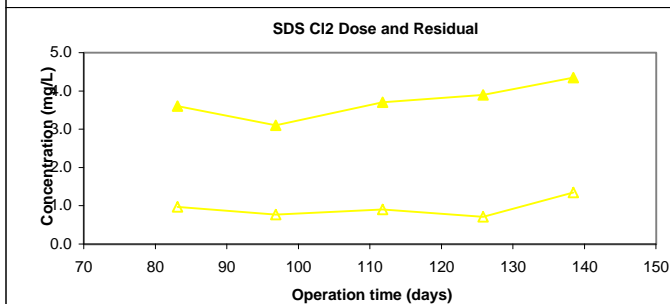
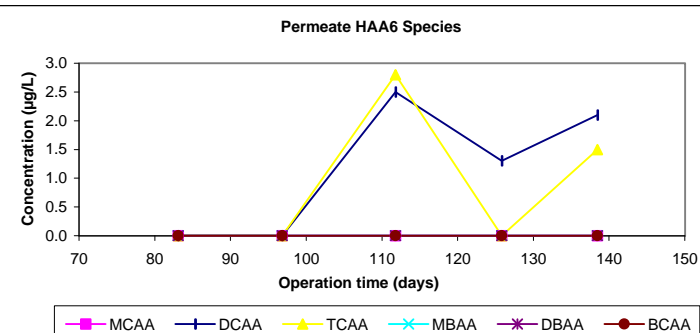
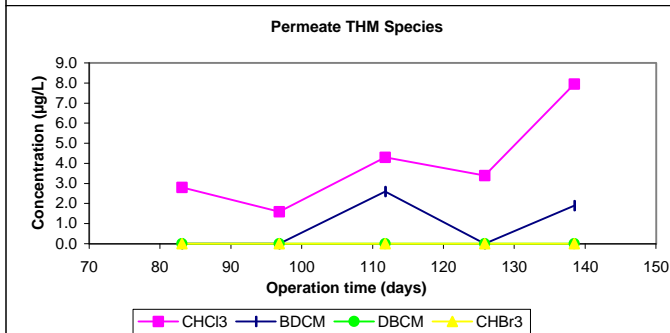
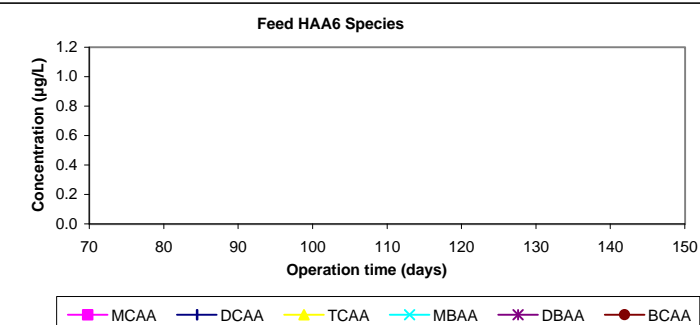
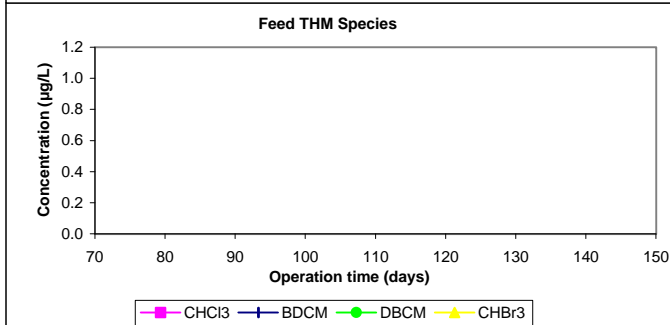
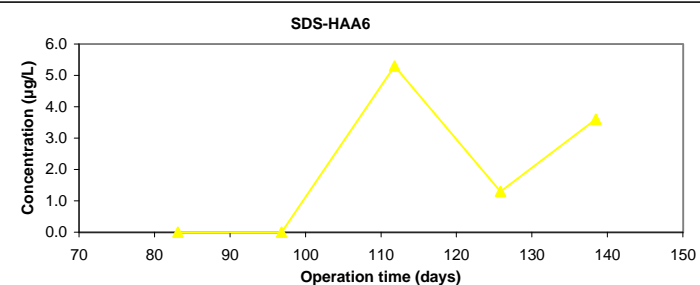
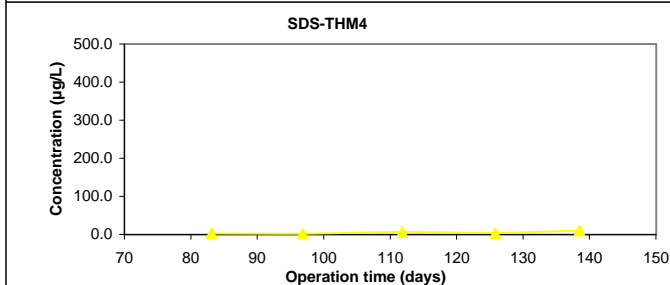
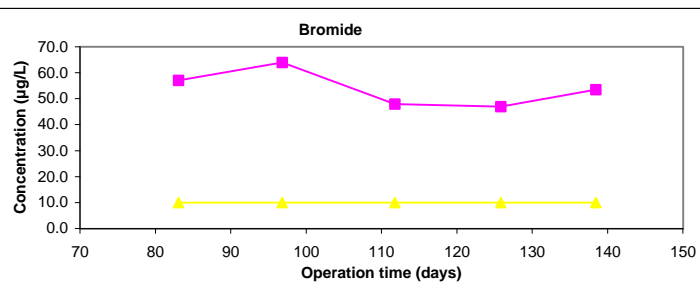
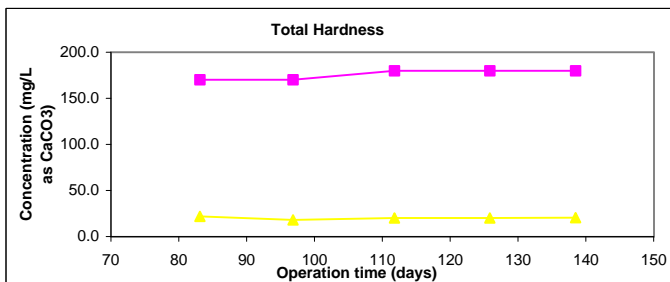
■ Feed (System)  
▲ Permeate (System)

## Water Quality Parameter Graphs

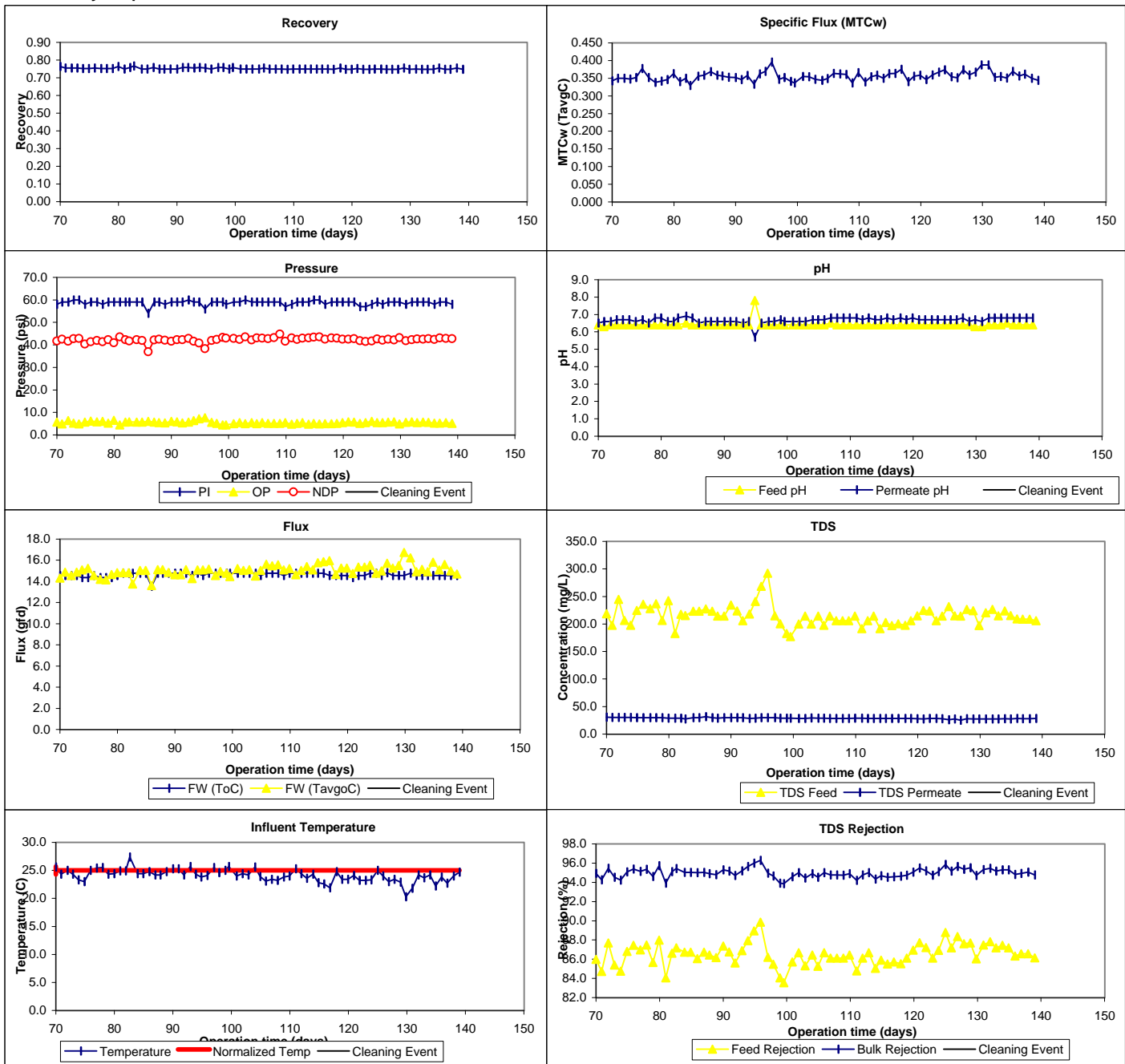




## Water Quality Graphs (Continued)



Productivity Graphs



| ICR Information   | Membrane Information  | Design Parameters  |
|---|---|--|
| <b>ID / ICR#:</b> FL3640287 / 1075<br><b>ICR Contact:</b> Craig J. Anderson<br><b>Phone No.:</b> 407-574-6691 ext. 155<br><b>Period:</b> 11/16/98 - 1/24/99 (69 days) | <b>Manufacturer:</b> Fluid Systems<br><b>Trade Name:</b> Fluid Systems 4921S<br><b>Membrane Model:</b> 4040-TFCS 4921S<br><b>MWCO:</b> 200 Daltons<br><b>Element Size:</b> 4-inch x 40-inch<br><b>Element Area:</b> 78.0 ft <sup>2</sup><br><b>Design Flux:</b> 20.5 gfd<br><b>Mfr. NDP:</b> 75.0 psi<br><b>Mfr. MTC<sub>w</sub>:</b> 0.270 (gfd/psi)<br><b>Mfr. Temp:</b> 25.0 °C<br><b>Maximum Flow:</b> 10.0 gpm<br><b>Minimum Flow:</b> 4.0 gpm<br><b>Total Width :</b> 13.8 ft<br><b>Feed Spacer Thickness:</b> 0.0027 ft<br><b>840 Element Area</b> 330.0 ft <sup>2</sup><br><b>840 Purchase Price:</b> \$790 | <b>Norm Temp:</b> 25.0 °C<br><b>Temp Norm MTC-w:</b> 0.270 TavGC<br><b>Design Recovery:</b> 0.75<br><b>Avg Sys Flux F<sub>w</sub>:</b> 13.1 gfd<br><b># of Elem in P.V.:</b> 3<br><b># Pres Ves in Stg 1:</b> 2<br><b># Pres Ves in Stg 2:</b> 1<br><b>Pres Ves in Stg 3:</b> NA<br><b>Design Flux:</b> 13.1 gfd<br><b>Recycle Ratio:</b> 0.59<br><b>Osmotic P Stage 1:</b> 4.4 psi<br><b>Osmotic P Stage 2:</b> 4.8 psi<br><b>Osmotic P Stage 3:</b> NA |

## Water Quality Summary

| Summary        | Feed (System) |      |       |               | Permeate (System)        |      |                                     |               | Concentrate (System)               |       |       |               |  |  |
|----------------|---------------|------|-------|---------------|--------------------------|------|-------------------------------------|---------------|------------------------------------|-------|-------|---------------|--|--|
|                | Mean          | SD   | Count | Min/Max       | Mean                     | SD   | Count                               | Min/Max       | Mean                               | SD    | Count | Min/Max       |  |  |
| pH             | 6.5           | 0.2  | 5     | 6.2 - 6.6     | 5.8                      | 0.2  | 5                                   | 5.6 - 6.1     | 6.9                                | 0.1   | 5     | 6.7 - 7.0     |  |  |
| Temp           | 21.7          | 1.0  | 5     | 20.3 - 22.9   | 21.7                     | 1.0  | 5                                   | 20.3 - 22.9   | 21.7                               | 1.0   | 5     | 20.3 - 22.9   |  |  |
| Alk            | 90            | 11   | 5     | 75 - 100      | 17                       | 1    | 5                                   | 16 - 18       | 314                                | 30    | 5     | 270 - 340     |  |  |
| TDS            | 229           | 31   | 5     | 180 - 265     | 31                       | 10   | 5                                   | 16 - 44       | 942                                | 219   | 5     | 670 - 1200    |  |  |
| TotHard        | 178           | 4    | 5     | 170 - 180     | 21                       | 1    | 5                                   | 20 - 23       | 674                                | 50    | 5     | 630 - 760     |  |  |
| CaHard         | 156           | 5    | 5     | 150 - 160     | 18                       | 1    | 5                                   | 17 - 20       | 574                                | 44    | 5     | 540 - 650     |  |  |
| Turb           | 0.01          | 0.0  | 5     | 0.00 - 0.06   | 0.00                     | 0.0  | 5                                   | 0.00 - 0.00   | 0.14                               | 0.0   | 5     | 0.11 - 0.17   |  |  |
| Amm            | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | NA                                 | NA    | 0     | 0.0 - 0.0     |  |  |
| TOC            | 2.4           | 0.2  | 5     | 2.0 - 2.5     | 0.3                      | 0.0  | 5                                   | 0.3 - 0.3     | 9.5                                | 1.0   | 5     | 8.5 - 11.0    |  |  |
| UV254          | 0.086         | 0.0  | 5     | 0.084 - 0.089 | 0.005                    | 0.0  | 5                                   | 0.005 - 0.005 | 0.366                              | 0.0   | 5     | 0.330 - 0.410 |  |  |
| SUVA           | 3.65          | 0.38 | 5     | 3.36 - 4.31   | 1.80                     | 0.00 | 5                                   | 1.80 - 1.80   | 3.85                               | 0.17  | 5     | 3.66 - 4.10   |  |  |
| Bromide        | 48            | 2    | 5     | 46 - 50       | 10                       | 0    | 5                                   | 10 - 10       |                                    |       |       |               |  |  |
| TOX            | 349           | 55   | 5     | 281 - 406     | 30                       | 15   | 5                                   | 13 - 54       |                                    |       |       |               |  |  |
| CHCl3          | 71.3          | 14.8 | 5     | 49.5 - 91.0   | 4.9                      | 1.5  | 5                                   | 3.5 - 6.7     | Mass Balance<br>Closure Errors (%) |       |       |               |  |  |
| BDCM           | 14.5          | 1.9  | 5     | 11.5 - 16.0   | 2.4                      | 0.6  | 5                                   | 2.0 - 3.3     |                                    |       |       |               |  |  |
| DBCM           | 1.8           | 0.3  | 5     | 1.6 - 2.3     | 0.7                      | 0.7  | 5                                   | 0.0 - 1.4     | WQP                                | Count | Avg   | SD/RD         |  |  |
| CHBr3          | 0.0           | 0.0  | 5     | 0.0 - 0.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Alk                                | 5     | -11   | 7             |  |  |
| THM4           | 87.6          | 16.6 | 5     | 62.8 - 108.8  | 8.0                      | 2.1  | 5                                   | 5.5 - 10.7    | TDS                                | 5     | 0     | 8             |  |  |
| MCAA           | 0.6           | 1.3  | 5     | 0.0 - 2.9     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | TotHard                            | 5     | -10   | 8             |  |  |
| DCAA           | 29.4          | 7.4  | 5     | 22.0 - 40.0   | 2.2                      | 0.8  | 5                                   | 1.0 - 3.3     | CaHard                             | 5     | -14   | 9             |  |  |
| TCAA           | 34.2          | 12.2 | 5     | 17.0 - 45.0   | 2.2                      | 0.4  | 5                                   | 1.6 - 2.8     | Turb                               | 0     | n/a   | n/a           |  |  |
| MBAA           | 0.0           | 0.0  | 5     | 0.0 - 0.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Amm                                | 0     | n/a   | n/a           |  |  |
| DBAA           | 0.7           | 1.0  | 5     | 0.0 - 2.2     | 0.2                      | 0.5  | 5                                   | 0.0 - 1.2     | TOC                                | 0     | n/a   | n/a           |  |  |
| BCAA           | 6.7           | 1.6  | 5     | 5.1 - 9.3     | 1.0                      | 1.0  | 5                                   | 0.0 - 2.2     | UV254                              | 0     | n/a   | n/a           |  |  |
| TBAA           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | TDS <sub>t</sub> 69 -15 10         |       |       |               |  |  |
| CDBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                                    |       |       |               |  |  |
| DCBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | Comments:                          |       |       |               |  |  |
| HAA5           | 64.9          | 18.2 | 5     | 41.9 - 83.0   | 4.7                      | 1.2  | 5                                   | 3.3 - 6.2     |                                    |       |       |               |  |  |
| HAA6           | 71.6          | 17.6 | 5     | 51.2 - 89.3   | 5.7                      | 1.9  | 5                                   | 3.6 - 8.4     |                                    |       |       |               |  |  |
| HAA9           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                                    |       |       |               |  |  |
| SDS Conditions |               |      |       |               | Pretreatment Information |      |                                     |               |                                    |       |       |               |  |  |
| WQP            | Avg           | SD   | Count | Min - Max     | Process                  |      | Description                         |               |                                    |       |       | Scale         |  |  |
| Res (0)        | 1.14          | 0.26 | 10    | 0.68 - 1.40   | Cartridge filtration     |      | 5 mm exclusion size                 |               |                                    |       |       | Pilot scale   |  |  |
| Temp (°C)      | 21.0          | 2.1  | 10    | 20.0 - 25.0   | Sulfuric Acid addition   |      | pH=6.4(@ 75% rec.), 6.2(@ 80% rec.) |               |                                    |       |       | Pilot scale   |  |  |
| pH (unit)      | 8.1           | 0.1  | 10    | 8.0 - 8.2     |                          |      |                                     |               |                                    |       |       |               |  |  |
| Time (hr)      | 48.0          | 0.0  | 10    | 48.0 - 48.0   |                          |      |                                     |               |                                    |       |       |               |  |  |

## 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  | -67.7% | 8.0%  |
| Sys Conc - Stg 2 Conc   | 0.0% | 0.0% | Sys Conc - Stg 2 Conc  | #VALUE! | #VALUE! | 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 | #VALUE! | #VALUE! | Stg 1 Conc - Stg 2 Inf  | -0.4%  | 2.8%  |
| Sys Perm - Avg Stg Perr | 0.0% | 0.0% | Sys Perm - Sum Stg Per | 2.8%    | 23.7%   | Sys Perm - Avg Stg Perm | -4.7%  | 11.4% |

# 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 |                  |          | 0.54  | 0.02  | 5     | 0.52 - 0.57   |                  |       |       |       |               |
| pH       | 6.5              | 6.9      | 6.6   | 0.2   | 5     | 6.3 - 6.7     | 5.8              | 5.7   | 0.2   | 5     | 5.5 - 6.1     |
| Temp     | 21.7             | 21.7     | 21.7  | 1.0   | 5     | 20.3 - 22.9   | 21.7             | 21.7  | 1.0   | 5     | 20.3 - 22.9   |
| Alk      | 90               | 314      | 142   | 18    | 5     | 120 - 160     | 17               | 13    | 2     | 5     | 11 - 15       |
| TDS      | 229              | 942      | 388   | 61    | 5     | 320 - 470     | 31               | 19    | 7     | 5     | 13 - 29       |
| TotHard  | 178              | 674      | 298   | 19    | 5     | 270 - 320     | 21               | 13    | 1     | 5     | 11 - 14       |
| CaHard   | 156              | 574      | 252   | 16    | 5     | 230 - 270     | 18               | 11    | 0     | 5     | 11 - 12       |
| Turb     | 0.01             | 0.14     | 0.02  | 0     | 5     | 0.00 - 0.12   | 0.00             | 0.00  | 0.00  | 5     | 0 - 0         |
| TOC      | 2.4              | 9.5      | 3.9   | 0.3   | 5     | 3.5 - 4.4     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.086            | 0.366    | 0.144 | 0.011 | 5     | 0.130 - 0.160 | 0.005            | 0.005 | 0.000 | 5     | 0.005 - 0.005 |
| SUVA     | 3.65             | 3.85     | 3.66  | 0.23  | 5     | 3.42 - 4.00   | 1.80             | 1.80  | 0.00  | 5     | 1.80 - 1.80   |

|          | Stage 2 Influent |          |       |       |       |               | Stage 2 Permeate |       |       |       |               |
|----------|------------------|----------|-------|-------|-------|---------------|------------------|-------|-------|-------|---------------|
| WQP      | Sys Feed         | Sys Conc | Mean  | SD    | Count | Min/Max       | Sys Perm         | Mean  | SD    | Count | Min/Max       |
| Recovery |                  |          | 0.51  | 0.03  | 5     | 0.49 - 0.56   |                  |       |       |       |               |
| pH       | 6.5              | 6.9      | 6.8   | 0.1   | 5     | 6.6 - 6.9     | 5.8              | 5.8   | 0.1   | 5     | 5.7 - 5.9     |
| Temp     | 21.7             | 21.7     | 21.7  | 1.0   | 5     | 20.3 - 22.9   | 21.7             | 21.7  | 1.0   | 5     | 20.3 - 22.9   |
| Alk      | 90               | 314      | 208   | 23    | 5     | 180 - 240     | 17               | 24    | 1     | 5     | 23 - 26       |
| TDS      | 229              | 942      | 578   | 120   | 5     | 420 - 750     | 31               | 46    | 10    | 5     | 28 - 54       |
| TotHard  | 178              | 674      | 442   | 50    | 5     | 400 - 520     | 21               | 34    | 2     | 5     | 33 - 37       |
| CaHard   | 156              | 574      | 376   | 42    | 5     | 340 - 440     | 18               | 29    | 2     | 5     | 28 - 32       |
| Turb     | 0.01             | 0.14     | 0.06  | 0     | 5     | 0.00 - 0.15   | 0.00             | 0.00  | 0.00  | 5     | 0 - 0         |
| TOC      | 2.4              | 9.5      | 5.9   | 0.6   | 5     | 5.2 - 6.7     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.086            | 0.366    | 0.224 | 0.023 | 5     | 0.200 - 0.260 | 0.005            | 0.011 | 0.002 | 5     | 0.009 - 0.012 |
| SUVA     | 3.65             | 3.85     | 3.79  | 0.18  | 5.00  | 3.61 - 4.04   | 1.80             | 4.20  | 0.60  | 5.00  | 3.60 - 4.80   |

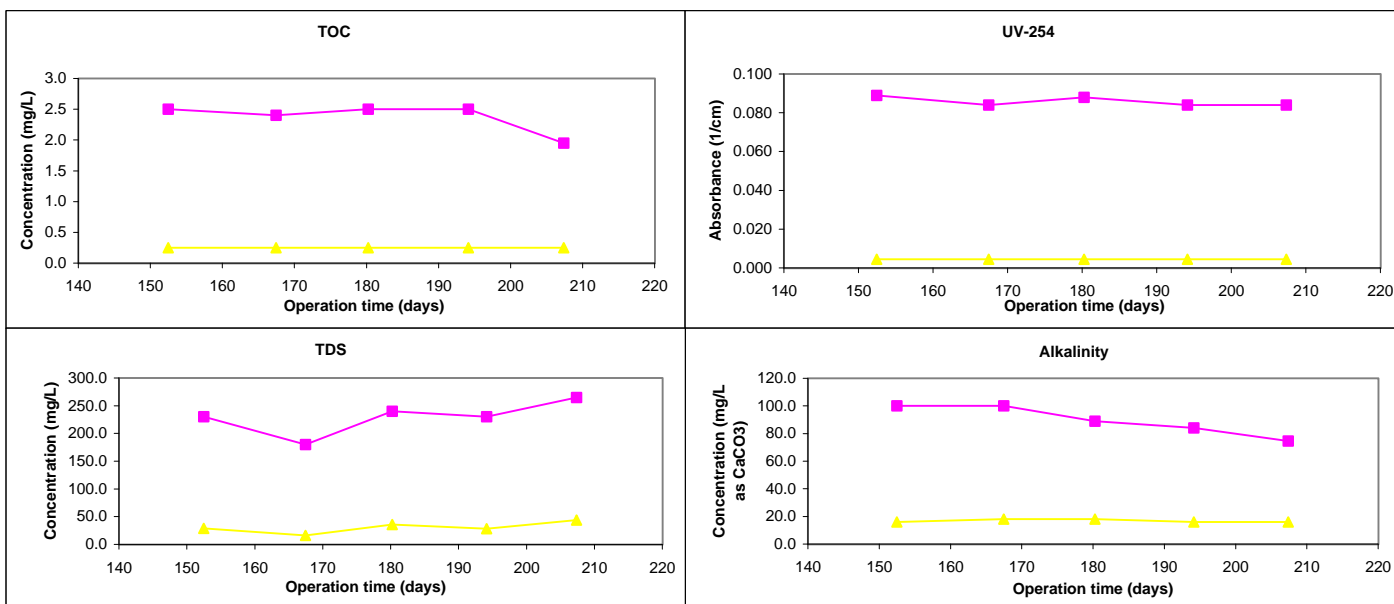
|          | Stage 3 Influent |          |      |    |       |         | Stage 3 Permeate |      |    |       |         |
|----------|------------------|----------|------|----|-------|---------|------------------|------|----|-------|---------|
| WQP      | Sys Feed         | Sys Conc | Mean | SD | Count | Min/Max | Sys Perm         | Mean | SD | Count | Min/Max |
| Recovery |                  |          |      |    |       |         |                  |      |    |       |         |
| pH       |                  |          |      |    |       |         |                  |      |    |       |         |
| Temp     |                  |          |      |    |       |         |                  |      |    |       |         |
| Alk      |                  |          |      |    |       |         |                  |      |    |       |         |
| TDS      |                  |          |      |    |       |         |                  |      |    |       |         |
| TotHard  |                  |          |      |    |       |         |                  |      |    |       |         |
| CaHard   |                  |          |      |    |       |         |                  |      |    |       |         |
| Turb     |                  |          |      |    |       |         |                  |      |    |       |         |
| TOC      |                  |          |      |    |       |         |                  |      |    |       |         |
| UV254    |                  |          |      |    |       |         |                  |      |    |       |         |
| SUVA     |                  |          |      |    |       |         |                  |      |    |       |         |

This was only a two stage study.

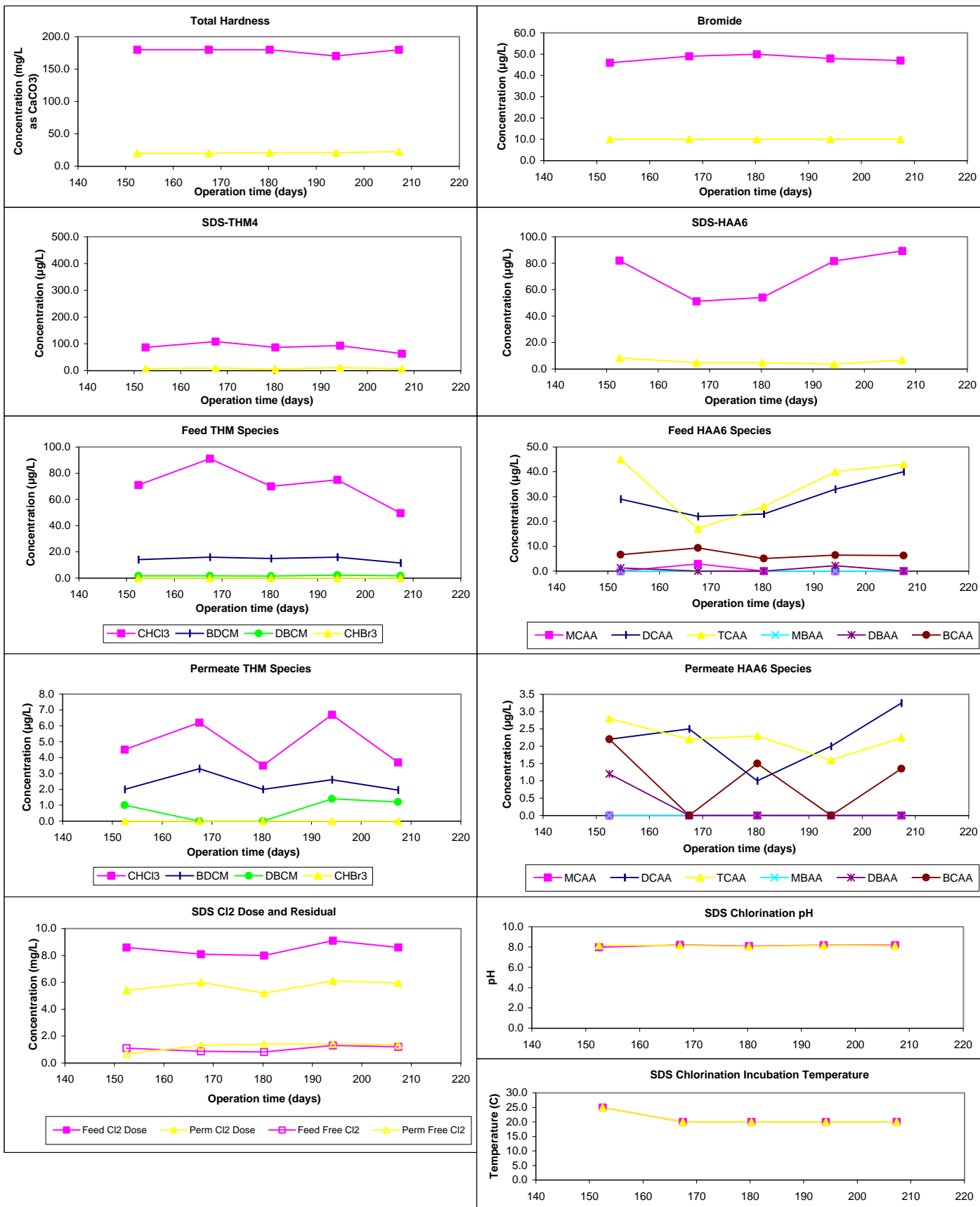
## Chart Legend:

- Feed (System)
- Permeate (System)

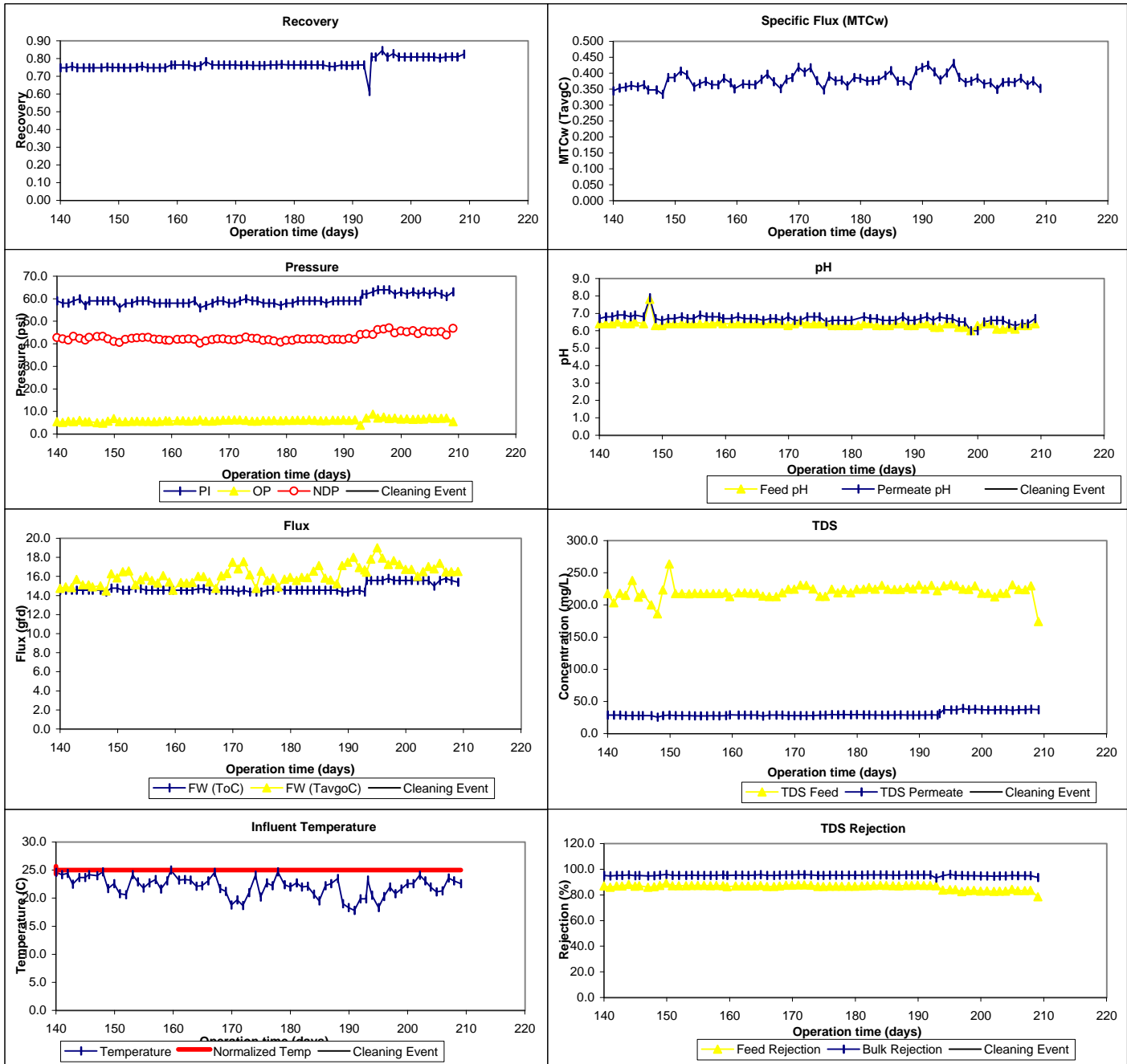
## Water Quality Parameter Graphs



## Water Quality Graphs (Continued)



Productivity Graphs



## ICR Information

ID / ICR#: FL3640287 / 1075  
 ICR Contact: Craig J. Anderson  
 Phone No.: 407-574-6691 ext. 155  
 Period: 1/25/99 - 4/11/99 (76 days)

## Membrane Information

Manufacturer: Fluid Systems  
 Trade Name: Fluid Systems 4921S  
 Membrane Model: 4040-TFCS 4921S  
 MWCO: 200 Daltons  
 Element Size: 4-inch x 40-inch  
 Element Area: 78.0 ft<sup>2</sup>  
 Design Flux: 20.5 gfd  
 Mfr. NDP: 75.0 psi  
 Mfr. MTC<sub>w</sub>: 0.270 (gfd/psi)  
 Mfr. Temp: 25.0 °C  
 Maximum Flow: 10.0 gpm  
 Minimum Flow: 4.0 gpm  
 Total Width : 13.8 ft  
 Feed Spacer Thickness: 0.0027 ft  
 840 Element Area 330.0 ft<sup>2</sup>  
 840 Purchase Price: \$790

## Design Parameters

Norm Temp: 25.0 °C  
 Temp Norm MTC-w: 0.270 TavGC  
 Design Recovery: 0.75  
 Avg Sys Flux F<sub>w</sub>: 13.1 gfd  
 # of Elem in P.V.: 3  
 # Pres Ves in Stg 1: 2  
 # Pres Ves in Stg 2: 1  
 Pres Ves in Stg 3: NA  
 Design Flux: 13.1 gfd  
 Recycle Ratio: 0.59  
 Osmotic P Stage 1: 4.4 psi  
 Osmotic P Stage 2: 4.8 psi  
 Osmotic P Stage 3: NA

## Water Quality Summary

| Summary        | Feed (System) |      |       |               | Permeate (System)        |      |                                     |               | Concentrate (System) |       |             |               |  |  |
|----------------|---------------|------|-------|---------------|--------------------------|------|-------------------------------------|---------------|----------------------|-------|-------------|---------------|--|--|
|                | Mean          | SD   | Count | Min/Max       | Mean                     | SD   | Count                               | Min/Max       | Mean                 | SD    | Count       | Min/Max       |  |  |
| pH             | 6.3           | 0.4  | 5     | 6.1 - 7.0     | 5.7                      | 0.2  | 5                                   | 5.4 - 6.0     | 6.7                  | 0.1   | 5           | 6.5 - 6.8     |  |  |
| Temp           | 22.1          | 2.0  | 5     | 19.3 - 24.7   | 22.1                     | 2.0  | 5                                   | 19.3 - 24.7   | 22.1                 | 2.0   | 5           | 19.3 - 24.7   |  |  |
| Alk            | 72            | 12   | 5     | 57 - 84       | 18                       | 8    | 5                                   | 14 - 32       | 264                  | 29    | 5           | 220 - 290     |  |  |
| TDS            | 244           | 30   | 5     | 210 - 280     | 37                       | 8    | 5                                   | 24 - 46       | 1140                 | 114   | 5           | 1000 - 1300   |  |  |
| TotHard        | 186           | 13   | 5     | 180 - 210     | 21                       | 2    | 5                                   | 20 - 25       | 874                  | 73    | 5           | 820 - 1000    |  |  |
| CaHard         | 162           | 11   | 5     | 150 - 180     | 19                       | 2    | 5                                   | 17 - 22       | 766                  | 77    | 5           | 710 - 900     |  |  |
| Turb           | 0.99          | 1.1  | 5     | 0.00 - 2.70   | 0.08                     | 0.2  | 5                                   | 0.00 - 0.40   | 3.38                 | 2.5   | 5           | 0.11 - 6.20   |  |  |
| Amm            | 0.28          | NA   | 1     | 0.28 - 0.28   | 0.13                     | NA   | 1                                   | 0.13 - 0.13   | 0.98                 | NA    | 1           | 1.0 - 1.0     |  |  |
| TOC            | 2.2           | 0.1  | 5     | 2.1 - 2.4     | 0.3                      | 0.0  | 5                                   | 0.3 - 0.3     | 11.0                 | 0.7   | 5           | 10.0 - 12.0   |  |  |
| UV254          | 0.085         | 0.0  | 5     | 0.083 - 0.086 | 0.005                    | 0.0  | 5                                   | 0.005 - 0.005 | 0.418                | 0.0   | 5           | 0.410 - 0.430 |  |  |
| SUVA           | 3.80          | 0.22 | 5     | 3.58 - 4.10   | 1.80                     | 0.00 | 5                                   | 1.80 - 1.80   | 3.81                 | 0.30  | 5           | 3.50 - 4.30   |  |  |
| Bromide        | 40            | 5    | 4     | 37 - 48       | 10                       | 0    | 5                                   | 10 - 10       |                      |       |             |               |  |  |
| TOX            | 310           | 105  | 5     | 138 - 384     | 36                       | 12   | 5                                   | 26 - 54       |                      |       |             |               |  |  |
| CHCl3          | 49.7          | 11.7 | 5     | 35.0 - 64.0   | 3.5                      | 0.4  | 5                                   | 3.1 - 4.2     | Mass Balance         |       |             |               |  |  |
| BDCM           | 11.7          | 2.6  | 5     | 7.7 - 14.0    | 1.9                      | 0.2  | 5                                   | 1.7 - 2.2     | Closure Errors (%)   |       |             |               |  |  |
| DBCM           | 1.7           | 0.3  | 5     | 1.3 - 2.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | WQP                  | Count | Avg         | SD/RD         |  |  |
| CHBr3          | 0.0           | 0.0  | 5     | 0.0 - 0.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Alk                  | 5     | -16         | 11            |  |  |
| THM4           | 63.2          | 14.4 | 5     | 44.0 - 80.0   | 5.4                      | 0.6  | 5                                   | 5.0 - 6.4     | TDS                  | 5     | -3          | 10            |  |  |
| MCAA           | 0.0           | 0.0  | 5     | 0.0 - 0.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | TotHard              | 5     | -4          | 3             |  |  |
| DCAA           | 22.3          | 9.6  | 5     | 8.1 - 34.0    | 2.0                      | 0.7  | 5                                   | 1.3 - 3.2     | CaHard               | 5     | -3          | 4             |  |  |
| TCAA           | 25.6          | 15.1 | 5     | 5.2 - 45.0    | 1.6                      | 0.5  | 5                                   | 1.3 - 2.4     | Turb                 | 1     | -7          | n/a           |  |  |
| MBAA           | 0.0           | 0.0  | 5     | 0.0 - 0.0     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | Amm                  | 1     | 2           | n/a           |  |  |
| DBAA           | 0.2           | 0.5  | 5     | 0.0 - 1.1     | 0.0                      | 0.0  | 5                                   | 0.0 - 0.0     | TOC                  | 0     | n/a         | n/a           |  |  |
| BCAA           | 4.0           | 1.1  | 5     | 2.5 - 5.3     | 0.5                      | 0.7  | 5                                   | 0.0 - 1.5     | UV254                | 0     | n/a         | n/a           |  |  |
| TBAA           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                      |       |             |               |  |  |
| CDBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | TDS <sub>t</sub>     | 72    | -25         | 7             |  |  |
| DCBAA          | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            | Comments:            |       |             |               |  |  |
| HAA5           | 48.2          | 24.6 | 5     | 13.3 - 79.0   | 3.6                      | 1.2  | 5                                   | 2.6 - 5.6     |                      |       |             |               |  |  |
| HAA6           | 52.2          | 25.5 | 5     | 15.8 - 84.3   | 4.1                      | 1.8  | 5                                   | 2.6 - 7.1     |                      |       |             |               |  |  |
| HAA9           | NA            | NA   | 0     | NA            | NA                       | NA   | 0                                   | NA            |                      |       |             |               |  |  |
| SDS Conditions |               |      |       |               | Pretreatment Information |      |                                     |               |                      |       |             |               |  |  |
| WQP            | Avg           | SD   | Count | Min - Max     | Process                  |      | Description                         |               |                      |       | Scale       |               |  |  |
| Res (0)        | 1.13          | 0.35 | 10    | 0.68 - 1.70   | Cartridge filtration     |      | 5 mm exclusion size                 |               |                      |       | Pilot scale |               |  |  |
| Temp (°C)      | 20.0          | 0.0  | 10    | 20.0 - 20.0   | Sulfuric Acid addition   |      | pH=6.4(@ 75% rec.), 6.2(@ 80% rec.) |               |                      |       | Pilot scale |               |  |  |
| pH (unit)      | 8.1           | 0.1  | 10    | 8.0 - 8.2     |                          |      |                                     |               |                      |       |             |               |  |  |
| Time (hr)      | 48.0          | 0.0  | 10    | 48.0 - 48.0   |                          |      |                                     |               |                      |       |             |               |  |  |

## Mass Balance Errors

| Pressure                | RPD  | SD   | Flow                   | RPD     | SD      | TDS                     | RPD    | SD   |
|-------------------------|------|------|------------------------|---------|---------|-------------------------|--------|------|
| System Inf - Stg 1 Inf  | 0.1% | 0.9% | System Inf - Stg 1 Inf | 0.0%    | 0.0%    | System Inf - Stg 1 Inf  | -59.2% | 8.6% |
| Sys Conc - Stg 2 Conc   | 0.0% | 0.0% | Sys Conc - Stg 2 Conc  | #VALUE! | #VALUE! | 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 | #VALUE! | #VALUE! | Stg 1 Conc - Stg 2 Inf  | 0.0%   | 0.0% |
| Sys Perm - Avg Stg Perr | 0.0% | 0.0% | Sys Perm - Sum Stg Per | 2.7%    | 23.2%   | Sys Perm - Avg Stg Perm | -6.9%  | 1.5% |

# Stage Summary

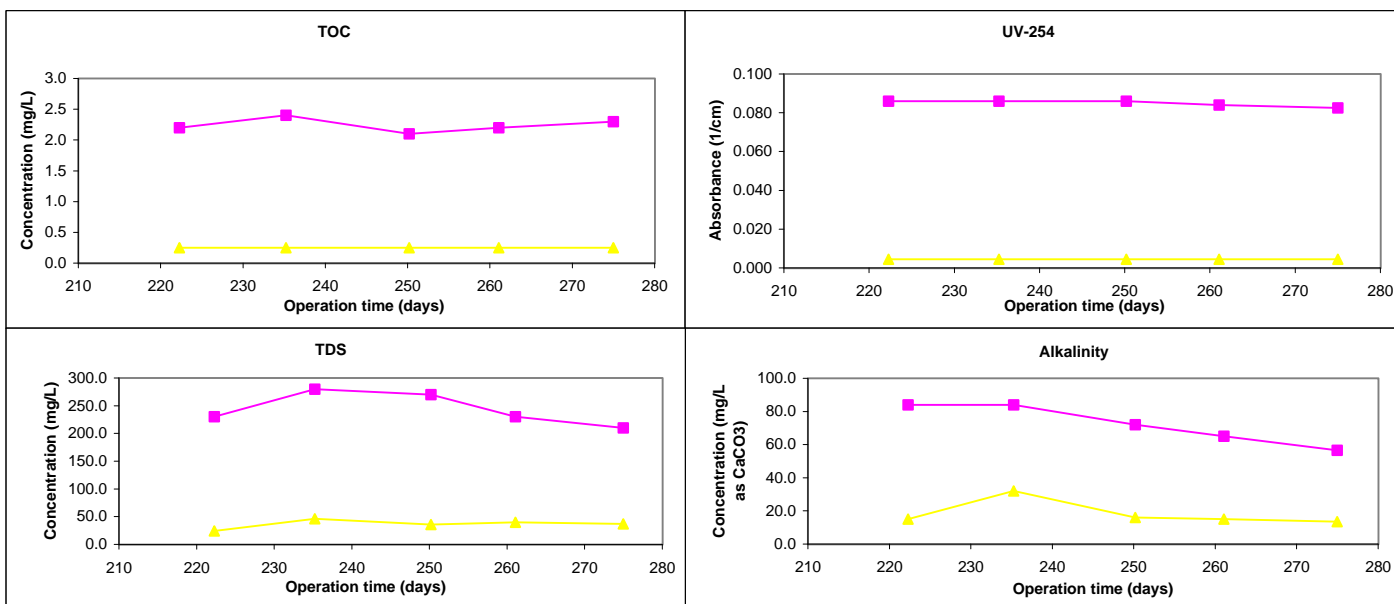
|          | Stage 1 Influent |          |       |       |       |               | Stage 1 Permeate |       |       |       |               |
|----------|------------------|----------|-------|-------|-------|---------------|------------------|-------|-------|-------|---------------|
| WQP      | Sys Feed         | Sys Conc | Mean  | SD    | Count | Min/Max       | Sys Perm         | Mean  | SD    | Count | Min/Max       |
| Recovery |                  |          | 0.57  | 0.01  | 5     | 0.55 - 0.58   |                  |       |       |       |               |
| pH       | 6.3              | 6.7      | 6.4   | 0.1   | 5     | 6.2 - 6.5     | 5.7              | 5.5   | 0.3   | 5     | 5.1 - 5.8     |
| Temp     | 22.1             | 22.1     | 22.1  | 2.0   | 5     | 19.3 - 24.7   | 22.1             | 22.1  | 2.0   | 5     | 19.3 - 24.7   |
| Alk      | 72               | 264      | 122   | 13    | 5     | 100 - 130     | 18               | 12    | 9     | 5     | 0 - 24        |
| TDS      | 244              | 1140     | 428   | 54    | 5     | 360 - 500     | 37               | 23    | 7     | 5     | 12 - 31       |
| TotHard  | 186              | 874      | 362   | 33    | 5     | 340 - 420     | 21               | 13    | 2     | 5     | 11 - 17       |
| CaHard   | 162              | 766      | 314   | 32    | 5     | 290 - 370     | 19               | 12    | 1     | 5     | 11 - 15       |
| Turb     | 0.99             | 3.38     | 2.62  | 2     | 5     | 0.00 - 4.40   | 0.08             | 0.15  | 0.24  | 5     | 0 - 1         |
| TOC      | 2.2              | 11.0     | 4.6   | 0.4   | 5     | 3.9 - 4.9     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.085            | 0.418    | 0.170 | 0.007 | 5     | 0.160 - 0.180 | 0.005            | 0.005 | 0.000 | 5     | 0.005 - 0.005 |
| SUVA     | 3.80             | 3.81     | 3.70  | 0.25  | 5     | 3.47 - 4.10   | 1.80             | 1.80  | 0.00  | 5     | 1.80 - 1.80   |
|          | 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  | 0.02  | 5     | 0.54 - 0.58   |                  |       |       |       |               |
| pH       | 6.3              | 6.7      | 6.6   | 0.1   | 5     | 6.5 - 6.7     | 5.7              | 5.8   | 0.2   | 5     | 5.5 - 6.0     |
| Temp     | 22.1             | 22.1     | 22.1  | 2.0   | 5     | 19.3 - 24.7   | 22.1             | 22.1  | 2.0   | 5     | 19.3 - 24.7   |
| Alk      | 72               | 264      | 184   | 30    | 5     | 140 - 220     | 18               | 25    | 6     | 5     | 19 - 35       |
| TDS      | 244              | 1140     | 658   | 69    | 5     | 560 - 740     | 37               | 58    | 15    | 5     | 44 - 82       |
| TotHard  | 186              | 874      | 510   | 53    | 5     | 460 - 600     | 21               | 38    | 4     | 5     | 34 - 44       |
| CaHard   | 162              | 766      | 444   | 50    | 5     | 400 - 530     | 19               | 33    | 3     | 5     | 30 - 38       |
| Turb     | 0.99             | 3.38     | 3.12  | 2     | 5     | 0.00 - 5.80   | 0.08             | 0.14  | 0.31  | 5     | 0 - 1         |
| TOC      | 2.2              | 11.0     | 6.5   | 0.5   | 5     | 5.8 - 7.0     | 0.3              | 0.3   | 0.0   | 5     | 0.3 - 0.3     |
| UV254    | 0.085            | 0.418    | 0.244 | 0.013 | 5     | 0.230 - 0.260 | 0.005            | 0.009 | 0.004 | 5     | 0.005 - 0.012 |
| SUVA     | 3.80             | 3.81     | 3.76  | 0.15  | 5.00  | 3.57 - 3.97   | 1.80             | 3.52  | 1.58  | 5.00  | 1.80 - 4.80   |
|          | 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      |                  |          |       |       |       |               |                  |       |       |       |               |
| TDS      |                  |          |       |       |       |               |                  |       |       |       |               |
| TotHard  |                  |          |       |       |       |               |                  |       |       |       |               |
| CaHard   |                  |          |       |       |       |               |                  |       |       |       |               |
| Turb     |                  |          |       |       |       |               |                  |       |       |       |               |
| TOC      |                  |          |       |       |       |               |                  |       |       |       |               |
| UV254    |                  |          |       |       |       |               |                  |       |       |       |               |
| SUVA     |                  |          |       |       |       |               |                  |       |       |       |               |

This was only a two stage study.

## Chart Legend:

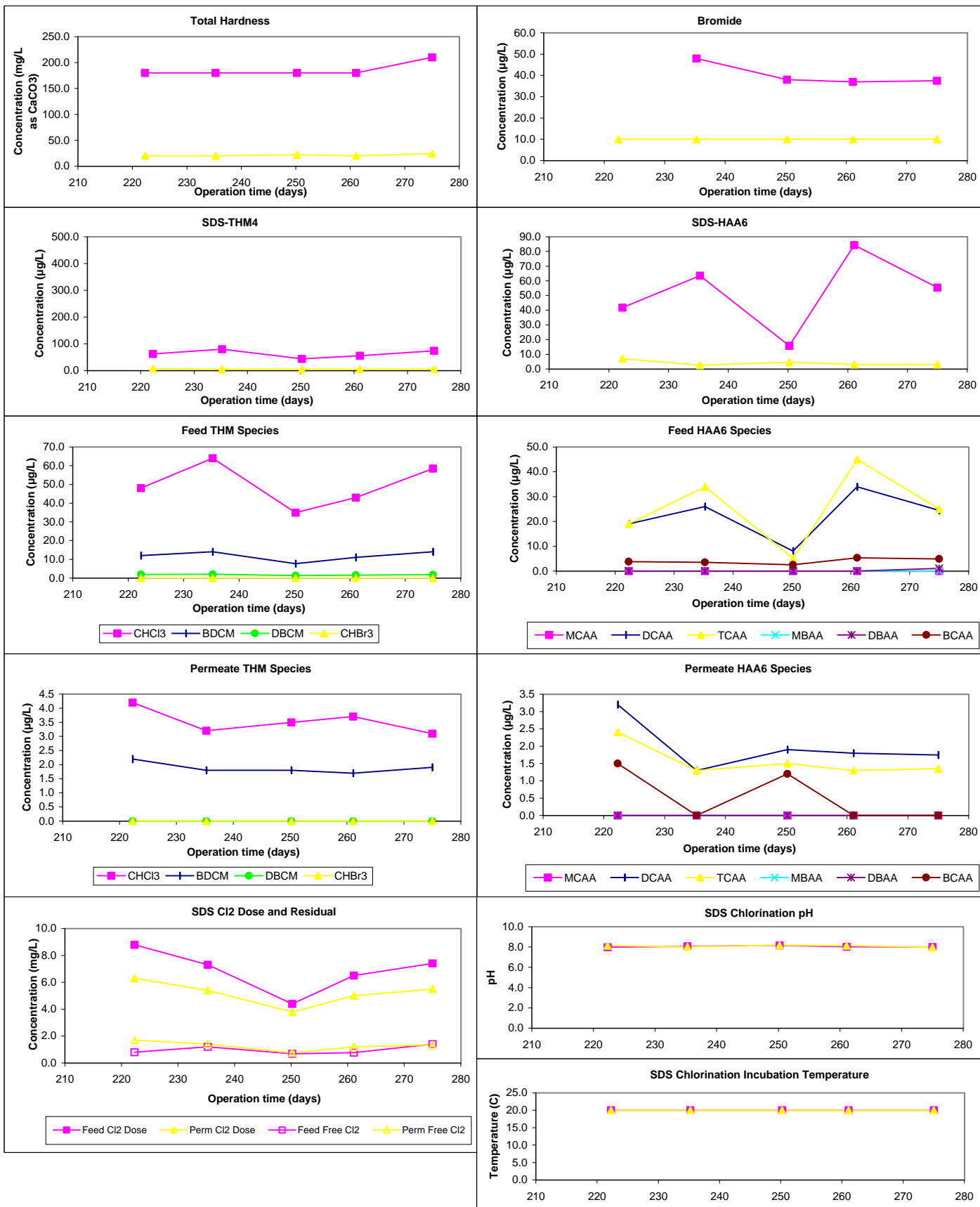
- Feed (System)
- Permeate (System)

## Water Quality Parameter Graphs





## Water Quality Graphs (Continued)



# Productivity Graphs

