ICR TREATMENT STUDY ANALYSIS

Base Analysis and Data Review Comments

Treatment Study ID 1002

Study Protocol 2-Stage Pilot System

Plant ICR Number 311

PWS Name Tampa Water Department

City, State, Zip Tampa, FL 33610

General Comments:

1. This utility was only required to perform a bench-scale evaluation under the ICR; however, they opted to conduct a pilot-scale study. Several different sets of operating conditions (fluxes, recoveries and pretreatments) and membranes were evaluated during this study. Separate, but concurrent, pilot-scale evaluations of Fluid Systems and Hydranautics membranes were done, although due to severe membrane fouling, both makes of membranes had to be replaced during these studies: the CALP (Fluid Systems) membranes were replaced after 43 days of operation and the ESNA (Hydranautics) membranes were replaced with LFC (Hydranautics) membranes after 160 of operation. The experimental design for this study is listed in Section 3.3 and Table 7 of the Summary Report.

2. During the first session of operation of both the Hydranautics and Fluid Systems membranes, the membrane feed was prechlorinated (in the full-scale plant) and then passed through GAC to dechlorinate the water prior to entering the membrane systems. However, during at least one weekly water quality sampling event there was a measurable free chlorine residual in the membrane feed. It is not clear whether a free chlorine residual was present in the membrane feed at any other time during the evaluation of this pretreatment. The DBPs formed in the membrane feed during prechlorination were not explicitly measured, thus the pre-formed feed DBP concentrations (i.e., prior to SDS chlorination of the feed sample) are not known. Therefore, none of the DBP data from this pretreatment evaluation will be used during data analysis.

3. During the remaining quarters microfiltration and chloramines (intermittently) were used as a pretreatment. Based on the pretreatment information provided in the Summary Report there is no reason to believe that the chloramine feed was shut off during water quality sampling.

4. Section 1, Conclusions and Recommendations, lists many productivity and water quality observations from this study.

5. A brief summary of the performance of the various membrane types and pretreatments evaluated is listed in Section 4.2.3. No cost estimates are given in the Summary Report.

Water Quality Comments:

1. 481 water quality outliers were identified and removed prior to base analysis.

2. During several weeks the permeate calcium hardness concentrations were reported as being higher than the permeate total hardness concentrations. While the consultant acknowledged that the total hardness numbers did not support these data, the calcium hardness concentrations were still reported, but were not used during data analysis. Additionally, during many weeks the calcium hardness data sets (i.e., feed, permeate and concentrate concentrations) had mass balance closure errors greater than 100% - these data were also not used during data analysis.

3. The relative formation of DBPs during this study often did not follow expected trends. For example, during most quarters the reported TOX concentrations were much lower than THM and HAA concentrations (even when compared on an equivalent basis). Also, often the reported TOX data were very erratic (relative to the reported TOC data and the formation of other DBPs). Therefore, none of the reported TOX data from this study were used during data analysis. Additionally, some weeks the reported HAA6 concentrations were 2 – 8 times the reported THM4 concentrations (i.e., HAA6 ranged from 2000 to 3000 µg/L). Although the utility verified these data, they were thought to be unrealistically high (possibly due to analytical error) and were not used during data analysis.

4. Based on the information provided in the data collection spreadsheets, the target SDS conditions during this study were: incubation time of 48 hours, at 22°C at a pH of 7.6. The measured reported residuals ranged from 0 to 5.5 mg/L.

5. The reported system, stage 1 and stage 2 permeate concentrations during the ESNA and LFC membrane evaluations were very erratic and did not follow any expected trends (i.e., the stage 2 permeate concentrations were not higher than stage 1, the permeate concentrations were not consistent between weeks, etc). Therefore, sieving was chosen as the rejection mechanism for the majority of water quality parameters and was used to predict the permeate water quality in the 3-stage array during EPA data analysis. It was anticipated that convective or diffusive transport would best represent the system and stage permeate water qualities; however, the reported data from this study did not support the use of either of these models.

Productivity Comments:

1. Three productivity outliers were identified and removed prior to base analysis.

2. Appendix A (Logbook Entries) of the Summary Report lists system downtimes due to membrane failure, cleanings, mechanical problems, etc.

3. The membrane systems were cleaned after a 25 to 50% drop in specific flux, with either a citric acid solution (for suspected membrane scaling), or some combination of sodium hydroxide, sodium tripolyphosphate, sodium dodecylbenzene sulfonate and/or tetrasodium EDTA (for suspected organic fouling). The cleaning procedure included 15 to 60 minutes of recirculation, followed by a 1 to 2 hour soak period, followed by 15 to 60 minutes of recirculation.

4. Section 4 discusses and Table 10 lists the observed NF productivity during this study. Projected, and not observed, runtimes are listed based on the slope of the flux decline curve and an anticipated 15% decline in productivity. Table 2, shown on pages 4 and 5 of the PDF Summary Report, also lists the operational times (hours) and dates that correspond to the projected cleaning intervals shown in Table 10. Often these projected runtimes were based on only one or two weeks of operation of the membrane system.

5. During this study the membrane flux and recovery was changed frequently; however, this did not appear to impact the specific flux of these membranes. The period of stable performance (with respect to specific flux) for the CALP membrane system was determined to be from 11/5/97 through 6/23/98 (approximately 142 days). During this time the average sustained system specific flux was 0.133 $\pm$ 0.010 gfd/psi, and the average system flux was 8.13 $\pm$ 2.44 gfd (this high standard deviation reflects the changing operating conditions). The projected cleaning interval for this membrane system was 173 days, based on the calculated slope of the flux decline curve.

6. The Hydranautics productivity data analysis was done for both the ESNA and the LFC membrane. For the ESNA membranes, the period of stable performance was defined from 8/15/97 through 9/24/97 (approximately 39 days). The sustained system specific flux and flux for the ESNA was 0.213 $\pm$ 0.023 gfd/psi and 8.50 $\pm$ 2.91 gfd, respectively. The corresponding projected cleaning interval for this membrane system was 19 days. For the LFC membranes, the period of stable performance was defined from 4/21/98 through 7/20/98 (approximately 78 days). During this time the sustained specific flux and flux were calculated as 0.149 $\pm$ 0.018 gfd/psi and 7.80 $\pm$ 2.70 gfd, respectively. The calculated slope of the system flux decline curve was positive, which is physically impossible; thus it was replaced with 0. Due to this positive slope, the projected cleaning interval exceeded one year. Therefore an upper-bound of 365 days was used as the cleaning interval for this membrane system. This upper-bound of one year serves as the minimum cleaning frequency necessary to mitigate problems beyond flux loss that can result from membrane fouling. Finally, the cleaning efficiencies of the ESNA and LFC membranes were estimated to be either 0%, or 100%, based on the reported productivity data.

7. Nanofiltration fouling mechanisms and associated pretreatment scenarios are listed in Tables 4 and 5 of the Summary Report.

TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 1

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 7/16/97 - 9/23/97 (69 days)

Membrane Information

Manufacturer:	Fluid Systems
Trade Name:	CALP
Membrane Model:	4231LP 4060
MWCO:	200 Daltons
Element Size:	4' x 60"
Element Area:	125.0 ft^2
Design Flux:	26.0 gfd
Mfr. NDP:	200.0 psi
Mfr. MTC_W:	0.130 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	11.3 gpm
Total Width :	19.3 ft
Feed Spacer Thickness:	0.0026 ft
840 Element Area	330.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.130 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 gfd
# of Elem in P.V.:	2
# Pres Ves in Stg 1:	2
# Pres Ves in Stg 2:	1
Pres Ves in Stg 3:	NA
Design Flux:	14.0 gfd
Recycle Ratio:	0.28
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.7	0.2	4	6.4 - 6.9	6.5	0.3	4	6.0 - 6.8	6.9	0.3	4	6.5 - 7.2
Temp	30.0	2.2	4	28.0 - 33.0	32.3	2.1	4	30.0 - 35.0	32.3	2.1	4	30.0 - 35.0
Alk	63	3	4	60 - 67	40	13	4	28 - 57	117	14	4	100 - 130
TDS	**307**	**27**	**3**	**276 - 323**	**105**	**25**	**4**	**73 - 134**	**857**	**374**	**4**	**631 - 1414**
TotHard	205	15	4	184 - 218	67	32	4	38 - 112	573	222	4	420 - 900
CaHard	123	27	4	83 - 138	77	25	4	45 - 103	145	34	4	95 - 168
Turb	6.09	11.9	4	0.09 - 24.00	2.05	4.0	4	0.07 - 8.00	0.14	NA	1	0.14 - 0.14
Amm	0.00	0.00	3	0.00 - 0.00	0.00	0.00	3	0.00 - 0.00	NA	NA	0	0.0 - 0.0
TOC	**2.9**	**1.1**	**4**	**1.4 - 3.8**	**0.4**	**0.3**	**4**	**0.3 - 0.9**	**11.5**	**6.3**	**4**	**7.3 - 20.7**
UV254	0.040	0.0	4	0.010 - 0.055	0.006	0.0	4	0.005 - 0.012	0.148	0.1	4	0.027 - 0.316
SUVA	1.28	0.37	4	0.73 - 1.49	1.68	0.25	4	1.30 - 1.80	1.16	0.54	4	0.37 - 1.53
Bromide	**25**	**5**	**3**	**20 - 30**	**19**	**9**	**3**	**10 - 28**				
TOX	**77**	**25**	**3**	**48 - 94**	**13**	**0**	**3**	**13 - 13**				
CHCl3	104.7	80.4	3	38.0 - 194.0	37.0	11.8	4	20.0 - 47.0				
BDCM	27.3	13.2	3	13.0 - 39.0	17.0	7.8	4	7.0 - 26.0				
DBCM	8.0	3.6	3	4.0 - 11.0	6.2	2.9	4	3.0 - 10.0				
CHBr3	0.7	0.6	3	0.0 - 1.0	1.0	0.8	4	0.0 - 2.0				
THM4	**140.7**	**96.4**	**3**	**55.0 - 245.0**	**61.2**	**22.5**	**4**	**31.0 - 85.0**				
MCAA	3.0	2.6	3	0.0 - 5.0	1.3	1.2	3	0.0 - 2.0				
DCAA	15.3	8.3	3	5.8 - 21.0	6.0	2.6	3	4.0 - 9.0				
TCAA	13.8	9.3	3	3.3 - 21.0	5.7	4.6	3	3.0 - 11.0				
MBAA	1.2	0.3	3	1.0 - 1.6	1.3	0.6	3	1.0 - 2.0				
DBAA	1.0	1.0	3	0.0 - 2.0	2.0	0.0	3	2.0 - 2.0				
BCAA	5.5	3.5	3	1.5 - 8.0	3.7	1.5	3	2.0 - 5.0				
TBAA	NA	NA	0	NA	16.0	NA	1	16.0 - 16.0				
CDBAA	NA	NA	0	NA	NA	NA	0	NA				
DCBAA	NA	NA	0	NA	NA	NA	0	NA				
HAA5	**34.2**	**20.6**	**3**	**10.7 - 49.0**	**16.3**	**7.6**	**3**	**11.0 - 25.0**				
HAA6	**39.7**	**24.0**	**3**	**12.2 - 56.0**	**20.0**	**8.9**	**3**	**13.0 - 30.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	4	0	6
TDS	3	-5	17
TotHard	4	-1	6
CaHard	4	-67	42
Turb	1	6	n/a
Amm	0	n/a	n/a
TOC	4	14	30
UV254	4	2	14
TDSt	23	-8	11

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	2.47	1.40	7	1.40 - 5.50
Temp (^oC)	22.2	0.0	7	22.2 - 22.2
pH (unit)	7.6	0.0	7	7.6 - 7.6
Time (hr)	48.0	0.0	7	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
COAGULATION	100-120 mg/L Fe2(SO4)3 as 12% Fe+3	Full Scale
FLOCCULATION	4-stage	Full Scale
SEDIMENTATION	rectanglular basin (4)	Full Scale
DUAL MEDIA FILTRATION	sand/anthracite	Full Scale
SULFURIC ACID ADDITION	57 ppm	Full Scale
POLYMER ADDITION	non-ionic polymer	Full Scale
LIME ADDITION	36 mg/L	Full Scale
GAC REMOVE CHLORINE RESIDUAL	NA	Pilot Scale
HYPERSPERSE AF200	ntiscalent	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	-5.2%	1.6%	System Inf - Stg 1 Inf	-39.0%	25.2%
Sys Conc - Stg 2 Conc	-0.2%	0.8%	Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.2%	0.7%
Stg 1 Conc - Stg 2 Inf	0.2%	1.0%	Stg 1 Conc - Stg 2 Inf	2.3%	1.1%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%
Sys Perm - Avg Stg Perm	0.2%	1.0%	Sys Perm - Sum Stg Pe	-8.1%	1.9%	Sys Perm - Avg Stg Perm	-4.9%	10.4%

Stage Summary

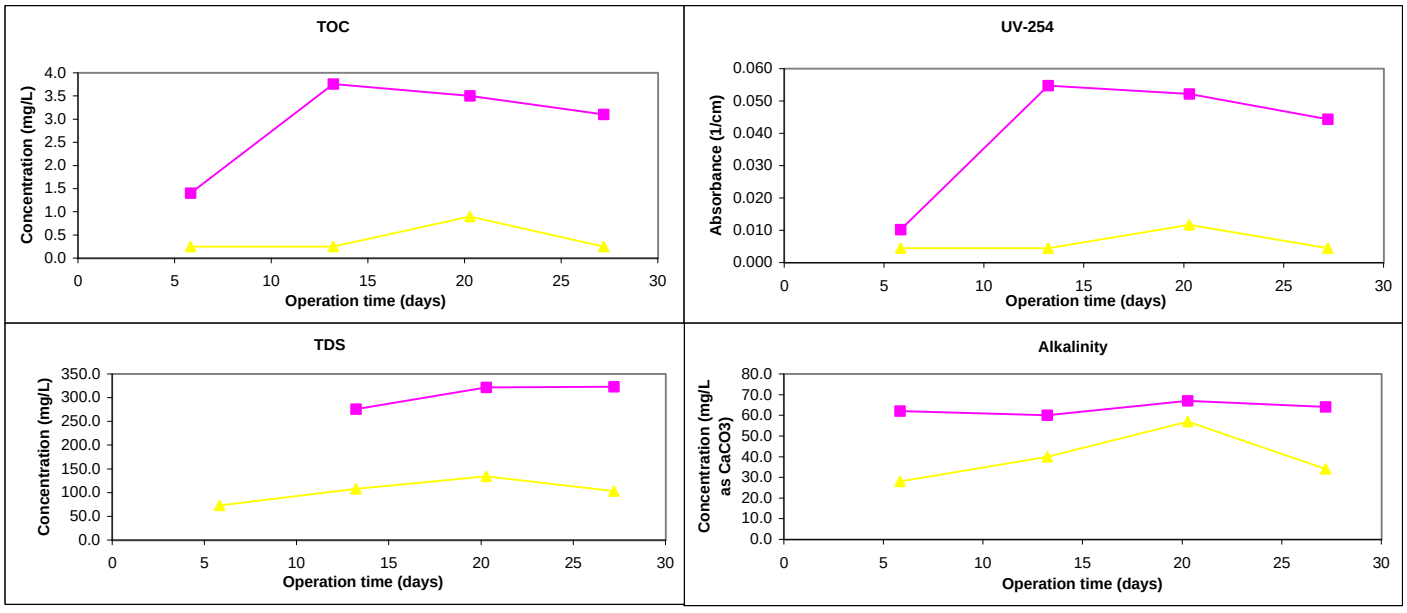
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.47**	**0.08**	**4**	**0.41 - 0.59**					
pH	6.7	6.9	6.6	0.2	3	6.4 - 6.8	6.5	6.4	0.3	3	6.1 - 6.6
Temp	30.0	32.3	32.3	2.1	4	30.0 - 35.0	32.3	32.3	2.1	4	30.0 - 35.0
Alk	63	117	82	11	4	72 - 98	40	37	13	4	25 - 55
TDS	**307**	**857**	541	**212**	**4**	**385 - 851**	**105**	**NA**	**NA**	**0**	**0 - 0**
TotHard	205	573	348	141	4	255 - 558	67	58	24	4	34 - 92
CaHard	123	145	134	31	4	88 - 153	77	70	25	4	40 - 100
Turb	6.09	0.14	4.35	8	4	0.11 - 17.00	2.05	3.72	6.30	3	0 - 11
TOC	**2.9**	**11.5**	5.9	**4.1**	**4**	**2.1 - 11.7**	**0.4**	**0.5**	**0.2**	**4**	**0.3 - 0.7**
UV254	0.040	**0.148**	0.085	0.070	4	0.015 - 0.181	0.006	0.006	0.003	4	0.005 - 0.011
SUVA	1.28	**1.16**	**1.30**	0.38	4	0.73 - 1.54	1.68	1.30	0.47	4	0.90 - 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			**0.45**	**0.18**	**4**	**0.32 - 0.72**					
pH	6.7	6.9	6.7	0.2	3	6.5 - 6.8	6.5	6.4	0.3	3	6.1 - 6.6
Temp	30.0	32.3	32.3	2.1	4	30.0 - 35.0	32.3	32.3	2.1	4	30.0 - 35.0
Alk	63	117	104	13	4	88 - 120	40	48	13	4	37 - 66
TDS	**307**	**857**	**NA**	**NA**	**0**	**0 - 0**	**105**	**NA**	**NA**	**0**	**0 - 0**
TotHard	205	573	484	209	4	340 - 792	67	76	32	4	46 - 122
CaHard	123	145	141	33	4	93 - 165	77	81	26	4	50 - 113
Turb	6.09	0.14	0.19	0	3	0.18 - 0.22	2.05	0.10	0.01	3	0 - 0
TOC	**2.9**	**11.5**	8.3	**6.1**	**4**	**2.5 - 16.8**	**0.4**	**0.6**	**0.3**	**4**	**0.3 - 1.0**
UV254	0.040	**0.148**	0.121	0.100	4	0.022 - 0.259	0.006	0.008	0.006	4	0.005 - 0.017
SUVA	1.28	**1.16**	**1.35**	0.31	4.00	0.89 - 1.54	1.68	1.24	0.57	4.00	0.75 - 1.80

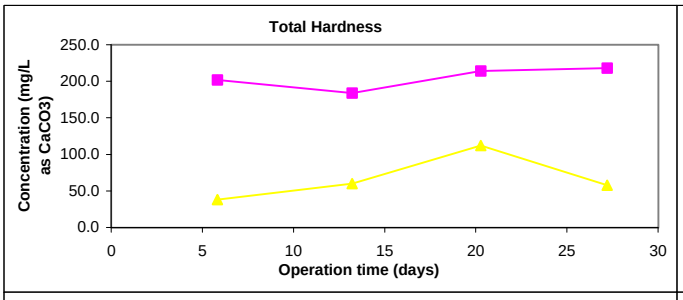
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage study.					
TDS											
TotHard											
CaHard		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

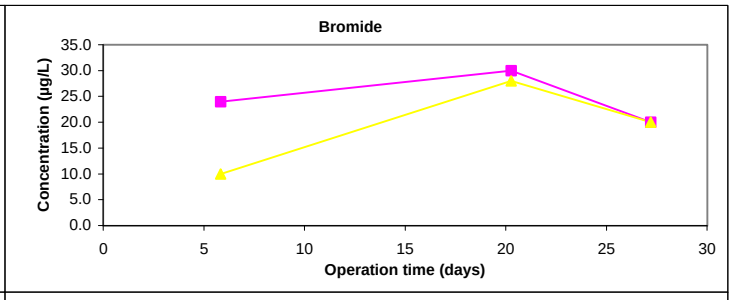
Chart Legend:
Feed (System)
Permeate (System)

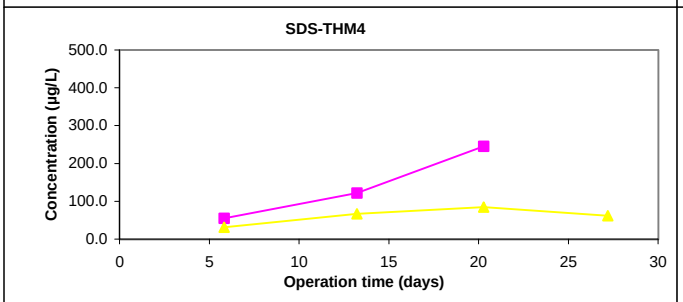
Water Quality Parameter Graphs

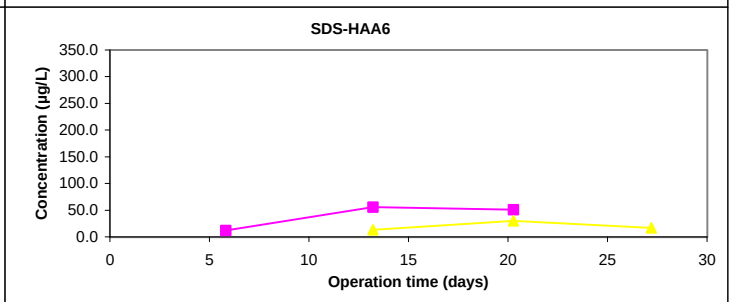


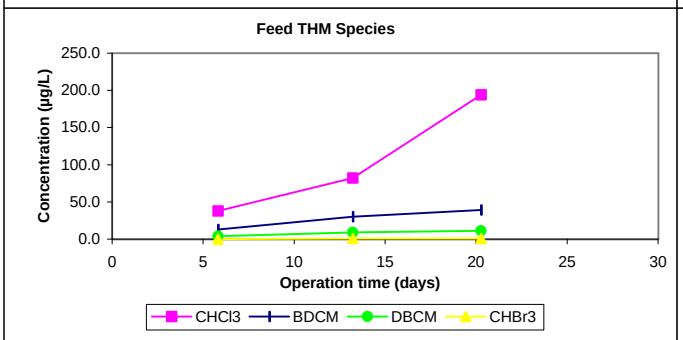
Water Quality Graphs (Continued)

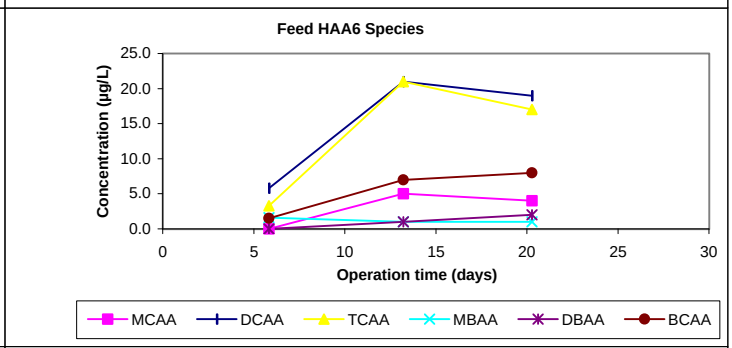


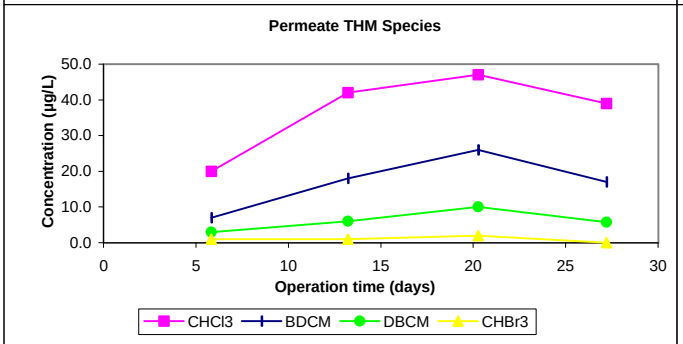


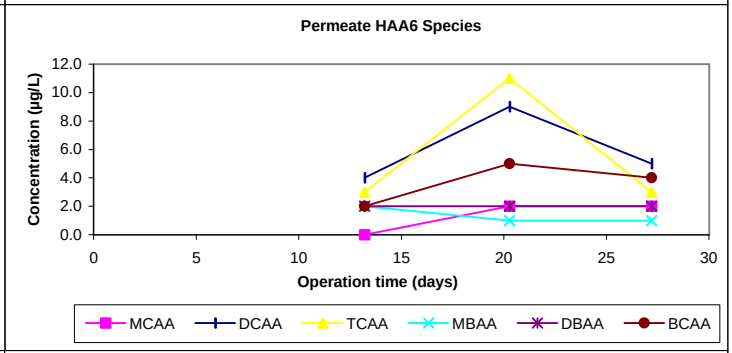


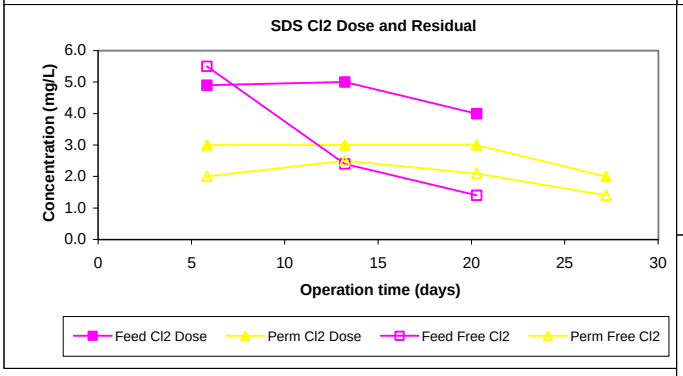


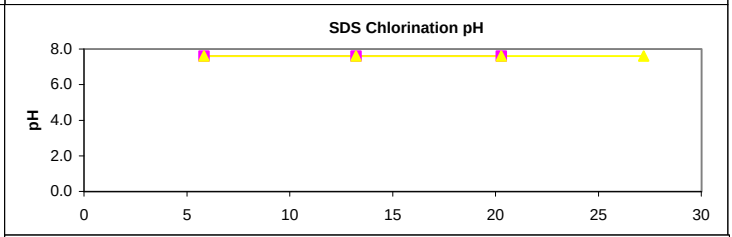


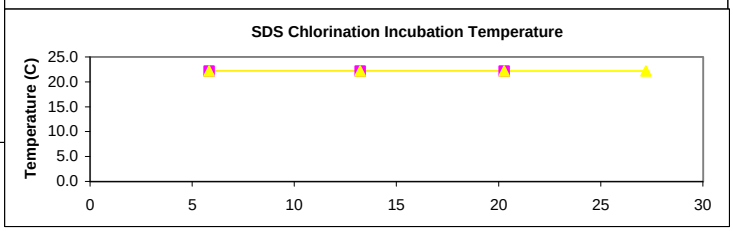




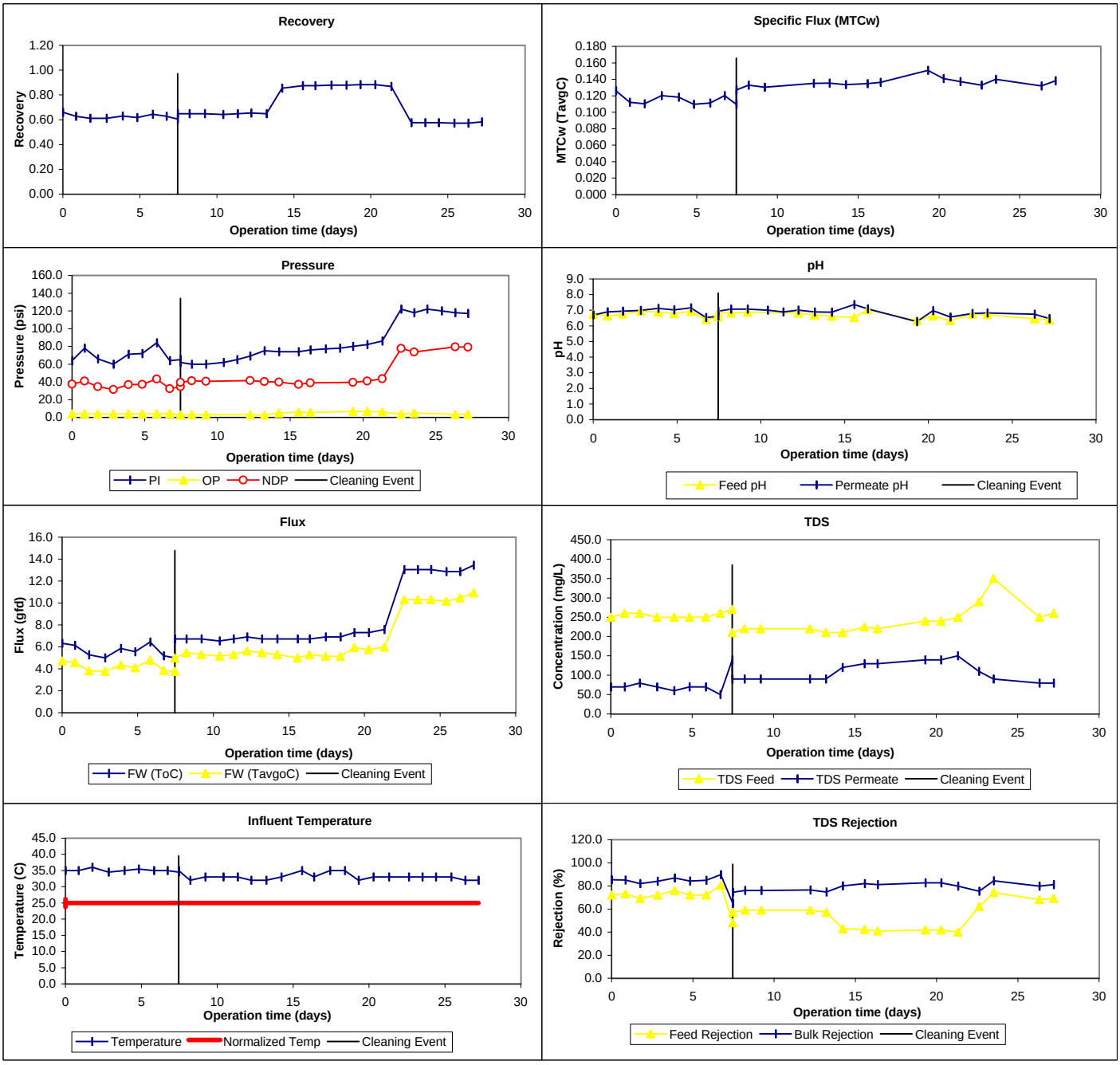








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 2

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 9/24/97 - 11/12/97 (49 days)

Membrane Information

Manufacturer:	Fluid Systems
Trade Name:	CALP
Membrane Model:	4231LP 4060
MWCO:	200 Daltons
Element Size:	4' x 60"
Element Area:	125.0 ft^2
Design Flux:	26.0 gfd
Mfr. NDP:	200.0 psi
Mfr. MTC_W:	0.130 (gfd/psi)
Mfr. Temp:	25.0 °C
Maximum Flow:	16.0 gpm
Minimum Flow:	11.3 gpm
Total Width :	19.3 ft
Feed Spacer Thickness:	0.0026 ft
840 Element Area	330.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 °C
Temp Norm MTC-w:	0.130 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 gfd
# of Elem in P.V.:	2
# Pres Ves in Stg 1:	2
# Pres Ves in Stg 2:	1
Pres Ves in Stg 3:	NA
Design Flux:	14.0 gfd
Recycle Ratio:	0.85
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.6	NA	1	6.6 - 6.6	6.4	NA	1	6.4 - 6.4	6.9	NA	1	6.9 - 6.9
Temp	29.0	NA	1	29.0 - 29.0	29.0	NA	1	29.0 - 29.0	29.0	NA	1	29.0 - 29.0
Alk	25	NA	1	25 - 25	17	NA	1	17 - 17	54	NA	1	54 - 54
TDS	**138**	**NA**	**1**	**138 - 138**	**33**	**NA**	**1**	**33 - 33**	**401**	**NA**	**1**	**401 - 401**
TotHard	86	NA	1	86 - 86	38	NA	1	38 - 38	250	NA	1	250 - 250
CaHard	60	NA	1	60 - 60	33	NA	1	33 - 33	85	NA	1	85 - 85
Turb	0.14	NA	1	0.14 - 0.14	0.06	NA	1	0.06 - 0.06	NA	NA	0	0.00 - 0.00
Amm	0.00	NA	1	0.00 - 0.00	0.00	NA	1	0.00 - 0.00	NA	NA	0	0.0 - 0.0
TOC	**2.3**	**NA**	**1**	**2.3 - 2.3**	**0.3**	**NA**	**1**	**0.3 - 0.3**	**7.9**	**NA**	**1**	**7.9 - 7.9**
UV254	0.036	NA	1	0.036 - 0.036	0.005	NA	1	0.005 - 0.005	0.121	NA	1	0.121 - 0.121
SUVA	1.56	NA	1	1.56 - 1.56	1.80	NA	1	1.80 - 1.80	1.53	NA	1	1.53 - 1.53
Bromide	**20**	**NA**	**1**	**20 - 20**	**20**	**NA**	**1**	**20 - 20**				
TOX	**80**	**NA**	**1**	**80 - 80**	**13**	**NA**	**1**	**13 - 13**				
CHCl3	60.0	NA	1	60.0 - 60.0	29.0	NA	1	29.0 - 29.0				
BDCM	10.0	NA	1	10.0 - 10.0	10.0	NA	1	10.0 - 10.0				
DBCM	4.0	NA	1	4.0 - 4.0	2.0	NA	1	2.0 - 2.0				
CHBr3	0.0	NA	1	0.0 - 0.0	0.0	NA	1	0.0 - 0.0				
THM4	**74.0**	**NA**	**1**	**74.0 - 74.0**	**41.0**	**NA**	**1**	**41.0 - 41.0**				
MCAA	7.0	NA	1	7.0 - 7.0	2.0	NA	1	2.0 - 2.0				
DCAA	32.0	NA	1	32.0 - 32.0	7.0	NA	1	7.0 - 7.0				
TCAA	29.0	NA	1	29.0 - 29.0	5.0	NA	1	5.0 - 5.0				
MBAA	2.0	NA	1	2.0 - 2.0	1.0	NA	1	1.0 - 1.0				
DBAA	3.0	NA	1	3.0 - 3.0	1.0	NA	1	1.0 - 1.0				
BCAA	12.0	NA	1	12.0 - 12.0	3.0	NA	1	3.0 - 3.0				
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	**73.0**	**NA**	**1**	**73.0 - 73.0**	**16.0**	**NA**	**1**	**16.0 - 16.0**				
HAA6	**85.0**	**NA**	**1**	**85.0 - 85.0**	**19.0**	**NA**	**1**	**19.0 - 19.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	1	8	n/a
TDS	1	-15	n/a
TotHard	1	6	n/a
CaHard	1	-70	n/a
Turb	0	n/a	n/a
Amm	0	n/a	n/a
TOC	1	-3	n/a
UV254	1	-8	n/a
TDSt	10	21	23

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.70	0.28	2	1.50 - 1.90
Temp (°C)	22.2	0.0	2	22.2 - 22.2
pH (unit)	7.6	0.0	2	7.6 - 7.6
Time (hr)	48.0	0.0	2	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
ZENON ULTRAFILTRATION	ZENON ZEEWEED UNIT	PILOT SCALE
5 MICRON FILTER	PARTICLE REMOVAL	PILOT SCALE
HYPERSPERSE AF200	ANTISCALENT	PILOT SCALE
HCL ADDITION	pH 4.5-6.5	PILOT SCALE

Mass Balance Errors

Pressure	**RPD**	**SD**	**Flow**	**RPD**	**SD**	**TDS**	**RPD**	**SD**
System Inf - Stg 1 Inf	0.0%	0.2%	System Inf - Stg 1 Inf	#VALUE!	#VALUE!	System Inf - Stg 1 Inf	-33.0%	13.3%
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%	0.2%	Stg 1 Conc - Stg 2 Inf	-38.3%	26.3%	Stg 1 Conc - Stg 2 Inf	0.0%	0.0%
Sys Perm - Avg Stg Perm	0.0%	0.2%	Sys Perm - Sum Stg Pe	-0.7%	1.9%	Sys Perm - Avg Stg Perm	#DIV/0!	#DIV/0!

Stage Summary

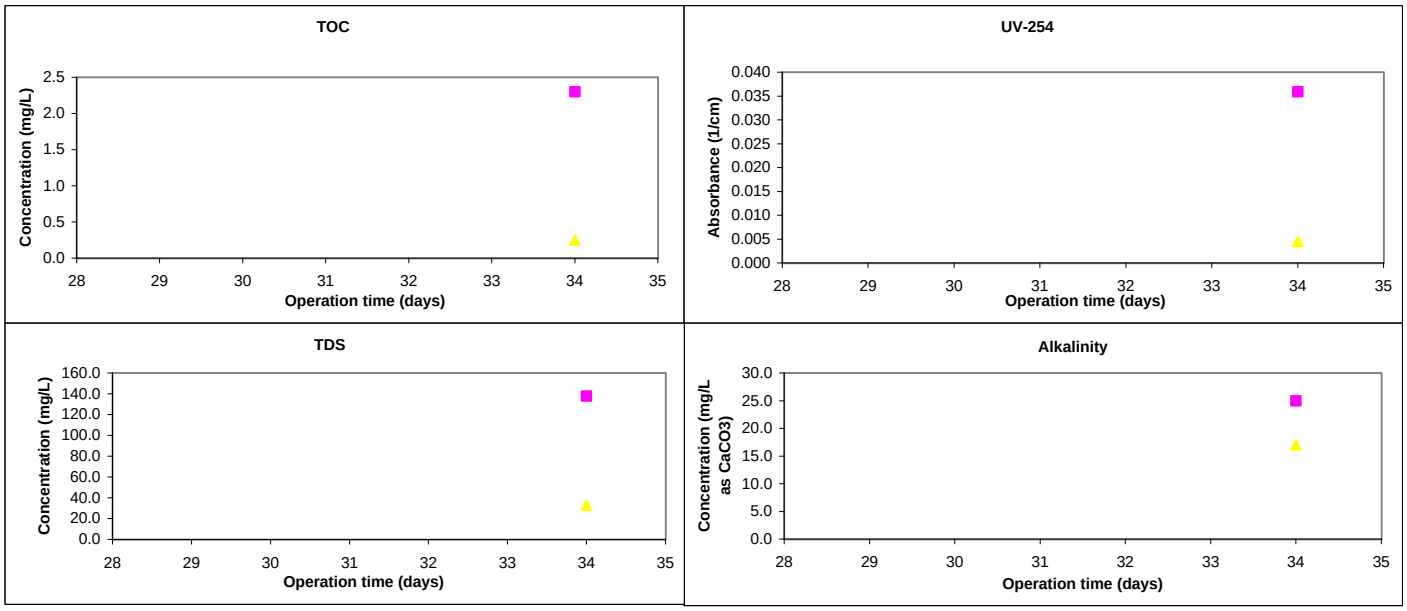
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**NA**	**NA**	**1**	**NA**					
pH	6.6	6.9	6.8	NA	1	6.8 - 6.8	6.4	6.4	NA	1	6.4 - 6.4
Temp	29.0	29.0	29.0	NA	1	29.0 - 29.0	29.0	29.0	NA	1	29.0 - 29.0
Alk	25	54	37	NA	1	37 - 37	17	16	NA	1	16 - 16
TDS	**138**	**401**	246	**NA**	**1**	**246 - 246**	**33**	**NA**	**NA**	**0**	**0 - 0**
TotHard	86	250	150	NA	1	150 - 150	38	20	NA	1	20 - 20
CaHard	60	85	75	NA	1	75 - 75	33	30	NA	1	30 - 30
Turb	0.14	NA	**0.12**	NA	1	0.12 - 0.12	0.06	0.07	NA	1	0 - 0
TOC	**2.3**	**7.9**	4.5	**NA**	**1**	**4.5 - 4.5**	**0.3**	**0.3**	**NA**	**1**	**0.3 - 0.3**
UV254	0.036	**0.121**	0.070	NA	1	0.070 - 0.070	0.005	0.005	NA	1	0.005 - 0.005
SUVA	1.56	**1.53**	1.55	NA	1	1.55 - 1.55	1.80	1.80	NA	1	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			**NA**	**NA**	**1**	**NA**					
pH	6.6	6.9	6.9	NA	1	6.9 - 6.9	6.4	6.5	NA	1	6.5 - 6.5
Temp	29.0	29.0	29.0	NA	1	29.0 - 29.0	29.0	29.0	NA	1	29.0 - 29.0
Alk	25	54	47	NA	1	47 - 47	17	21	NA	1	21 - 21
TDS	**138**	**401**	**NA**	**NA**	**0**	**0 - 0**	**33**	**NA**	**NA**	**0**	**0 - 0**
TotHard	86	250	216	NA	1	216 - 216	38	38	NA	1	38 - 38
CaHard	60	85	80	NA	1	80 - 80	33	35	NA	1	35 - 35
Turb	0.14	NA	**0.13**	NA	1	0.13 - 0.13	0.06	0.06	NA	1	0 - 0
TOC	**2.3**	**7.9**	6.3	**NA**	**1**	**6.3 - 6.3**	**0.3**	**0.6**	**NA**	**1**	**0.6 - 0.6**
UV254	0.036	**0.121**	0.101	NA	1	0.101 - 0.101	0.005	0.005	NA	1	0.005 - 0.005
SUVA	1.56	**1.53**	**1.60**	NA	1.00	1.60 - 1.60	1.80	0.75	NA	1.00	0.75 - 0.75

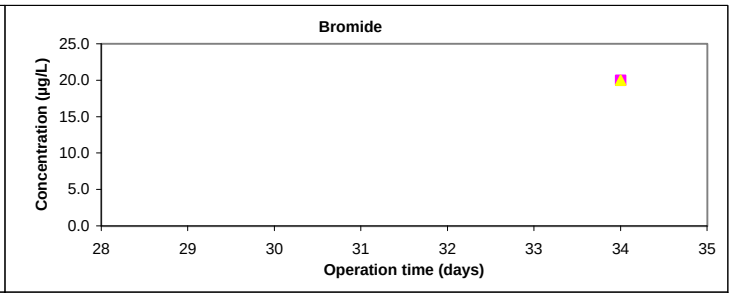
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage study.					
TDS											
TotHard											
CaHard		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

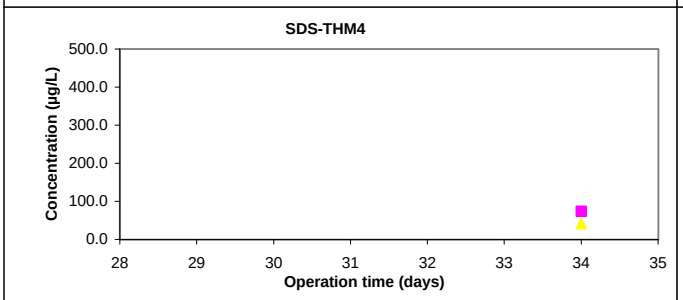
Chart Legend:
Feed (System)
Permeate (System)

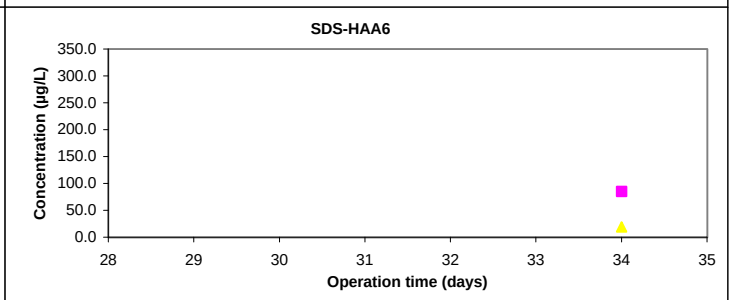
Water Quality Parameter Graphs

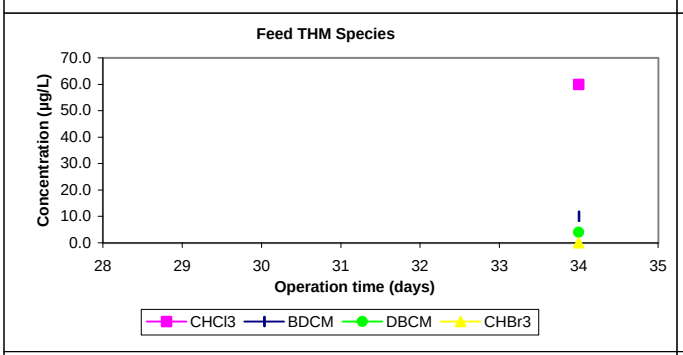


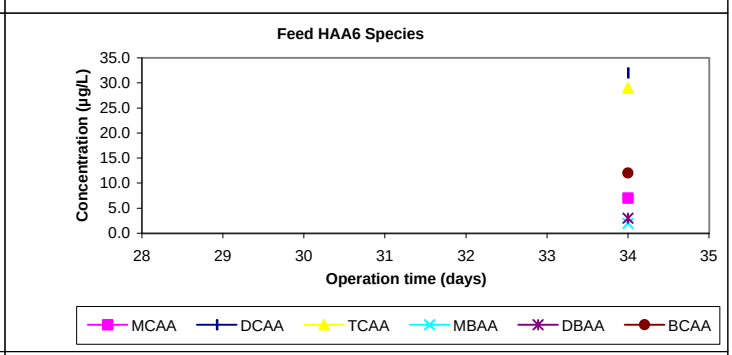
Water Quality Graphs (Continued)

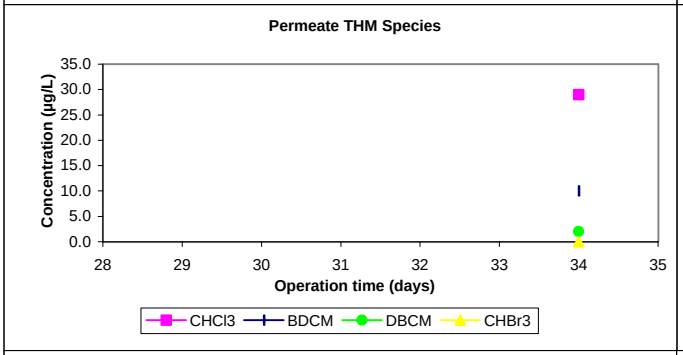


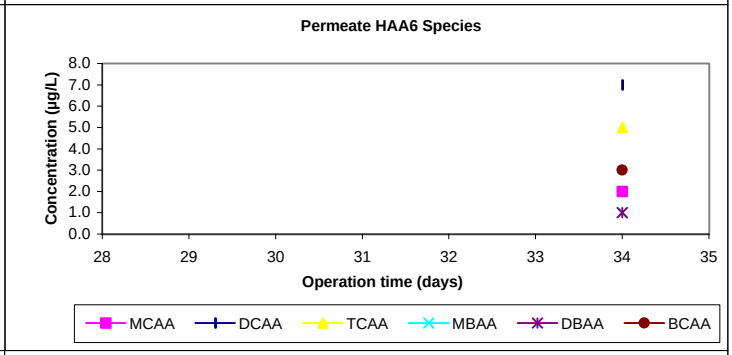


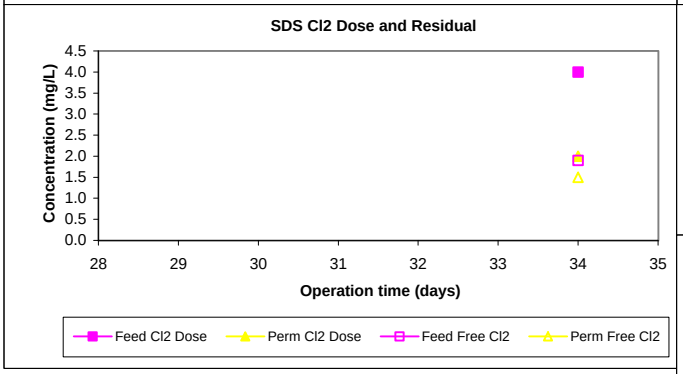


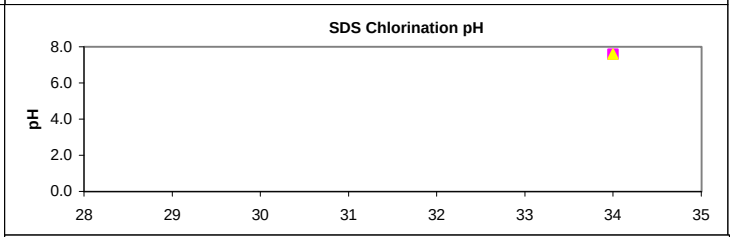


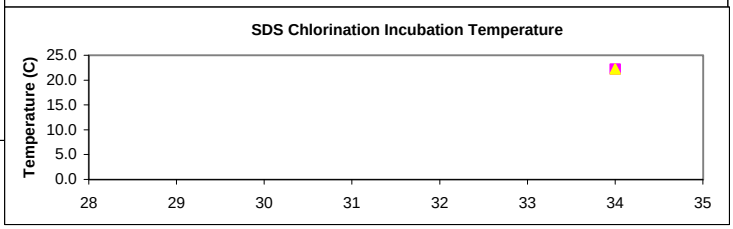




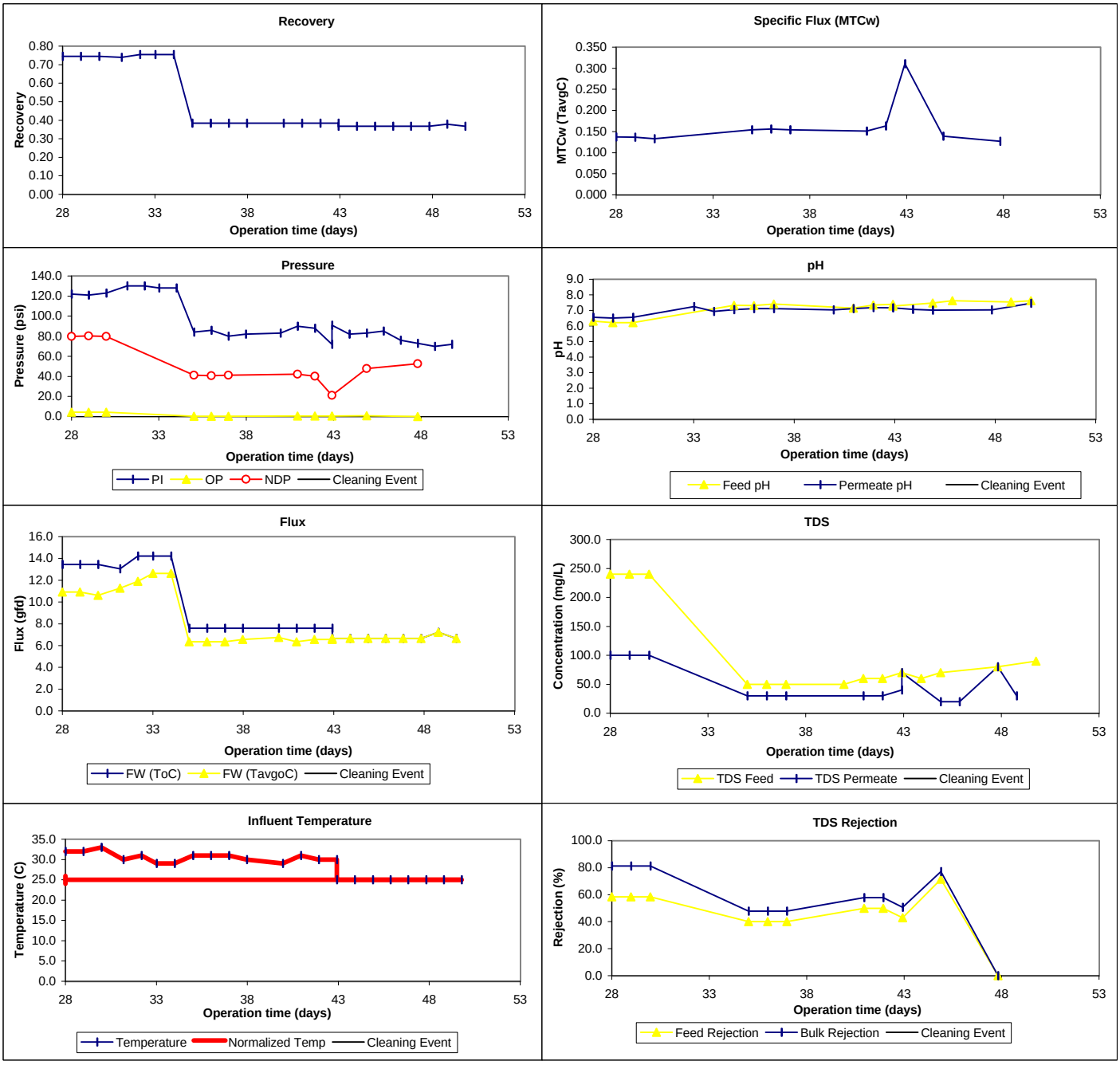








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 3

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 1/21/98 - 2/9/98 (19 days)

Membrane Information

Manufacturer:	Fluid Systems
Trade Name:	CALP
Membrane Model:	4231LP 4060
MWCO:	200 Daltons
Element Size:	4' x 60"
Element Area:	125.0 ft^2
Design Flux:	26.0 gfd
Mfr. NDP:	200.0 psi
Mfr. MTC_w:	0.130 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	11.3 gpm
Total Width :	19.3 ft
Feed Spacer Thickness:	0.0026 ft
840 Element Area	330.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.130 TavgC
Design Recovery:	0.85
Avg Sys Flux F_w:	14.0 gfd
# of Elem in P.V.:	2
# Pres Ves in Stg 1:	2
# Pres Ves in Stg 2:	1
Pres Ves in Stg 3:	NA
Design Flux:	14.0 gfd
Recycle Ratio:	0.28
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.0	0.6	2	5.6 - 6.4	5.7	0.4	2	5.4 - 6.0	6.1	0.7	2	5.6 - 6.6
Temp	17.5	2.1	2	16.0 - 19.0	21.5	0.7	2	21.0 - 22.0	21.5	0.7	2	21.0 - 22.0
Alk	24	13	2	15 - 34	8	5	2	4 - 12	46	35	2	21 - 70
TDS	**172**	**9**	**2**	**166 - 178**	**93**	**23**	**2**	**77 - 109**	**345**	**66**	**2**	**298 - 391**
TotHard	81	16	2	70 - 92	27	1	2	26 - 28	149	7	2	144 - 154
CaHard	61	3	2	59 - 64	21	1	2	20 - 21	128	11	2	120 - 136
Turb	0.14	0.0	2	0.13 - 0.14	0.09	0.0	2	0.09 - 0.09	NA	NA	0	0.00 - 0.00
Amm	1.15	0.21	2	1.00 - 1.30	1.00	0.00	2	1.00 - 1.00	2.00	NA	1	2.0 - 2.0
TOC	**16.6**	**1.1**	**2**	**15.9 - 17.4**	**0.8**	**0.1**	**2**	**0.7 - 0.8**	**46.7**	**0.6**	**2**	**46.3 - 47.1**
UV254	0.737	0.1	2	0.665 - 0.809	0.028	0.0	2	0.025 - 0.032	1.948	0.2	2	1.818 - 2.077
SUVA	4.42	0.33	2	4.18 - 4.66	3.78	0.27	2	3.59 - 3.97	4.17	0.34	2	3.93 - 4.41
Bromide	**55**	**64**	**2**	**10 - 100**	**10**	**0**	**2**	**10 - 10**				
TOX	**956**	**393**	**2**	**678 - 1234**	**13**	**0**	**2**	**13 - 13**				
CHCl3	511.5	321.7	2	284.0 - 739.0	6.5	0.7	2	6.0 - 7.0				
BDCM	25.5	0.7	2	25.0 - 26.0	2.8	0.4	2	2.5 - 3.0				
DBCM	0.5	0.7	2	0.0 - 1.0	1.0	0.0	2	1.0 - 1.0				
CHBr3	0.0	0.0	2	0.0 - 0.0	0.0	0.0	2	0.0 - 0.0				
THM4	**537.5**	**321.7**	**2**	**310.0 - 765.0**	**10.3**	**0.4**	**2**	**10.0 - 10.5**				
MCAA	61.1	12.6	2	52.3 - 70.0	4.0	1.4	2	3.0 - 5.0				
DCAA	816.0	132.9	2	722.0 - 910.0	18.8	6.0	2	14.5 - 23.0				
TCAA	1610.5	214.3	2	1459.0 - 1762.0	11.3	8.1	2	5.5 - 17.0				
MBAA	2.8	0.4	2	2.5 - 3.0	4.3	0.4	2	4.0 - 4.5				
DBAA	1.0	0.0	2	1.0 - 1.0	0.5	0.7	2	0.0 - 1.0				
BCAA	19.0	1.4	2	18.0 - 20.0	7.8	1.8	2	6.5 - 9.0				
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	**2491.4**	**360.1**	**2**	**2236.8 - 2746.0**	**38.8**	**15.9**	**2**	**27.5 - 50.0**				
HAA6	**2510.4**	**361.5**	**2**	**2254.8 - 2766.0**	**46.5**	**17.7**	**2**	**34.0 - 59.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	2	-38	29
TDS	2	5	17
TotHard	2	-31	27
CaHard	2	-7	2
Turb	0	n/a	n/a
Amm	1	8	n/a
TOC	2	2	3
UV254	2	-5	4
TDSt	10	5	6

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.88	0.25	4	1.50 - 2.00
Temp (^oC)	22.1	0.1	4	22.0 - 22.1
pH (unit)	7.6	0.0	4	7.6 - 7.6
Time (hr)	48.0	0.0	4	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
RAW WATER HILLSBOROUGH		
ZENON ULTRAFILTRATION	ZENON ZEEWEED UNIT	PILOT SCALE
5 MICRON FILTER	PARTICLE REMOVAL	PILOT SCALE
HYPERSPERSE AF200	ANTISCALENT	PILOT SCALE
HCL ADDITION	pH 4.5-6.5	PILOT SCALE
NAOCL + NH4CL ADDITION	AMINE .5-2.0 PPM RES.	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	-28.6%	3.5%
Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	0.0%	0.0%	Sys Conc - Stg 2 Conc	#DIV/0!	#DIV/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	#DIV/0!	#DIV/0!
Sys Perm - Avg Stg Perm	0.0%	0.0%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	#DIV/0!	#DIV/0!

Stage Summary

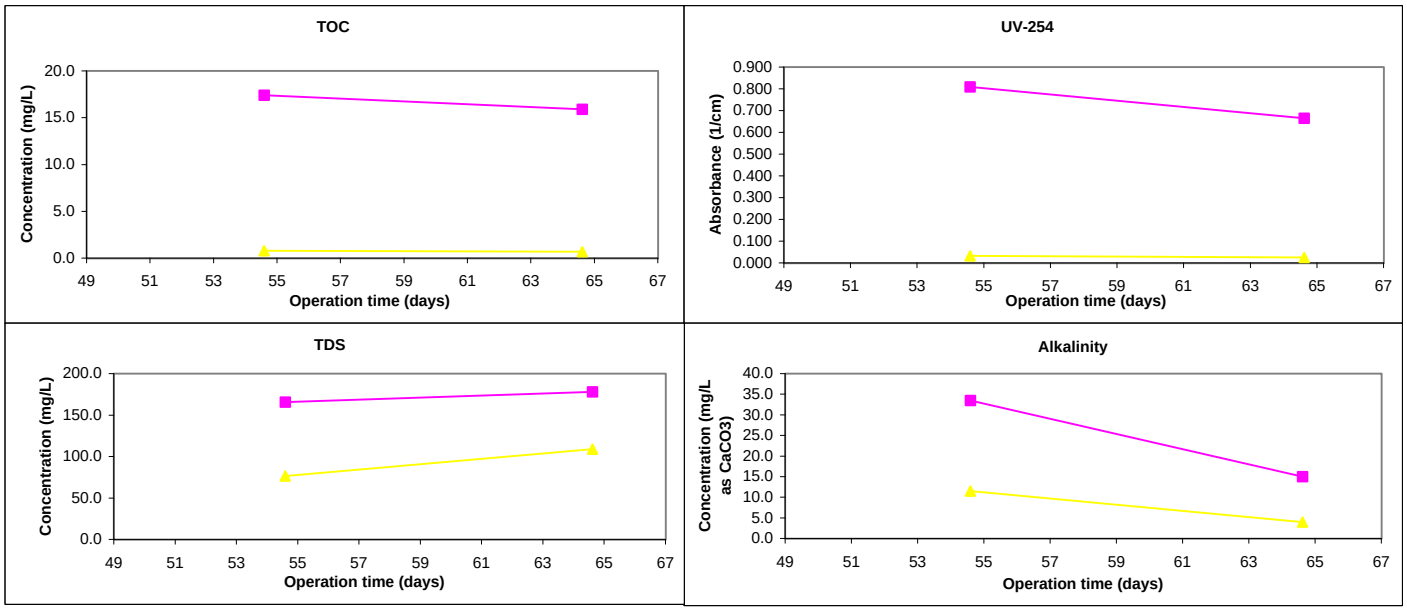
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.43**	**0.00**	**2**	**0.43 - 0.43**					
pH	6.0	6.1	6.0	0.6	2	5.6 - 6.4	5.7	5.7	0.4	2	5.5 - 6.0
Temp	17.5	21.5	21.5	0.7	2	21.0 - 22.0	21.5	21.5	0.7	2	21.0 - 22.0
Alk	24	46	30	18	2	17 - 42	8	8	4	2	5 - 10
TDS	**172**	**345**	215	**0**	**2**	**215 - 215**	**93**	**51**	**53**	**2**	**13 - 88**
TotHard	81	149	98	11	2	90 - 106	27	26	0	2	26 - 26
CaHard	61	128	79	6	2	75 - 83	21	18	1	2	18 - 19
Turb	0.14	NA	0.16	0	2	0.15 - 0.17	0.09	0.09	0.03	2	0 - 0
TOC	**16.6**	**46.7**	20.6	**6.6**	**2**	**15.9 - 25.2**	**0.8**	**1.0**	**0.1**	**2**	**0.9 - 1.1**
UV254	0.737	**1.948**	0.924	0.365	2	0.665 - 1.182	0.028	0.032	0.005	2	0.029 - 0.035
SUVA	4.42	**4.17**	**4.44**	0.36	2	4.18 - 4.69	3.78	3.32	0.84	2	2.72 - 3.91

	Stage 2 Influent						Stage 2 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.38**	**0.00**	**2**	**0.38 - 0.38**					
pH	6.0	6.1	6.0	0.7	2	5.5 - 6.5	5.7	5.7	0.5	2	5.4 - 6.0
Temp	17.5	21.5	21.5	0.7	2	21.0 - 22.0	21.5	21.5	0.7	2	21.0 - 22.0
Alk	24	46	36	28	2	16 - 55	8	8	5	2	**5 - 12**
TDS	**172**	**345**	305	**NA**	**1**	**305 - 305**	**93**	**87**	**12**	**2**	**78 - 95**
TotHard	81	149	126	20	2	112 - 140	27	29	4	2	26 - 31
CaHard	61	128	103	8	2	98 - 109	21	21	2	2	20 - 23
Turb	0.14	NA	0.24	0	2	0.22 - 0.26	0.09	0.08	0.00	2	0 - 0
TOC	**16.6**	**46.7**	33.8	**1.8**	**2**	**32.5 - 35.1**	**0.8**	**0.3**	**0.0**	**2**	**0.3 - 0.3**
UV254	0.737	**1.948**	1.509	0.222	2	1.353 - 1.666	0.028	0.013	0.001	2	0.012 - 0.013
SUVA	4.42	**4.17**	**4.45**	0.41	2.00	4.16 - 4.75	3.78	5.06	0.25	2.00	4.88 - 5.24

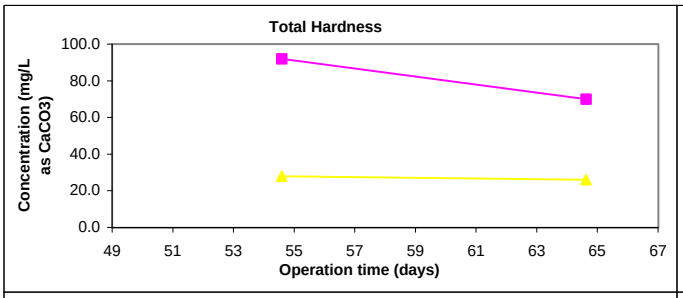
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage study.					
TDS											
TotHard											
CaHard		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

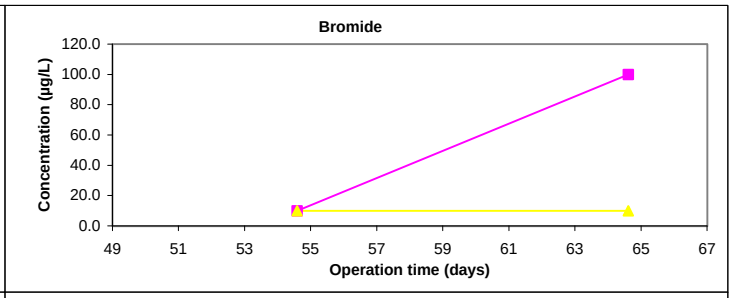
Chart Legend:
- Feed (System)
- Permeate (System)

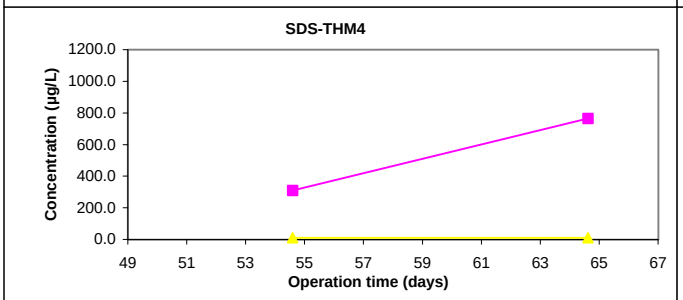
Water Quality Parameter Graphs

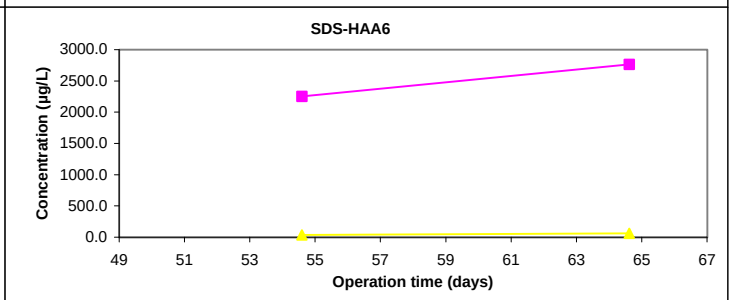


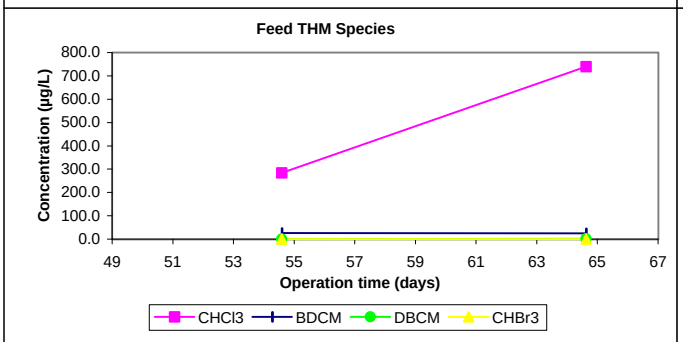
Water Quality Graphs (Continued)

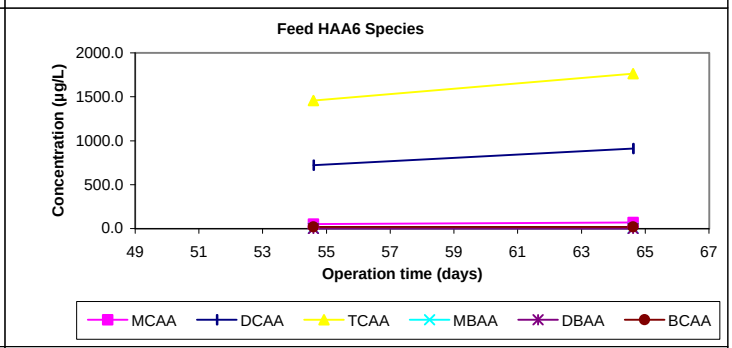


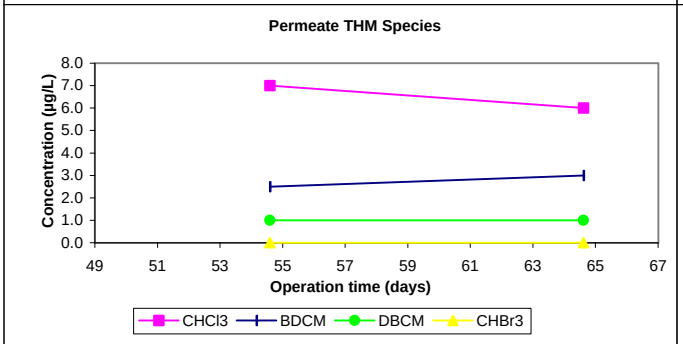


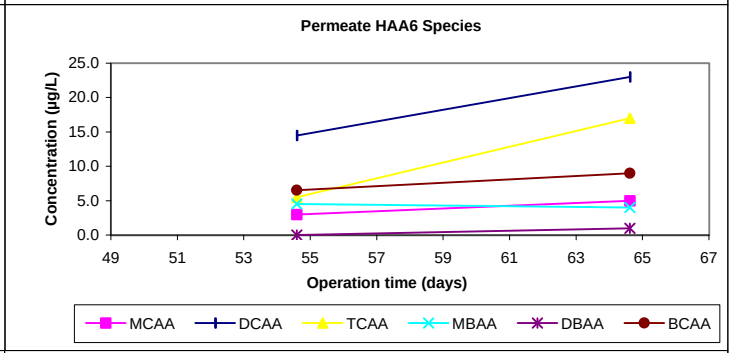


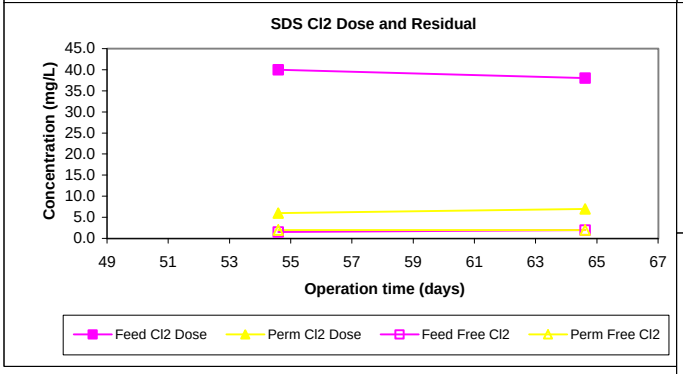


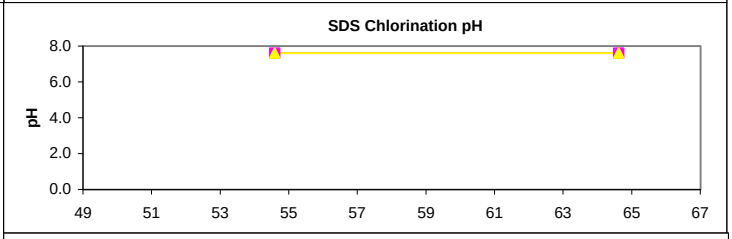


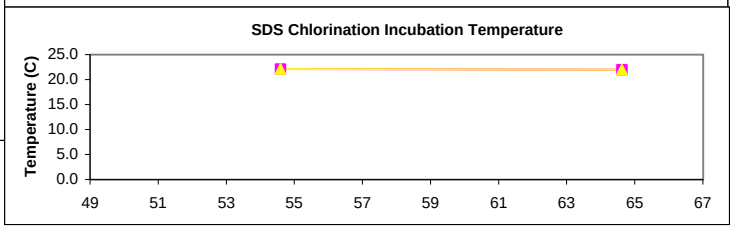




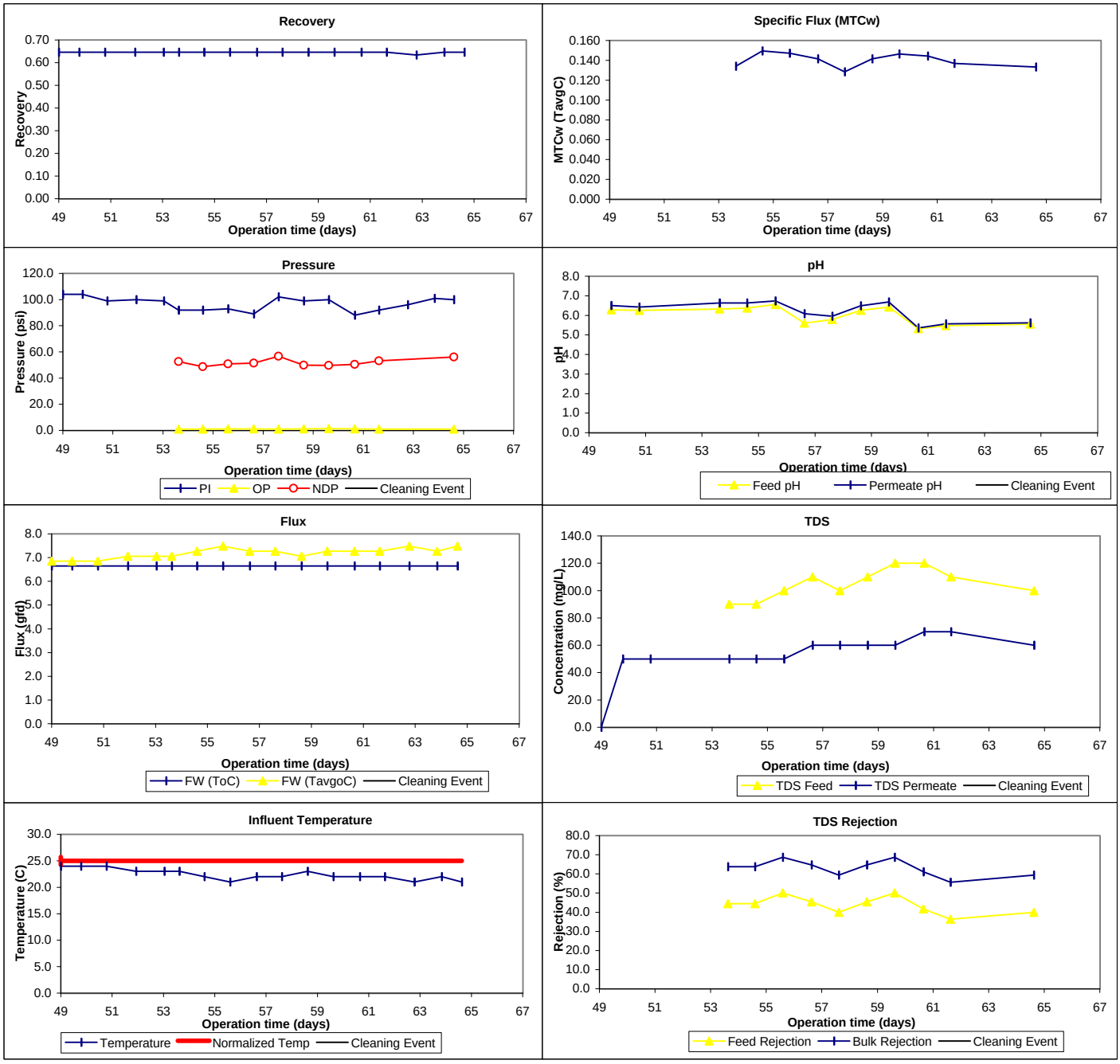








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 4

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 2/11/98 - 4/27/98 (75 days)

Membrane Information

Manufacturer:	Fluid Systems
Trade Name:	CALP
Membrane Model:	4231LP 4060
MWCO:	200 Daltons
Element Size:	4' x 60"
Element Area:	125.0 ft^2
Design Flux:	26.0 gfd
Mfr. NDP:	200.0 psi
Mfr. MTC_w:	0.130 (gfd/psi)
Mfr. Temp:	25.0 °C
Maximum Flow:	16.0 gpm
Minimum Flow:	11.3 gpm
Total Width :	19.3 ft
Feed Spacer Thickness:	0.0026 ft
840 Element Area	330.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 °C
Temp Norm MTC-w:	0.130 TavgC
Design Recovery:	0.85
Avg Sys Flux F_w:	14.0 gfd
# of Elem in P.V.:	2
# Pres Ves in Stg 1:	2
# Pres Ves in Stg 2:	1
Pres Ves in Stg 3:	NA
Design Flux:	14.0 gfd
Recycle Ratio:	0.43
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	4.4	2.9	4	0.1 - 6.0	5.6	0.2	5	5.2 - 5.8	6.3	0.2	5	6.2 - 6.6
Temp	19.8	1.5	5	18.0 - 22.0	25.8	0.8	5	25.0 - 27.0	25.8	0.8	5	25.0 - 27.0
Alk	24	15	5	15 - 51	8	4	5	6 - 16	78	77	5	34 - 215
TDS	**173**	**71**	**5**	**96 - 279**	**77**	**33**	**5**	**32 - 112**	**503**	**271**	**5**	**303 - 972**
TotHard	73	30	5	48 - 118	26	8	5	21 - 40	226	145	5	126 - 480
CaHard	56	22	5	38 - 88	20	8	5	15 - 33	175	109	5	98 - 366
Turb	0.14	0.0	5	0.13 - 0.16	0.09	0.0	5	0.06 - 0.11	NA	NA	0	0.00 - 0.00
Amm	0.77	0.75	5	0.00 - 1.70	0.84	0.52	5	0.00 - 1.32	1.47	0.85	5	0.2 - 2.6
TOC	**14.2**	**0.7**	**5**	**13.5 - 15.1**	**0.5**	**0.4**	**5**	**0.3 - 1.1**	**58.0**	**20.9**	**5**	**30.3 - 77.4**
UV254	0.629	0.1	5	0.536 - 0.681	0.029	0.0	5	0.014 - 0.043	2.733	0.9	5	1.718 - 3.500
SUVA	4.44	0.27	5	3.97 - 4.68	6.69	2.77	5	3.90 - 10.80	4.81	0.56	5	4.30 - 5.67
Bromide	**52**	**49**	**5**	**10 - 130**	**34**	**54**	**5**	**10 - 130**				
TOX	**779**	**130**	**5**	**668 - 1002**	**46**	**30**	**5**	**13 - 91**				
CHCl3	977.7	107.9	5	857.0 - 1136.5	43.4	35.8	5	11.0 - 100.0	**Mass Balance**			
BDCM	29.7	13.1	5	17.0 - 45.5	12.0	2.2	5	9.0 - 15.0	**Closure Errors (%)**			
DBCM	0.4	0.5	5	0.0 - 1.0	4.2	2.5	5	2.0 - 8.0	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	-26	30
THM4	**1007.8**	**114.4**	**5**	**881.0 - 1183.0**	**59.6**	**33.9**	**5**	**25.0 - 113.0**	TDS	5	-7	27
MCAA	61.6	21.1	5	38.0 - 92.0	0.0	0.0	5	0.0 - 0.0	TotHard	5	-13	12
DCAA	630.9	161.5	5	463.5 - 827.0	24.2	14.5	5	7.0 - 43.0	CaHard	5	-13	10
TCAA	1250.2	403.4	5	861.0 - 1795.0	33.0	24.7	5	8.0 - 61.0	Turb	0	n/a	n/a
MBAA	3.8	2.4	5	1.0 - 7.0	0.0	0.0	5	0.0 - 0.0	Amm	3	-8	62
DBAA	0.2	0.4	5	0.0 - 1.0	0.7	1.0	5	0.0 - 2.0	TOC	2	-16	6
BCAA	11.9	2.4	5	9.0 - 15.5	7.0	1.2	5	5.0 - 8.0	UV254	5	-11	9
TBAA	NA	NA	0	NA	NA	NA	0	NA				
CDBAA	NA	NA	0	NA	NA	NA	0	NA	TDSt	42	-5	39
DCBAA	NA	NA	0	NA	NA	NA	0	NA	**Comments:**			
HAA5	**1946.7**	**552.6**	**5**	**1400.5 - 2683.0**	**57.9**	**38.1**	**5**	**16.5 - 104.0**				
HAA6	**1958.6**	**552.2**	**5**	**1416.0 - 2695.0**	**64.9**	**38.7**	**5**	**21.5 - 111.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	2.16	0.92	10	0.10 - 3.50
Temp (°C)	22.2	0.0	10	22.2 - 22.2
pH (unit)	7.6	0.0	10	7.6 - 7.6
Time (hr)	48.0	0.0	10	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
ZENON ZEEWEED ULTRAFIL	ULTRAFILTRATION	PILOT SCALE
5 MICRON FILTER	PARTICLE REMOVAL	PILOT SCALE
HYPERSPERSE AF200	ANTISCALENT	PILOT SCALE
HCL ADDITION	pH 4.5-6.5	PILOT SCALE
NAOCL + NH4CL ADDITION	MONOCHLORAMINE .5-2.0 PPM RES.	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	-40.0%	55.8%
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	#DIV/0!	#DIV/0!
Sys Perm - Avg Stg Perm	0.0%	0.0%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	0.0%	7.0%

Stage Summary

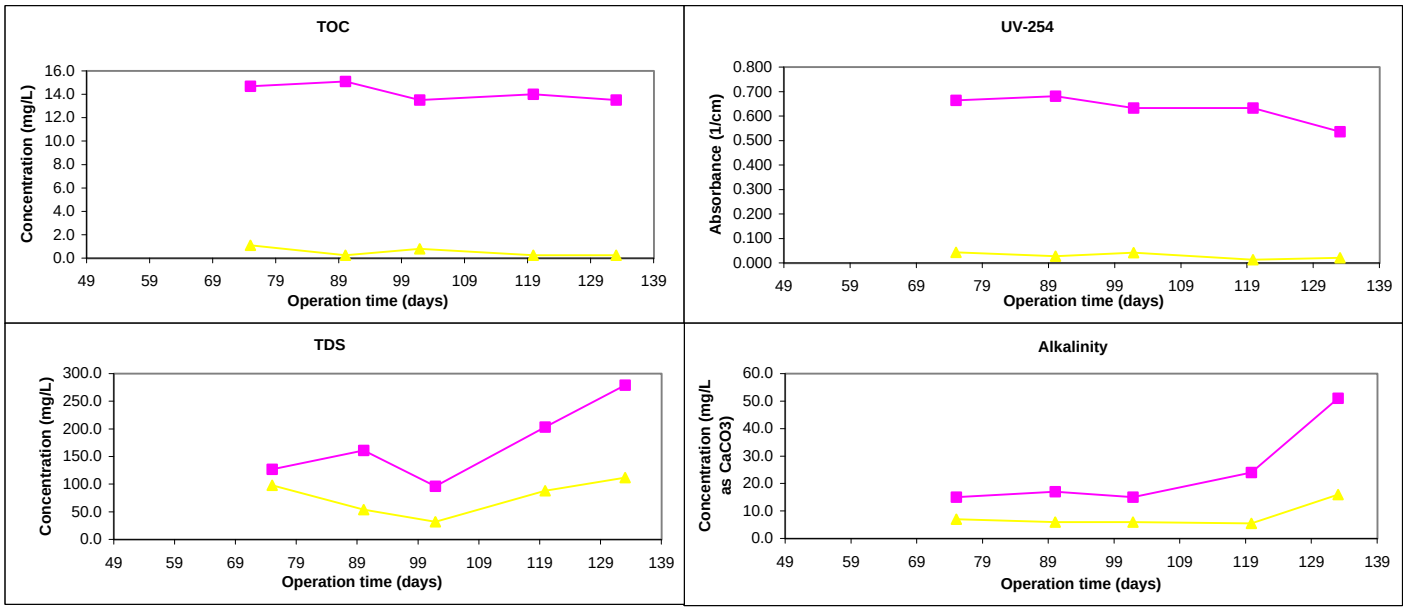
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.51**	**0.07**	**5**	**0.43 - 0.57**					
pH	4.4	6.3	6.1	0.2	5	5.8 - 6.4	5.6	5.6	0.2	5	5.2 - 5.8
Temp	19.8	25.8	25.2	1.9	5	22.0 - 27.0	25.8	25.2	1.9	5	22.0 - 27.0
Alk	24	78	46	47	5	22 - 129	8	10	5	5	6 - 16
TDS	**173**	**503**	311	**169**	**5**	**189 - 603**	**77**	**74**	**40**	**5**	**41 - 134**
TotHard	73	226	140	92	5	76 - 302	26	28	9	5	19 - 40
CaHard	56	175	100	74	5	34 - 225	20	17	8	5	7 - 30
Turb	0.14	NA	0.20	0	5	0.15 - 0.25	0.09	0.09	0.02	5	0 - 0
TOC	**14.2**	**58.0**	34.7	**11.3**	**5**	**18.6 - 44.8**	**0.5**	**0.9**	**0.5**	**5**	**0.3 - 1.4**
UV254	0.629	**2.733**	1.586	0.502	5	1.009 - 1.984	0.029	0.034	0.015	5	0.016 - 0.050
SUVA	4.44	**4.81**	4.62	0.60	5	3.88 - 5.43	6.69	4.11	1.27	5	3.29 - 6.36

	Stage 2 Influent						Stage 2 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.55**	**0.16**	**5**	**0.37 - 0.67**					
pH	4.4	6.3	6.3	0.2	5	6.0 - 6.5	5.6	5.6	0.2	5	5.2 - 5.8
Temp	19.8	25.8	25.2	1.9	5	22.0 - 27.0	25.8	25.2	1.9	5	22.0 - 27.0
Alk	24	78	63	62	5	27 - 173	8	8	5	5	**5 - 18**
TDS	**173**	**503**	398	**205**	**5**	**251 - 756**	**77**	**79**	**34**	**5**	**50 - 126**
TotHard	73	226	166	129	5	53 - 384	26	29	10	5	22 - 46
CaHard	56	175	140	80	5	80 - 280	20	22	9	5	18 - 38
Turb	0.14	NA	0.23	0	5	0.17 - 0.30	0.09	0.09	0.02	5	0 - 0
TOC	**14.2**	**58.0**	45.2	**15.6**	**5**	**24.3 - 62.6**	**0.5**	**0.3**	**0.2**	**5**	**0.3 - 0.7**
UV254	0.629	**2.733**	2.132	0.673	5	1.391 - 2.740	0.029	0.032	0.044	5	0.005 - 0.110
SUVA	4.44	**4.81**	4.80	0.62	5.00	4.12 - 5.72	6.69	11.68	18.05	5.00	1.80 - 43.84

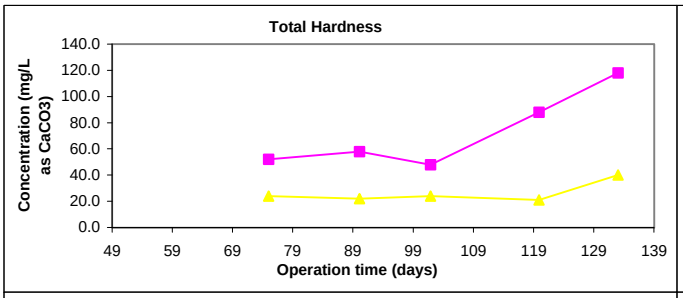
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

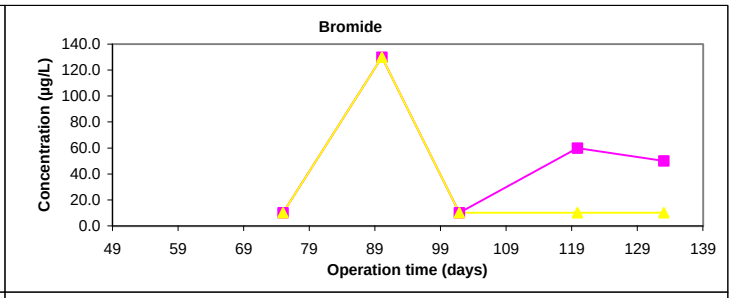
Chart Legend:
Feed (System)
Permeate (System)

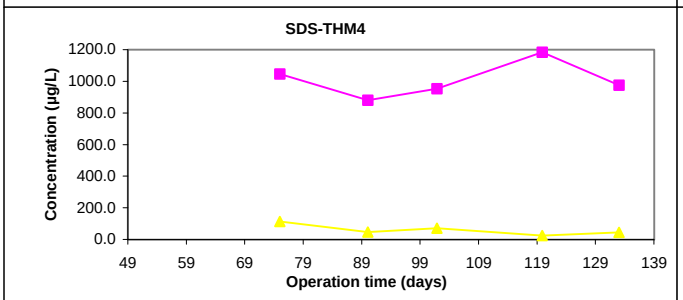
Water Quality Parameter Graphs

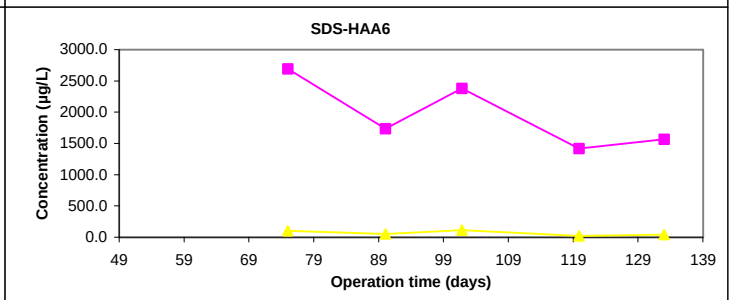


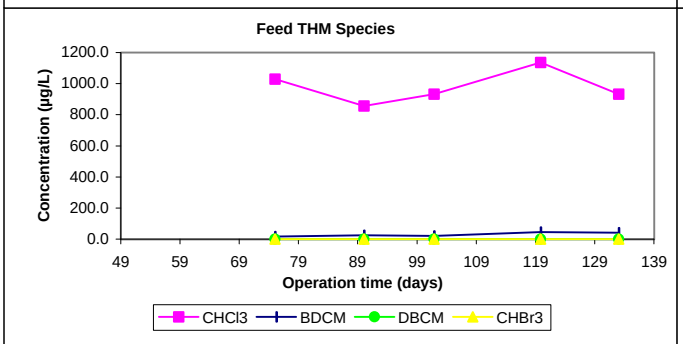
Water Quality Graphs (Continued)

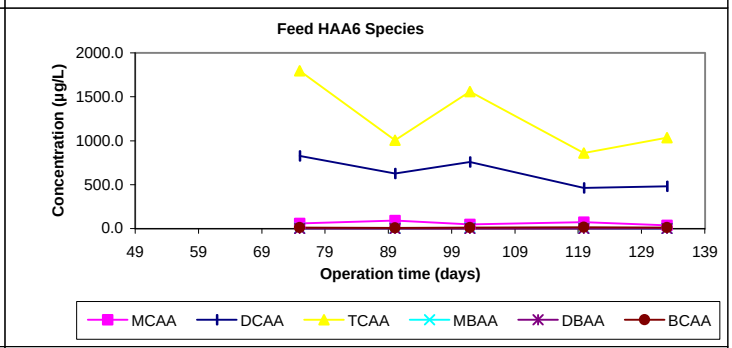


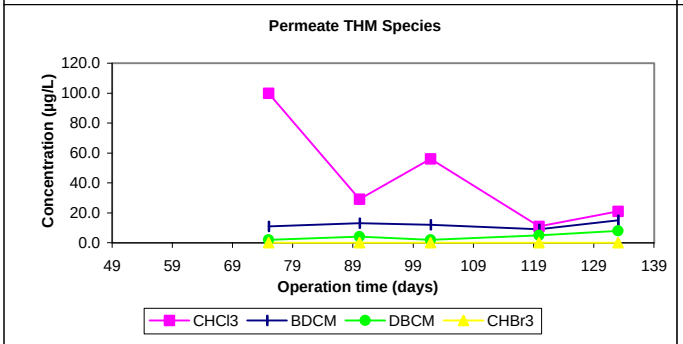


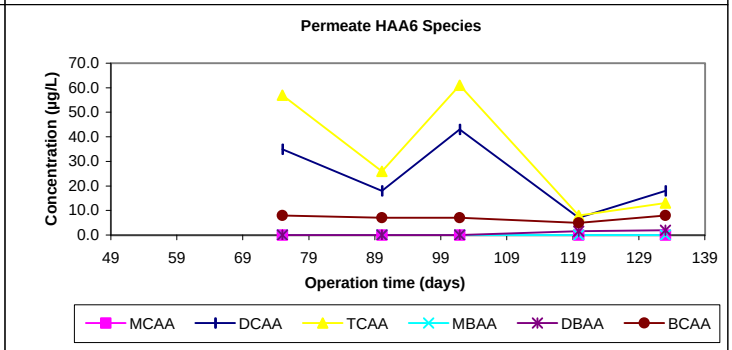


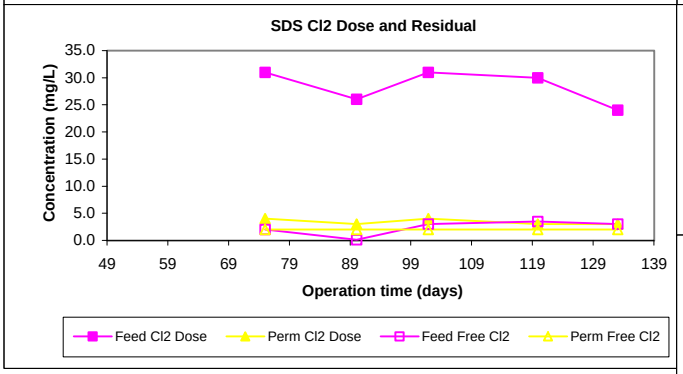


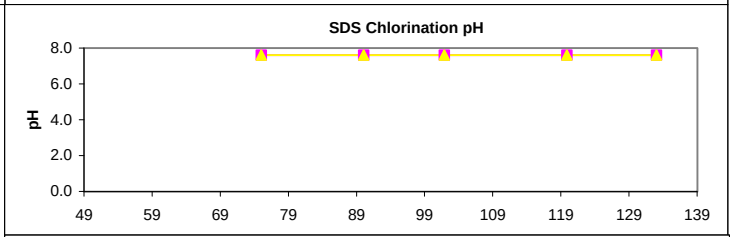


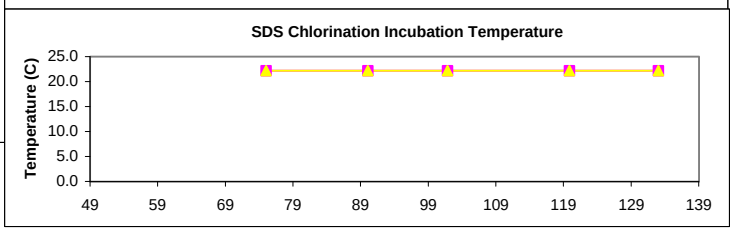




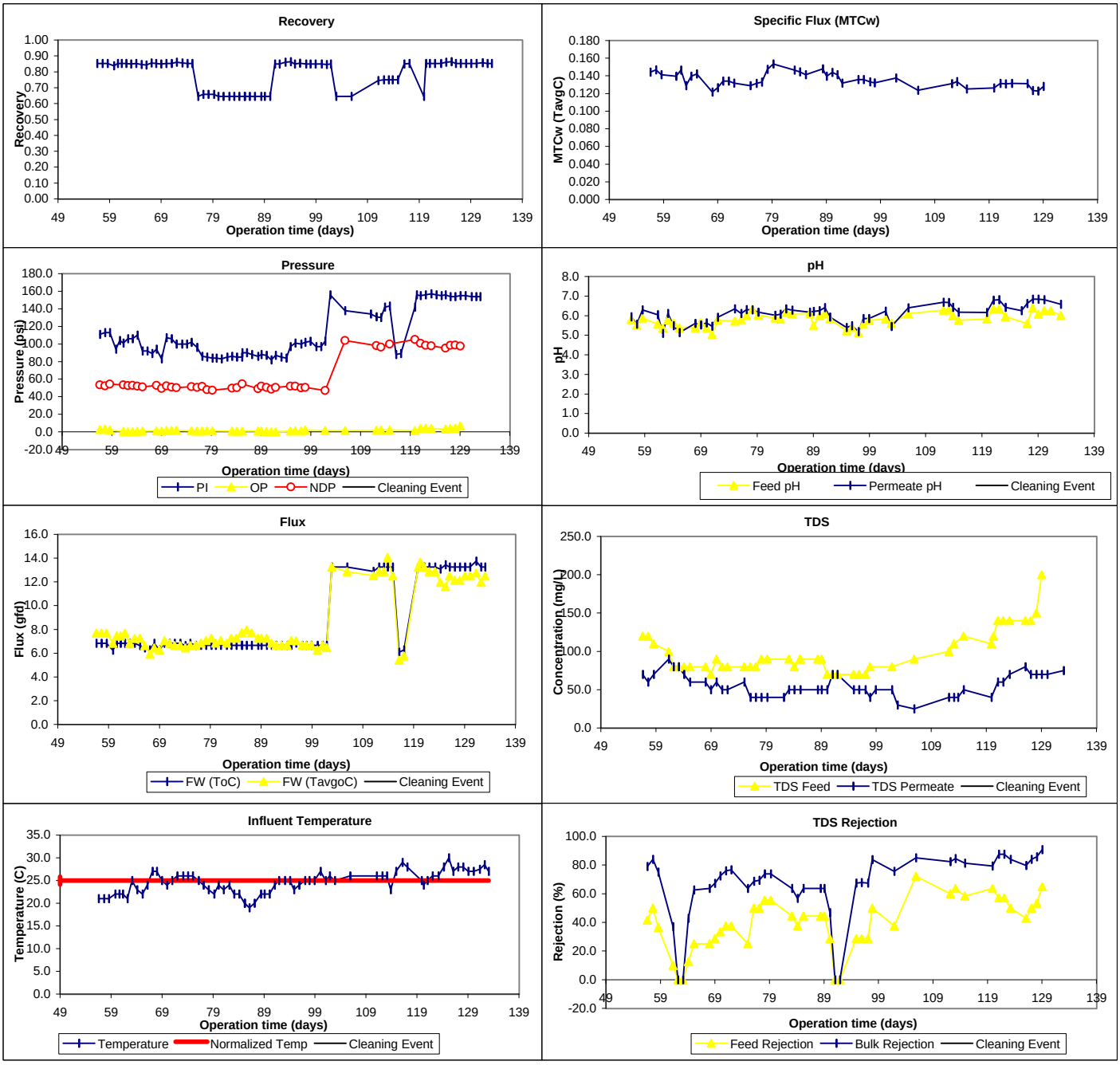








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 5

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 4/28/98 - 7/20/98 (83 days)

Membrane Information

Manufacturer: Fluid Systems
Trade Name: CALP
Membrane Model: 4231LP 4060
MWCO: 200 Daltons
Element Size: 4' x 60"
Element Area: 125.0 ft^2
Design Flux: 26.0 gfd
Mfr. NDP: 200.0 psi
Mfr. MTC_W: 0.130 (gfd/psi)
Mfr. Temp: 25.0 ^oC
Maximum Flow: 16.0 gpm
Minimum Flow: 11.3 gpm
Total Width : 19.3 ft
Feed Spacer Thickness: 0.0026 ft
840 Element Area 330.0 ft^2
840 Purchase Price: NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.130 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 gfd
# of Elem in P.V.:	2
# Pres Ves in Stg 1:	2
# Pres Ves in Stg 2:	1
Pres Ves in Stg 3:	NA
Design Flux:	14.0 gfd
Recycle Ratio:	0.43
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	5.9	0.6	4	5.3 - 6.6	5.7	0.5	5	5.1 - 6.3	6.2	0.8	5	5.0 - 7.0
Temp	27.4	1.5	5	25.0 - 29.0	34.2	1.5	5	32.0 - 36.0	34.2	1.5	5	32.0 - 36.0
Alk	47	28	5	9 - 85	23	14	5	4 - 41	137	105	5	5 - 290
TDS	**338**	**60**	**5**	**295 - 435**	**220**	**52**	**5**	**171 - 285**	**860**	**166**	**5**	**644 - 1042**
TotHard	165	16	5	140 - 185	79	21	5	52 - 100	377	88	5	282 - 500
CaHard	136	10	5	120 - 145	61	17	5	45 - 80	382	114	5	270 - 550
Turb	0.13	0.0	5	0.10 - 0.16	0.09	0.0	5	0.08 - 0.11	NA	NA	0	0.00 - 0.00
Amm	1.11	0.24	5	1.00 - 1.54	0.84	0.48	5	0.00 - 1.20	1.78	0.44	5	1.0 - 2.0
TOC	**5.7**	**3.2**	**5**	**2.9 - 10.7**	**0.4**	**0.1**	**5**	**0.3 - 0.5**	**18.7**	**8.8**	**5**	**7.4 - 29.5**
UV254	0.207	0.1	5	0.082 - 0.436	0.019	0.0	5	0.016 - 0.022	6.416	12.9	5	0.207 - 29.500
SUVA	3.48	0.45	5	2.84 - 4.08	5.98	2.06	5	3.12 - 7.80	23.10	43.00	5	2.79 - 100.00
Bromide	**26**	**22**	**5**	**10 - 50**	**10**	**0**	**5**	**10 - 10**				
TOX	**325**	**223**	**5**	**119 - 628**	**13**	**0**	**5**	**13 - 13**				
CHCl3	371.2	304.4	5	74.0 - 845.0	11.8	6.6	5	6.0 - 20.0				
BDCM	142.1	222.6	5	31.0 - 540.0	11.7	4.6	5	7.0 - 18.0				
DBCM	3.4	1.5	5	1.0 - 5.0	8.9	1.9	5	6.0 - 11.0				
CHBr3	0.0	0.0	5	0.0 - 0.0	1.1	0.7	5	0.0 - 2.0				
THM4	**516.7**	**414.2**	**5**	**110.0 - 1023.0**	**33.5**	**12.5**	**5**	**20.0 - 50.0**				
MCAA	11.5	15.3	5	0.0 - 38.0	0.0	0.0	5	0.0 - 0.0				
DCAA	150.7	98.3	5	43.0 - 292.0	8.2	3.2	5	6.0 - 13.0				
TCAA	163.9	150.9	5	41.0 - 408.0	4.9	3.5	5	2.0 - 10.0				
MBAA	1.9	1.2	5	1.0 - 4.0	0.0	0.0	5	0.0 - 0.0				
DBAA	0.0	0.0	5	0.0 - 0.0	2.8	0.8	5	2.0 - 4.0				
BCAA	12.5	1.7	5	10.0 - 14.0	6.1	1.7	5	5.0 - 9.0				
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	**328.0**	**262.3**	**5**	**85.0 - 740.0**	**15.9**	**6.6**	**5**	**11.0 - 25.0**				
HAA6	**340.5**	**263.7**	**5**	**95.0 - 754.0**	**22.0**	**7.3**	**5**	**16.0 - 30.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	5	-51	119
TDS	5	9	29
TotHard	5	-25	41
CaHard	5	0	9
Turb	0	n/a	n/a
Amm	4	34	32
TOC	2	-39	0
UV254	5	17	44
TDSt	48	-8	12

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.90	0.99	10	1.00 - 4.00
Temp (^oC)	22.2	0.0	10	22.2 - 22.2
pH (unit)	7.6	0.0	10	7.6 - 7.6
Time (hr)	48.0	0.0	10	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
MEMCOR DIRECTFLOW	MICROFILTRATION	PILOT SCALE
5 MICRON FILTER	PARTICLE REMOVAL	PILOT SCALE
HYPERSPERSE AF200	ANTISCALENT	PILOT SCALE
HCL ADDITION	pH 4.5-6.5	PILOT SCALE
NAOCL + NH4CL ADDITION	MONOCHLORAMINE .5-2.0 PPM RES.	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	-44.7%	16.6%
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	12.9%	19.8%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	-4.0%	20.9%

Stage Summary

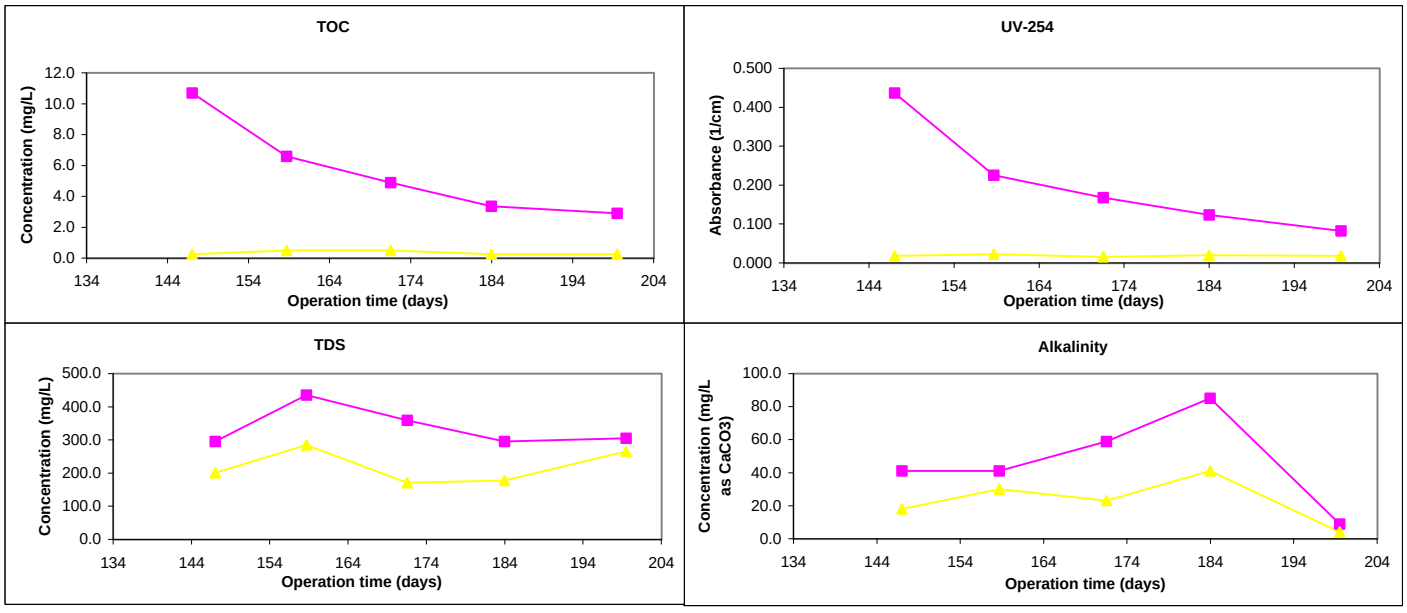
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.50**	**0.07**	**5**	**0.43 - 0.57**					
pH	5.9	6.2	6.0	0.7	5	4.9 - 6.8	5.7	5.7	0.5	5	5.0 - 6.3
Temp	27.4	34.2	34.2	1.5	5	32.0 - 36.0	34.2	34.2	1.5	5	32.0 - 36.0
Alk	47	137	91	69	5	7 - 194	23	21	13	5	6 - 37
TDS	**338**	**860**	569	**117**	**5**	**394 - 695**	**220**	**282**	**190**	**5**	**166 - 613**
TotHard	165	377	286	88	5	184 - 410	79	77	18	5	60 - 98
CaHard	136	382	244	89	5	155 - 375	61	62	13	5	48 - 75
Turb	0.13	NA	0.24	0	5	0.12 - 0.37	0.09	0.10	0.01	5	0 - 0
TOC	**5.7**	**18.7**	12.9	**6.3**	**5**	**4.4 - 20.9**	**0.4**	**0.3**	**0.2**	**5**	**0.3 - 0.6**
UV254	0.207	**6.416**	0.460	0.231	5	0.120 - 0.698	0.019	0.016	0.005	5	0.012 - 0.022
SUVA	3.48	**23.10**	3.49	0.57	5	2.74 - 4.20	5.98	5.52	1.60	5	3.73 - 8.04

	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**	**0.14**	**5**	**0.38 - 0.65**					
pH	5.9	6.2	6.2	0.7	5	5.1 - 6.9	5.7	5.7	0.6	5	4.9 - 6.4
Temp	27.4	34.2	34.2	1.5	5	32.0 - 36.0	34.2	34.2	1.5	5	32.0 - 36.0
Alk	47	137	114	87	5	5 - 242	23	25	15	5	**6 - 48**
TDS	**338**	**860**	661	**232**	**5**	**316 - 877**	**220**	**338**	**225**	**5**	**201 - 730**
TotHard	165	377	370	133	5	254 - 586	79	89	26	5	58 - 115
CaHard	136	382	311	102	5	190 - 458	61	74	16	5	55 - 90
Turb	0.13	NA	0.20	0	5	0.17 - 0.22	0.09	0.09	0.01	5	0 - 0
TOC	**5.7**	**18.7**	16.2	**7.6**	**5**	**5.8 - 26.6**	**0.4**	**0.3**	**0.0**	**5**	**0.3 - 0.3**
UV254	0.207	**6.416**	0.603	0.314	5	0.160 - 0.977	0.019	0.014	0.003	5	0.011 - 0.019
SUVA	3.48	**23.10**	3.59	0.54	5.00	2.76 - 4.20	5.98	5.49	1.35	5.00	4.44 - 7.68

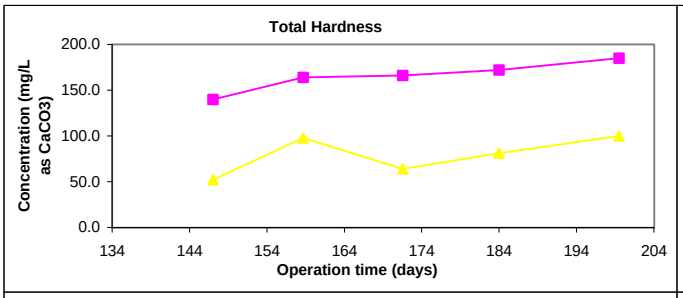
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

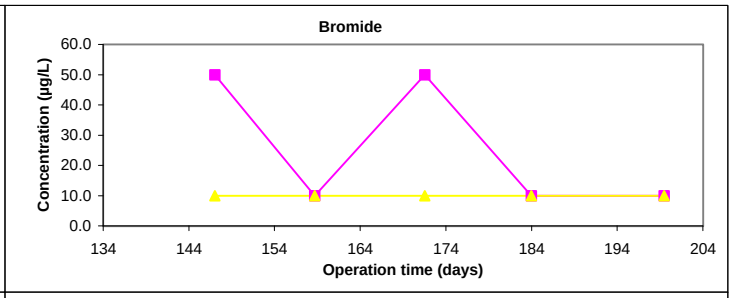
Chart Legend:
Feed (System)
Permeate (System)

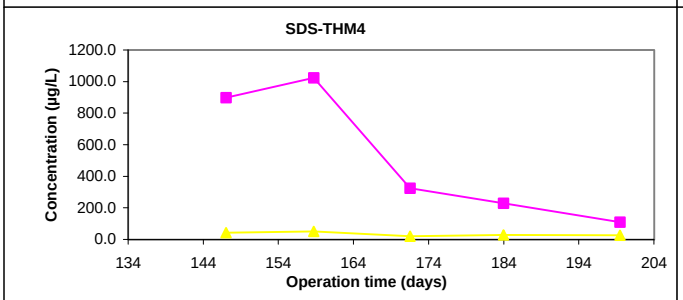
Water Quality Parameter Graphs

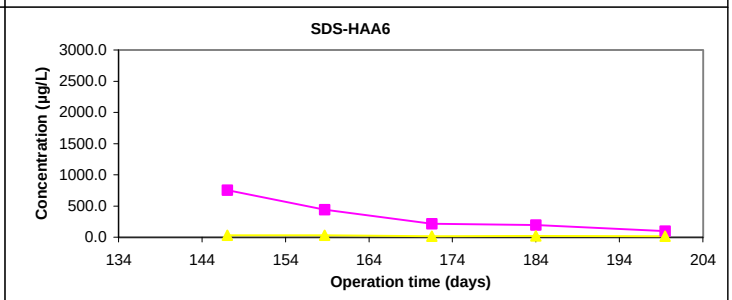


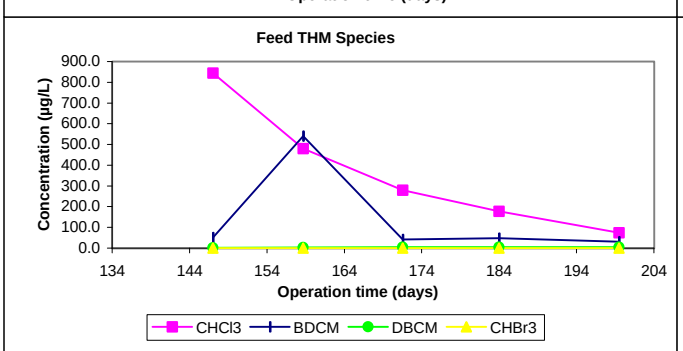
Water Quality Graphs (Continued)

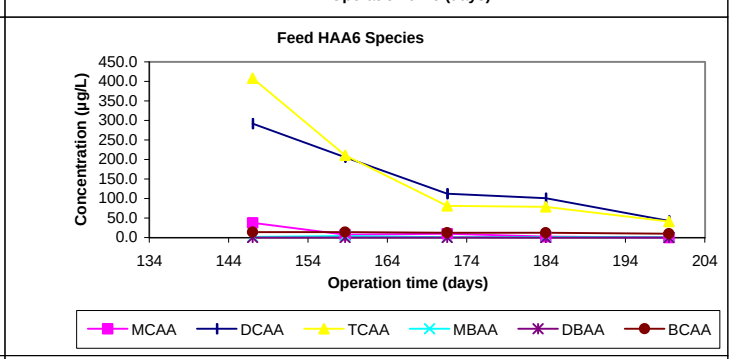


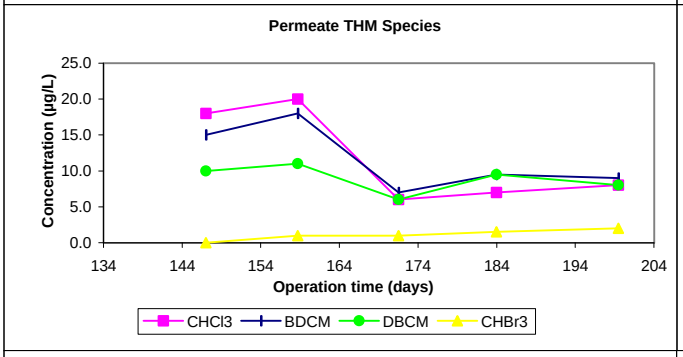


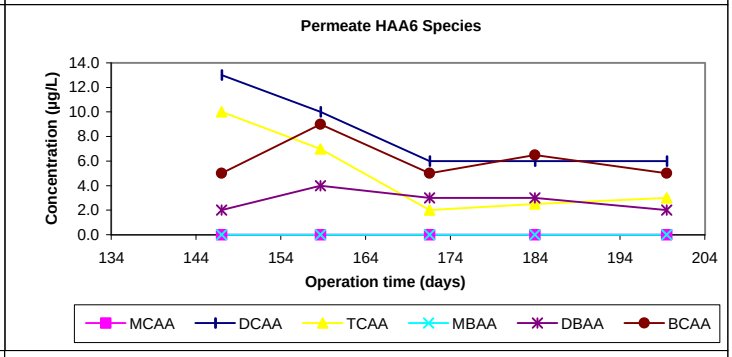


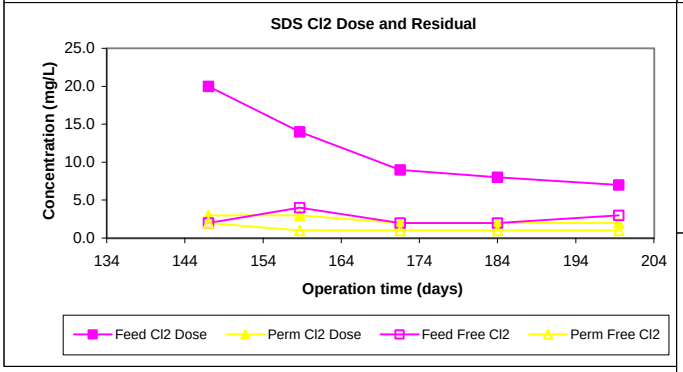


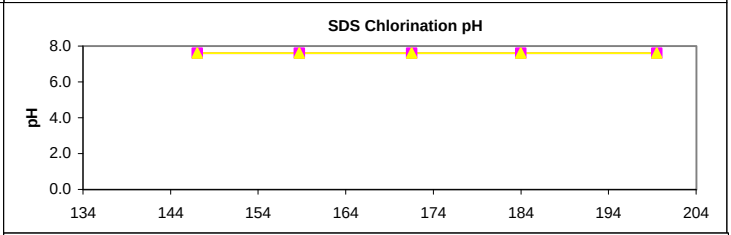


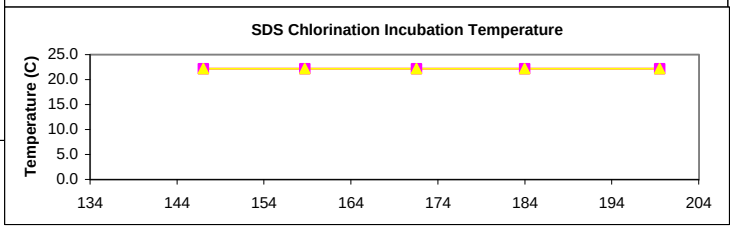




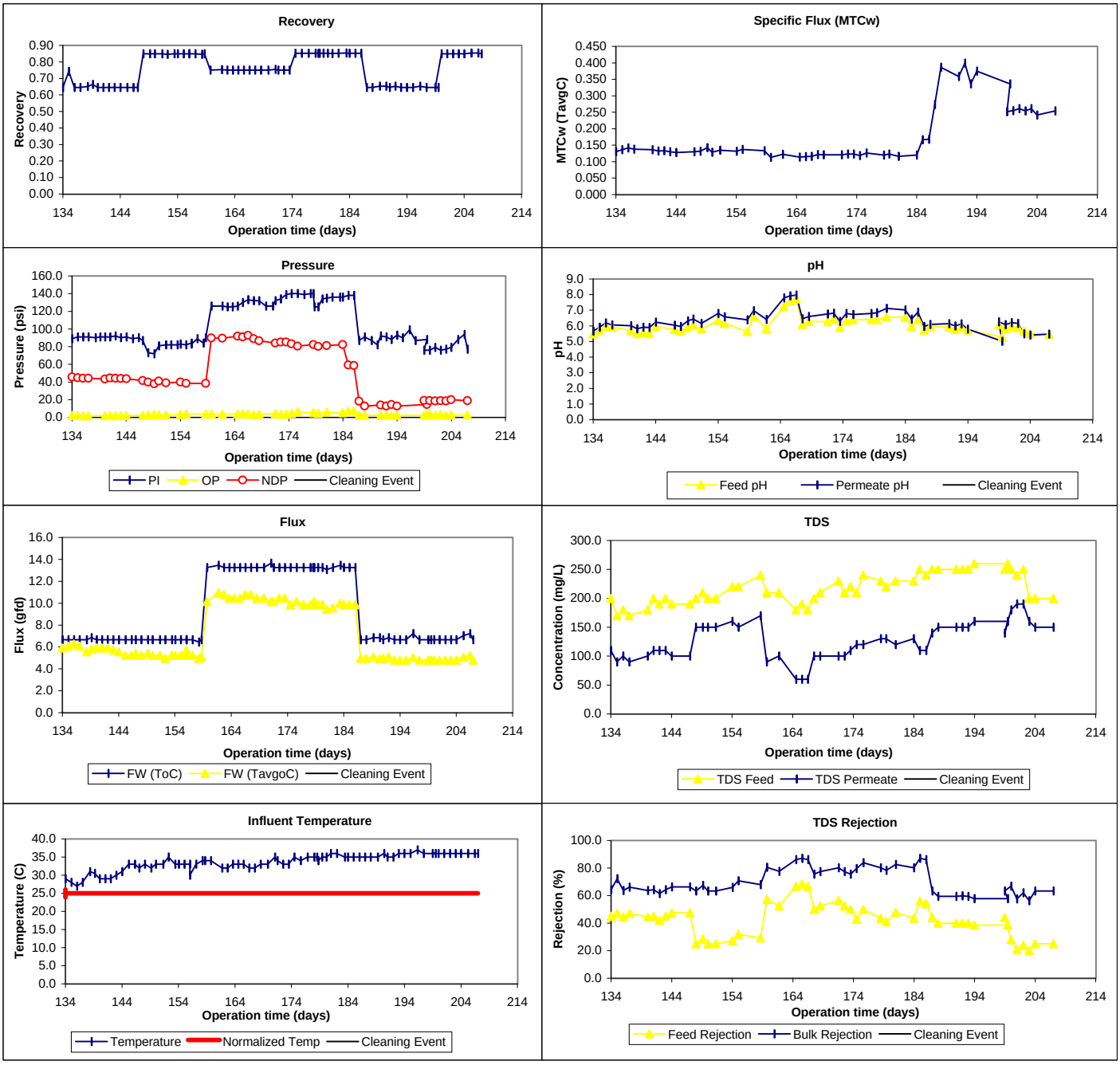








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 1

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 7/17/97 - 9/23/97 (68 days)

Membrane Information

Manufacturer:	Hydranautics
Trade Name:	ESNA
Membrane Model:	4040-UHA-ESNA
MWCO:	300-500 Daltons
Element Size:	4' x 40"
Element Area:	85.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	67.0 psi
Mfr. MTC_W:	0.300 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	4.0 gpm
Total Width :	15.0 ft
Feed Spacer Thickness:	0.0022 ft
840 Element Area	400.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.300 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 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:	14.0 gfd
Recycle Ratio:	0.27
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.4	0.2	5	6.1 - 6.6	6.1	0.1	5	6.0 - 6.3	7.0	0.1	5	6.9 - 7.2
Temp	29.8	1.8	5	29.0 - 33.0	33.5	0.7	5	32.5 - 34.0	33.5	0.7	5	32.5 - 34.0
Alk	61	7	5	51 - 70	14	5	5	11 - 24	182	63	5	131 - 290
TDS	**269**	**43**	**4**	**215 - 315**	**26**	**27**	**4**	**1 - 61**	**958**	**346**	**5**	**660 - 1551**
TotHard	192	21	5	158 - 210	19	10	5	10 - 36	611	161	5	448 - 880
CaHard	132	3	5	128 - 135	30	17	5	14 - 55	155	7	5	150 - 168
Turb	0.11	0.0	5	0.09 - 0.13	0.08	0.0	5	0.05 - 0.15	NA	NA	0	0.00 - 0.00
Amm	0.00	0.00	5	0.00 - 0.00	0.00	0.00	5	0.00 - 0.00	NA	NA	0	0.0 - 0.0
TOC	**3.0**	**1.1**	**5**	**1.3 - 4.0**	**0.3**	**0.0**	**5**	**0.3 - 0.3**	**10.6**	**7.3**	**5**	**3.3 - 22.5**
UV254	0.039	0.0	5	0.011 - 0.053	0.005	0.0	5	0.005 - 0.005	0.150	0.1	5	0.030 - 0.333
SUVA	1.24	0.27	5	0.80 - 1.46	1.80	0.00	5	1.80 - 1.80	1.34	0.25	5	0.90 - 1.48
Bromide	**22**	**18**	**5**	**10 - 51**	**18**	**18**	**5**	**10 - 50**				
TOX	**73**	**12**	**5**	**58 - 89**	**13**	**0**	**5**	**13 - 13**				
CHCl3	54.2	17.1	5	39.0 - 83.0	33.4	10.4	5	19.0 - 46.0	**Mass Balance**			
BDCM	22.2	8.8	5	13.0 - 36.0	11.0	4.8	5	5.0 - 18.0	**Closure Errors (%)**			
DBCM	6.4	3.4	5	3.0 - 10.0	3.6	2.3	5	1.0 - 7.0	WQP	Count	Avg	SD/RD
CHBr3	0.6	0.9	5	0.0 - 2.0	0.4	0.5	5	0.0 - 1.0	Alk	5	-5	5
THM4	**83.4**	**28.6**	**5**	**56.0 - 131.0**	**48.4**	**16.5**	**5**	**25.0 - 69.0**	TDS	4	0	0
MCAA	2.0	1.4	5	0.0 - 4.0	0.0	0.0	5	0.0 - 0.0	TotHard	5	-10	12
DCAA	15.6	5.7	5	5.9 - 21.0	1.2	0.9	5	0.0 - 2.1	CaHard	5	-162	62
TCAA	13.9	7.5	5	3.5 - 23.0	0.2	0.4	5	0.0 - 1.0	Turb	0	n/a	n/a
MBAA	1.4	0.9	5	0.0 - 2.1	0.6	0.9	5	0.0 - 2.0	Amm	0	n/a	n/a
DBAA	0.6	0.9	5	0.0 - 2.0	0.0	0.0	5	0.0 - 0.0	TOC	4	-13	9
BCAA	3.5	1.8	5	1.6 - 6.0	0.8	0.8	5	0.0 - 2.0	UV254	5	-7	9
TBAA	NA	NA	0	NA	NA	NA	0	NA				
CDBAA	NA	NA	0	NA	NA	NA	0	NA	TDSt	49	-36	58
DCBAA	NA	NA	0	NA	NA	NA	0	NA	**Comments:**			
HAA5	**33.5**	**13.7**	**5**	**11.5 - 48.0**	**2.0**	**1.2**	**5**	**0.0 - 3.0**				
HAA6	**37.0**	**14.7**	**5**	**13.1 - 52.0**	**2.8**	**1.1**	**5**	**2.0 - 4.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.83	0.52	10	1.00 - 2.60
Temp (^oC)	22.0	0.0	10	22.0 - 22.0
pH (unit)	7.6	0.0	10	7.6 - 7.6
Time (hr)	48.0	0.0	10	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
COAGULATION	100-120 mg/L Fe2(SO4)3 as 12% Fe+3	Full Scale
FLOCCULATION	4-stage	Full Scale
SEDIMENTATION	rectanglular basin (4)	Full Scale
DUAL MEDIA FILTRATION	sand/anthracite	Full Scale
SULFURIC ACID ADDITION	pH= 4.0-4.6	Full Scale
POLYMER ADDITION	non-ionic polymer	Full Scale
LIME ADDITION	36 mg/L	Full Scale
GAC REMOVE CHLORINE RESIDUAL	NA	Pilot Scale
HYPERSPERSE AF200	ntiscalent	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	-40.5%	55.9%
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	#DIV/0!	#DIV/0!
Sys Perm - Avg Stg Perm	0.0%	0.0%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	3.0%	34.2%

TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 1

Stage Summary

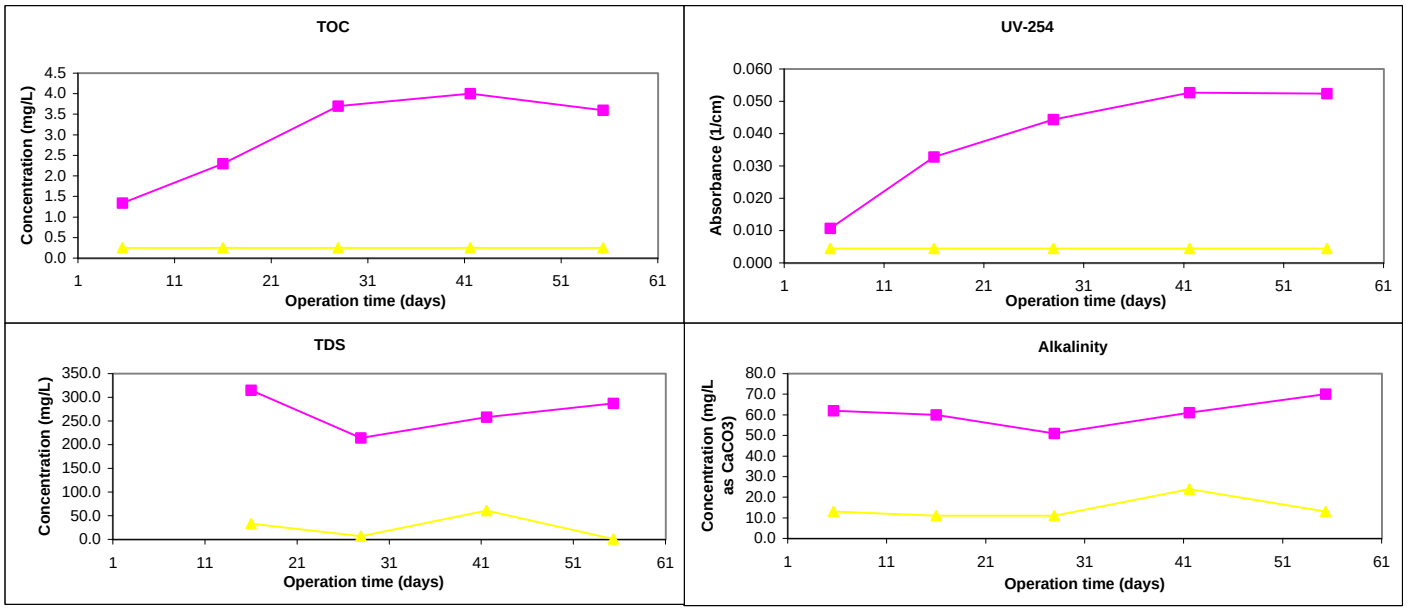
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**NA**	**NA**	**5**	**NA**					
pH	6.4	7.0	6.8	0.2	5	6.5 - 7.0	6.1	6.0	0.2	4	5.8 - 6.3
Temp	29.8	33.5	33.5	0.7	5	32.5 - 34.0	33.5	33.5	0.7	5	32.5 - 34.0
Alk	61	182	105	35	5	76 - 165	14	16	6	5	12 - 27
TDS	**269**	**958**	**NA**	**NA**	**0**	**0 - 0**	**26**	**NA**	**NA**	**0**	**0 - 0**
TotHard	192	611	362	126	5	250 - 580	19	22	8	5	14 - 36
CaHard	132	155	143	10	5	128 - 155	30	35	15	5	23 - 60
Turb	0.11	NA	0.14	0	5	0.10 - 0.24	0.08	0.06	0.01	4	0 - 0
TOC	**3.0**	**10.6**	5.8	**3.9**	**5**	**2.0 - 12.3**	**0.3**	**0.3**	**0.0**	**5**	**0.3 - 0.3**
UV254	0.039	**0.150**	0.075	0.064	5	0.018 - 0.182	0.005	0.005	0.000	5	0.005 - 0.005
SUVA	1.24	**1.34**	**1.21**	0.36	5	0.77 - 1.48	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			**NA**	**NA**	**5**	**NA**					
pH	6.4	7.0	6.9	0.1	4	6.8 - 7.1	6.1	5.9	0.1	4	5.8 - 6.1
Temp	29.8	33.5	33.5	0.7	5	32.5 - 34.0	33.5	33.5	0.7	5	32.5 - 34.0
Alk	61	182	139	48	5	99 - 221	14	13	4	5	**10 - 20**
TDS	**269**	**958**	**NA**	**NA**	**0**	**0 - 0**	**26**	**NA**	**NA**	**0**	**0 - 0**
TotHard	192	611	497	184	5	326 - 806	19	17	7	5	**10 - 28**
CaHard	132	155	152	8	5	145 - 165	30	31	14	5	15 - 50
Turb	0.11	NA	0.24	0	4	0.13 - 0.42	0.08	0.09	0.04	4	0 - 0
TOC	**3.0**	**10.6**	8.2	**5.5**	**5**	**2.6 - 17.2**	**0.3**	**0.3**	**0.1**	**5**	**0.3 - 0.5**
UV254	0.039	**0.150**	0.116	0.086	5	0.022 - 0.252	0.005	0.005	0.000	5	0.005 - 0.005
SUVA	1.24	**1.34**	1.32	0.27	5.00	0.85 - 1.53	1.80	1.62	0.40	5.00	0.90 - 1.80

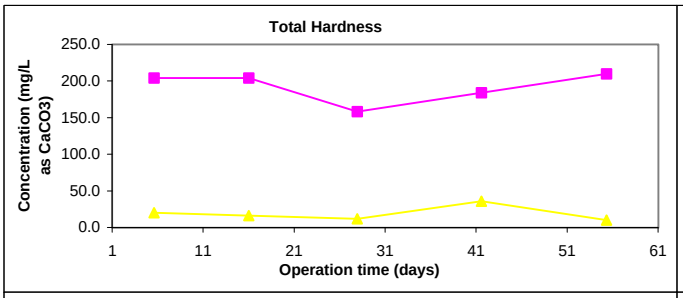
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

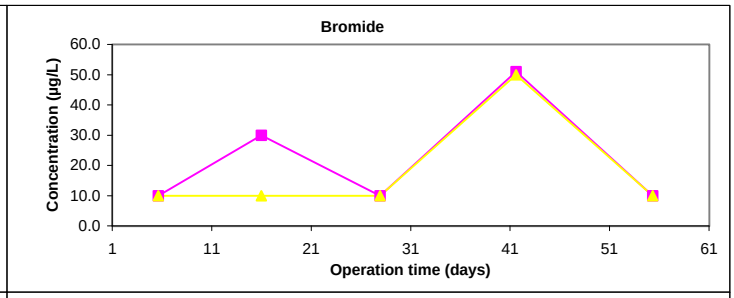
Chart Legend:
Feed (System)
Permeate (System)

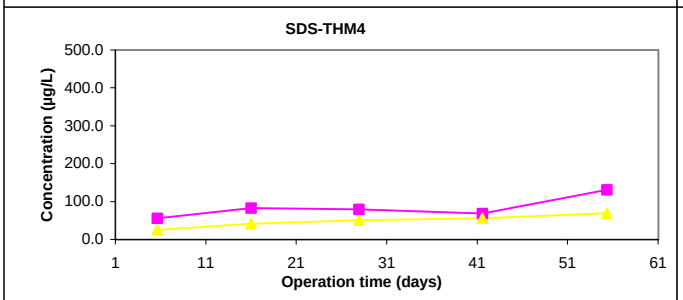
Water Quality Parameter Graphs

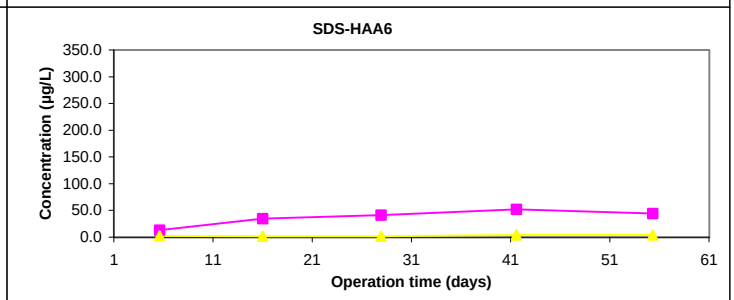


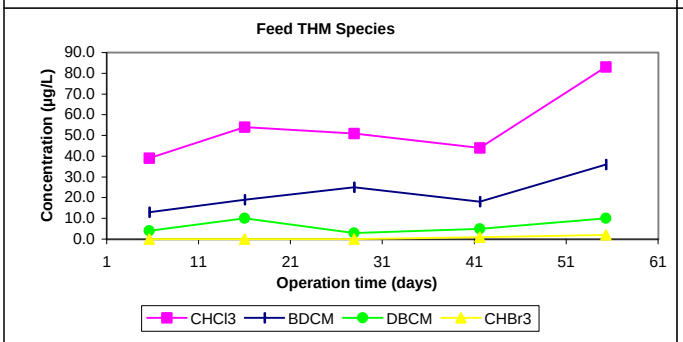
Water Quality Graphs (Continued)

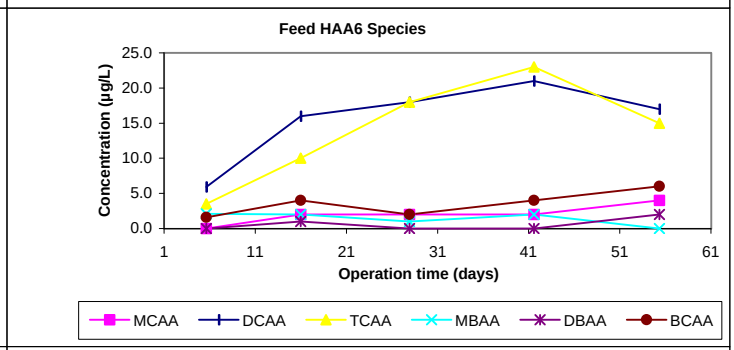


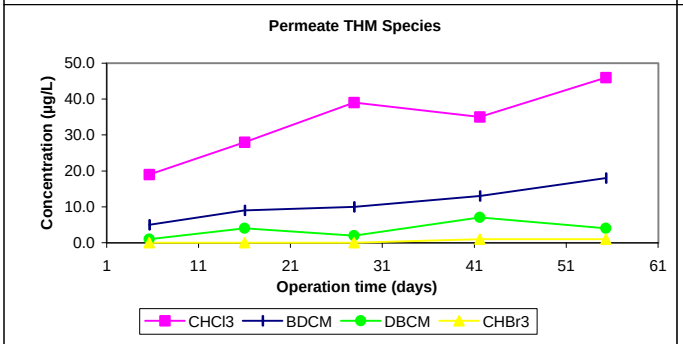


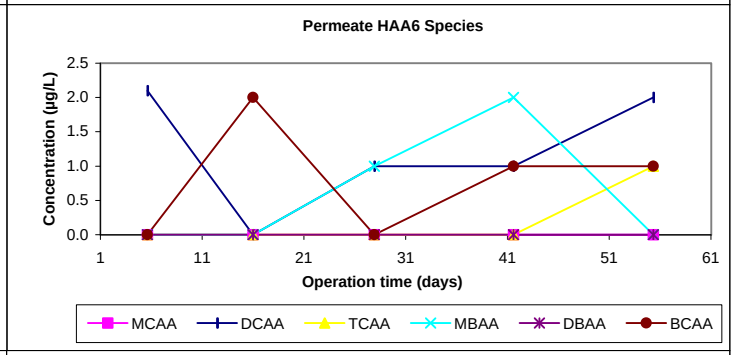


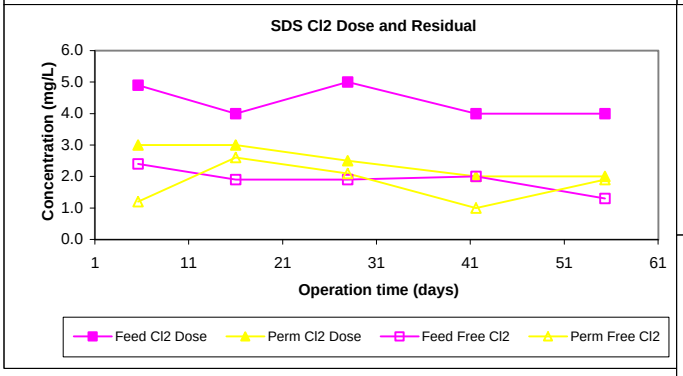


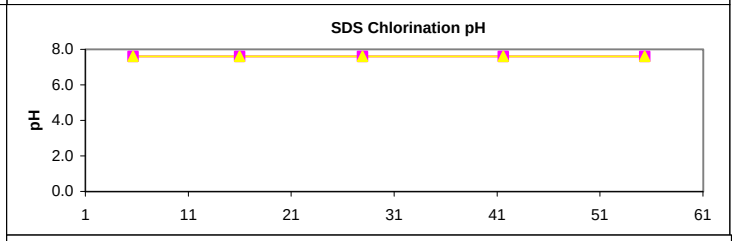


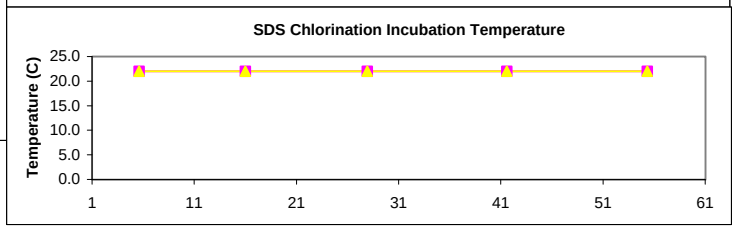




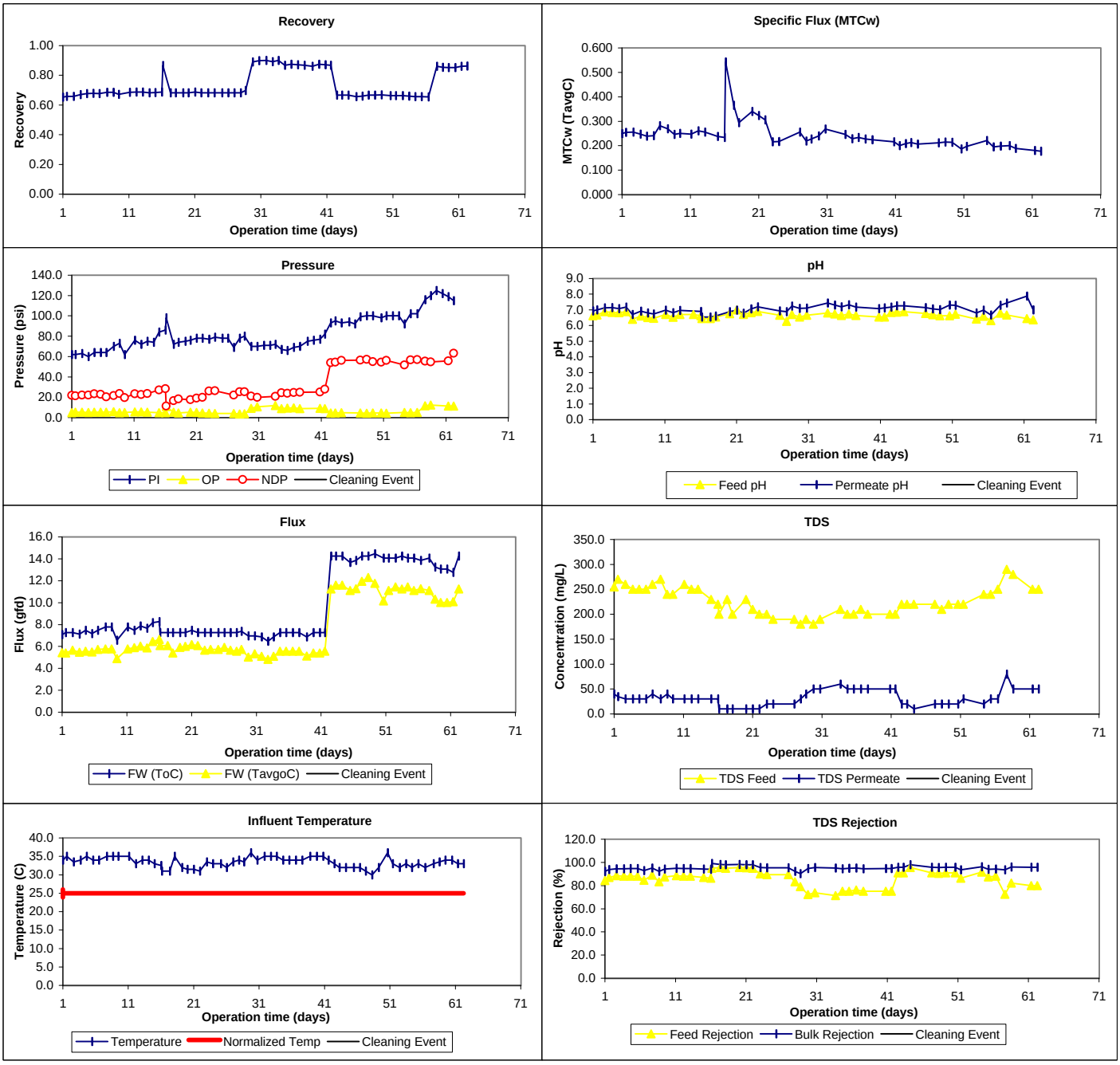








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 2

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 9/24/97 - 12/2/97 (69 days)

Membrane Information

Manufacturer:	Hydranautics
Trade Name:	ESNA
Membrane Model:	4040-UHA-ESNA
MWCO:	300-500 Daltons
Element Size:	4' x 40"
Element Area:	85.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	67.0 psi
Mfr. MTC_W:	0.300 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	4.0 gpm
Total Width :	15.0 ft
Feed Spacer Thickness:	0.0022 ft
840 Element Area	400.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.300 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 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:	14.0 gfd
Recycle Ratio:	0.27
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.9	0.3	3	6.7 - 7.2	6.4	0.3	3	6.2 - 6.7	7.4	0.1	3	7.3 - 7.4
Temp	21.7	6.4	3	17.0 - 29.0	21.5	9.5	3	11.0 - 29.5	24.8	4.3	3	21.0 - 29.5
Alk	54	27	3	26 - 79	16	11	3	6 - 28	141	4	3	139 - 146
TDS	**124**	**39**	**3**	**90 - 167**	**37**	**25**	**3**	**8 - 53**	**434**	**141**	**3**	**345 - 596**
TotHard	90	10	3	80 - 100	18	11	3	10 - 30	326	234	3	186 - 596
CaHard	71	16	3	60 - 89	17	7	3	13 - 25	139	40	3	93 - 163
Turb	0.14	0.0	3	0.10 - 0.19	0.08	0.0	3	0.06 - 0.09	NA	NA	0	0.00 - 0.00
Amm	0.18	0.32	3	0.00 - 0.55	0.00	0.00	3	0.00 - 0.00	0.00	0.00	2	0.0 - 0.0
TOC	**14.7**	**10.9**	**3**	**2.2 - 21.5**	**0.5**	**0.5**	**3**	**0.3 - 1.1**	**35.3**	**27.3**	**2**	**16.0 - 54.6**
UV254	0.559	0.5	3	0.036 - 0.858	0.006	0.0	3	0.005 - 0.009	1.347	1.0	3	0.243 - 2.100
SUVA	3.15	1.32	3	1.63 - 4.00	1.48	0.56	3	0.84 - 1.80	NA	NA	2	NA
Bromide	**32**	**10**	**3**	**20 - 40**	**13**	**6**	**3**	**10 - 20**				
TOX	**378**	**255**	**3**	**84 - 538**	**13**	**0**	**3**	**13 - 13**				
CHCl3	754.3	602.8	3	68.0 - 1198.0	14.0	10.4	3	7.0 - 26.0				
BDCM	34.5	21.5	3	13.0 - 56.0	7.2	1.4	3	5.5 - 8.0				
DBCM	0.7	1.2	3	0.0 - 2.0	3.3	2.5	3	1.0 - 6.0				
CHBr3	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0				
THM4	**789.5**	**621.9**	**3**	**83.0 - 1254.0**	**24.5**	**9.3**	**3**	**17.5 - 35.0**				
MCAA	82.7	69.5	3	3.0 - 131.0	1.5	1.3	3	0.0 - 2.5				
DCAA	280.7	467.2	3	1.0 - 820.0	5.2	6.5	3	0.0 - 12.5				
TCAA	789.2	883.4	3	21.0 - 1754.5	7.3	6.8	3	2.0 - 15.0				
MBAA	38.8	64.2	3	1.0 - 113.0	1.7	2.9	3	0.0 - 5.0				
DBAA	5.5	8.3	3	0.0 - 15.0	1.0	1.7	3	0.0 - 3.0				
BCAA	5.0	5.6	3	0.0 - 11.0	2.3	1.5	3	1.0 - 4.0				
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	**1196.8**	**1368.1**	**3**	**46.0 - 2709.5**	**16.7**	**11.9**	**3**	**7.0 - 30.0**				
HAA6	**1201.8**	**1372.5**	**3**	**50.0 - 2720.5**	**19.0**	**13.5**	**3**	**8.0 - 34.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	3	4	8
TDS	3	27	32
TotHard	3	5	7
CaHard	3	-89	169
Turb	0	n/a	n/a
Amm	0	n/a	n/a
TOC	2	2	1
UV254	3	3	4
TDSt	16	3	16

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.02	0.72	6	0.10 - 2.00
Temp (^oC)	22.0	0.0	6	22.0 - 22.0
pH (unit)	7.6	0.0	6	7.6 - 7.6
Time (hr)	48.0	0.0	6	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
Memcor Direct Microfiltration	Microfiltration	pilot scale
Hypersperse AF 200	5.0 mg/l@7 gfd, 2.5 mg/l@ 14 gfd	pilot scale
Cartridge Filtration	5 mm exclusion 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	-3.3%	2.0%	System Inf - Stg 1 Inf	-26.5%	18.5%
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	-5.8%	17.7%	Sys Perm - Sum Stg Pe	-8.8%	5.5%	Sys Perm - Avg Stg Perm	18.3%	23.3%

Stage Summary

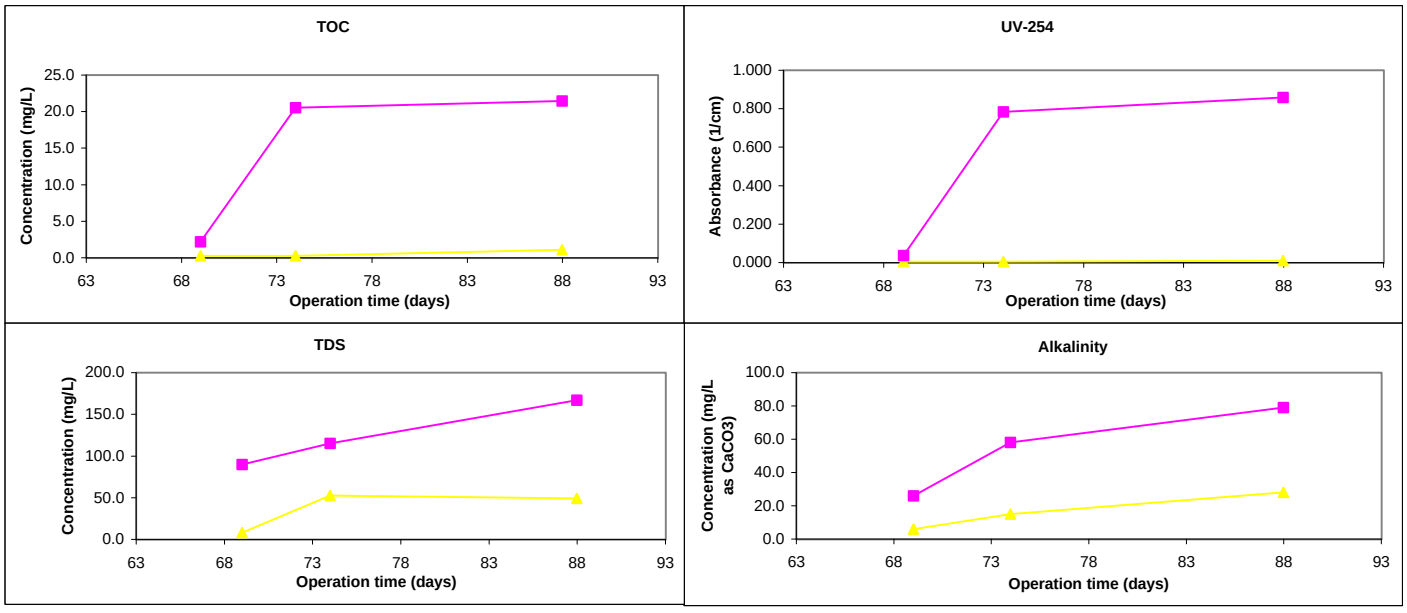
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.41**	**0.18**	**3**	**0.22 - 0.58**					
pH	6.9	7.4	7.2	0.1	3	7.1 - 7.3	6.4	6.5	0.3	3	6.1 - 6.8
Temp	21.7	24.8	24.8	4.3	3	21.0 - 29.5	21.5	21.5	9.5	3	11.0 - 29.5
Alk	54	141	87	9	3	82 - 97	16	22	17	3	8 - 40
TDS	**124**	**434**	215	**11**	**2**	**207 - 222**	**37**	**44**	**37**	**2**	**17 - 70**
TotHard	90	326	187	114	3	112 - 318	18	24	18	3	10 - 44
CaHard	71	139	99	12	3	90 - 112	17	22	15	3	13 - 40
Turb	0.14	NA	0.17	0	3	0.13 - 0.20	0.08	0.07	0.02	3	0 - 0
TOC	**14.7**	**35.3**	23.4	**12.8**	**3**	**8.6 - 31.7**	**0.5**	**0.9**	**0.6**	**3**	**0.3 - 1.4**
UV254	0.559	**1.347**	**0.479**	0.589	3	0.136 - 1.158	0.006	0.009	0.008	3	0.005 - 0.018
SUVA	3.15	**NA**	**1.97**	1.75	3	0.45 - 3.88	1.48	1.19	0.69	3	0.44 - 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			**0.48**	**0.17**	**3**	**0.37 - 0.68**					
pH	6.9	7.4	7.3	0.0	3	7.3 - 7.3	6.4	6.3	0.2	3	6.1 - 6.5
Temp	21.7	24.8	24.8	4.3	3	21.0 - 29.5	21.5	21.5	9.5	3	11.0 - 29.5
Alk	54	141	110	6	3	104 - 116	16	9	6	3	**5 - 16**
TDS	**124**	**434**	177	**122**	**2**	**91 - 263**	**37**	**27**	**4**	**2**	**24 - 30**
TotHard	90	326	261	195	3	142 - 486	18	15	5	3	**10 - 20**
CaHard	71	139	114	21	3	90 - 126	17	10	4	3	**6 - 13**
Turb	0.14	NA	0.20	0	3	0.13 - 0.26	0.08	0.09	0.01	3	0 - 0
TOC	**14.7**	**35.3**	29.7	**15.0**	**3**	**13.0 - 41.9**	**0.5**	**0.4**	**0.2**	**3**	**0.3 - 0.6**
UV254	0.559	**1.347**	1.070	0.772	3	0.204 - 1.685	0.006	0.005	0.000	3	0.005 - 0.005
SUVA	3.15	**NA**	3.15	1.37	3.00	1.57 - 4.02	1.48	1.44	0.63	3.00	0.71 - 1.80

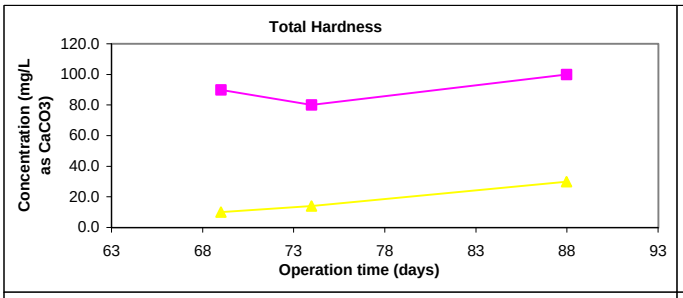
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage study.					
TDS											
TotHard											
CaHard		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

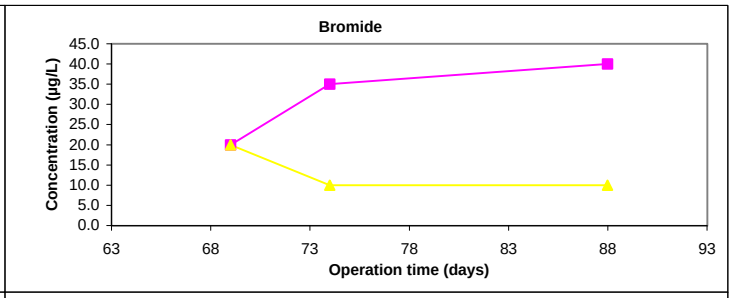
Chart Legend:
Feed (System)
Permeate (System)

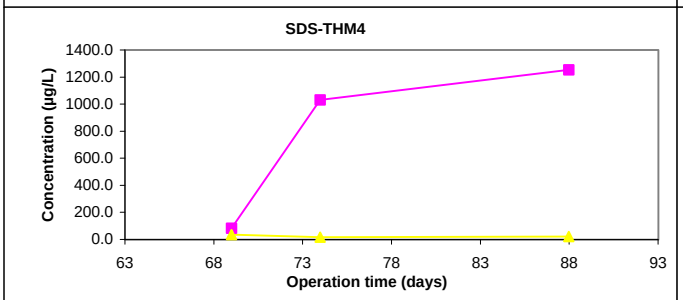
Water Quality Parameter Graphs

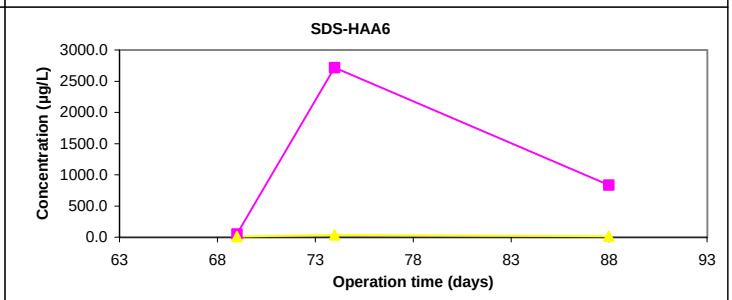


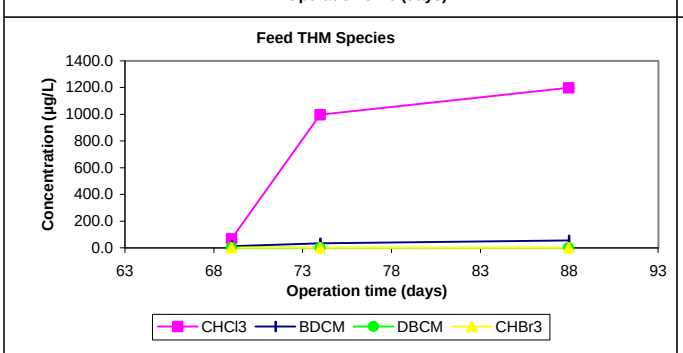
Water Quality Graphs (Continued)

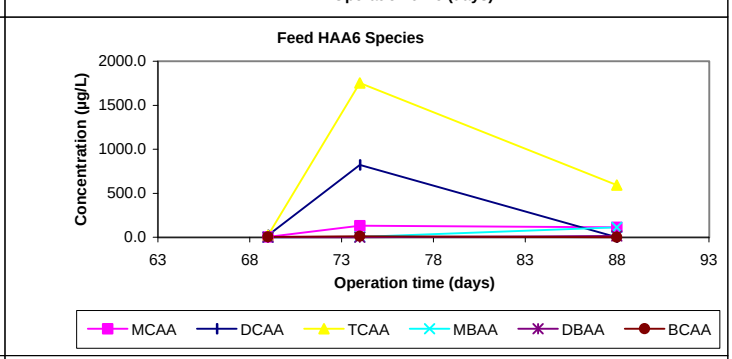


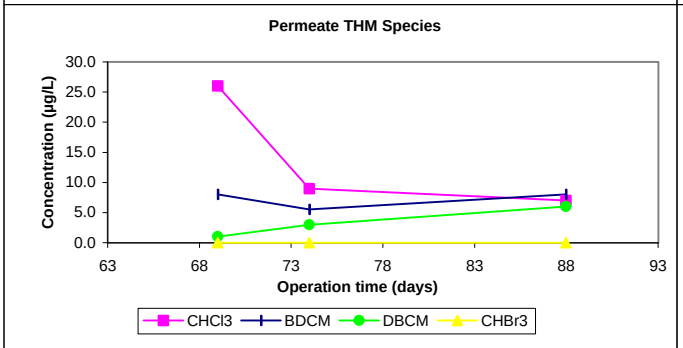


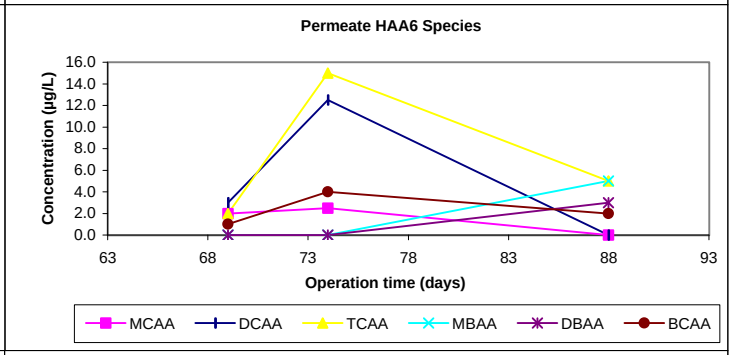


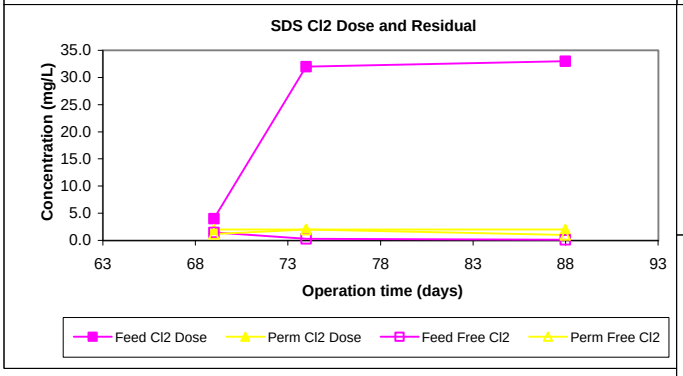


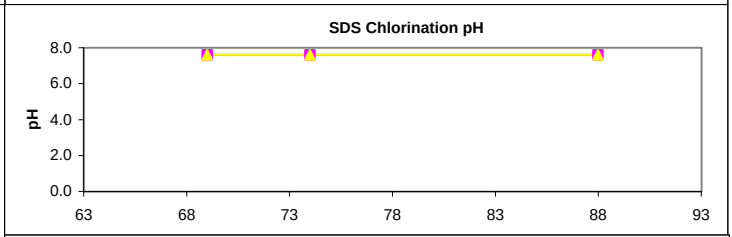


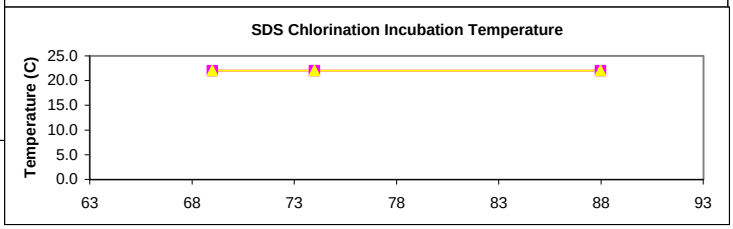




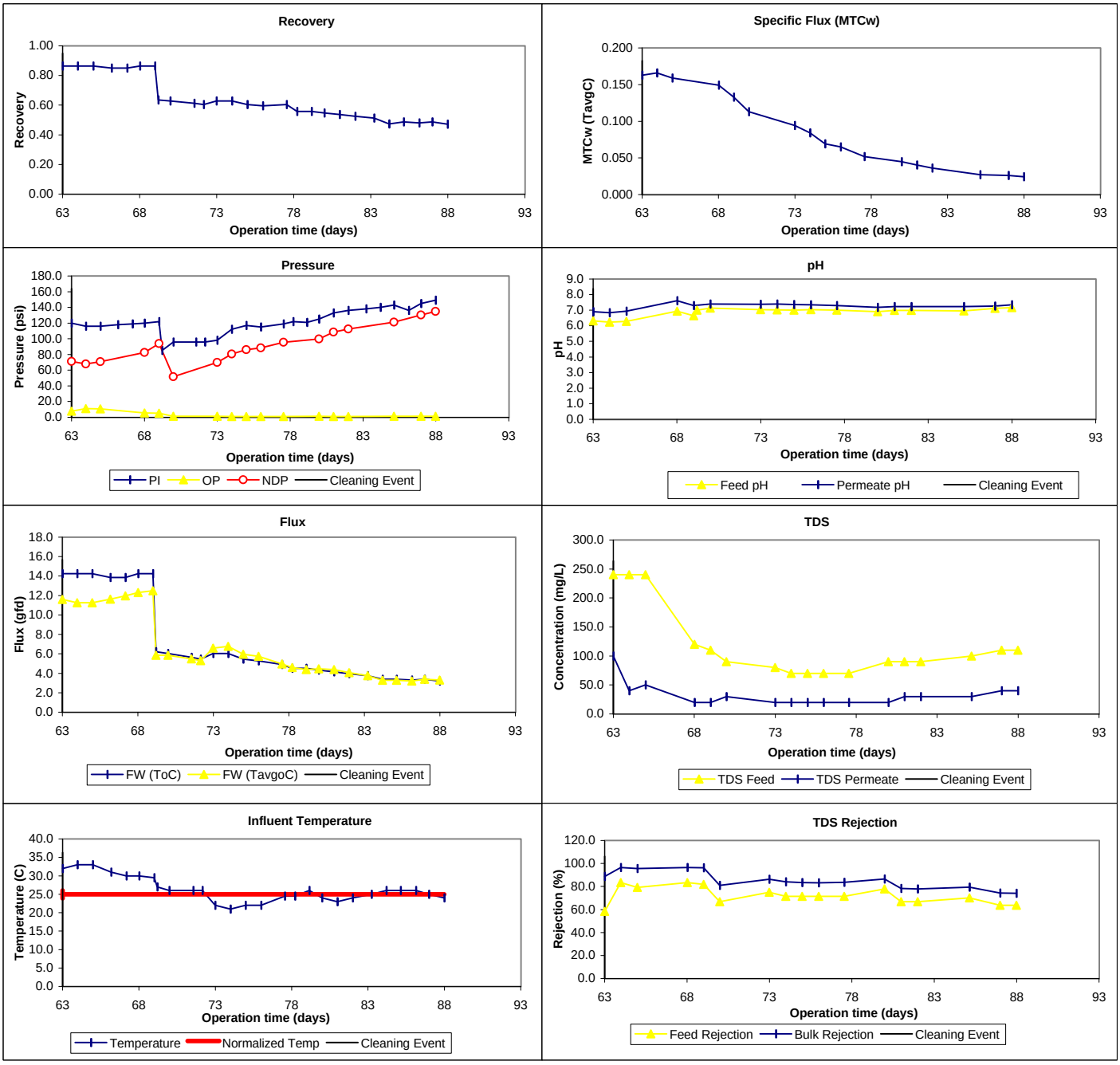








Productivity Graphs



TAMPA WATER DEPARTMENT | **Pilot-Scale Membrane Treatment Study Summary** | **Session:** 3

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 12/3/97 - 2/9/98 (68 days)

Membrane Information

Manufacturer:	Hydranautics
Trade Name:	ESNA
Membrane Model:	4040-UHA-ESNA
MWCO:	300-500 Daltons
Element Size:	4' x 40"
Element Area:	85.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	67.0 psi
Mfr. MTC_W:	0.300 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	4.0 gpm
Total Width :	15.0 ft
Feed Spacer Thickness:	0.0022 ft
840 Element Area	400.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.300 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 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:	14.0 gfd
Recycle Ratio:	0.27
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.5	0.3	5	6.2 - 7.0	6.4	0.2	5	6.3 - 6.7	6.6	0.2	5	6.4 - 6.9
Temp	17.2	1.3	5	16.0 - 19.0	20.4	4.9	5	12.2 - 25.0	22.8	1.9	5	20.0 - 25.0
Alk	32	5	5	25 - 39	26	4	5	22 - 32	35	7	5	27 - 43
TDS	**150**	**42**	**4**	**102 - 203**	**105**	**51**	**5**	**46 - 182**	**182**	**59**	**5**	**111 - 244**
TotHard	90	24	5	52 - 116	62	20	5	34 - 83	107	33	5	60 - 142
CaHard	81	23	5	46 - 106	51	20	5	25 - 74	94	32	5	53 - 135
Turb	0.16	0.0	5	0.11 - 0.22	0.08	0.0	5	0.06 - 0.10	NA	NA	0	0.00 - 0.00
Amm	0.00	0.00	5	0.00 - 0.00	0.00	0.00	5	0.00 - 0.00	0.00	0.00	5	0.0 - 0.0
TOC	**5.6**	**5.9**	**5**	**2.6 - 16.2**	**1.8**	**0.6**	**5**	**1.0 - 2.5**	**6.4**	**7.4**	**5**	**2.5 - 19.6**
UV254	0.212	0.3	5	0.048 - 0.649	0.034	0.0	5	0.023 - 0.041	0.203	0.3	5	0.049 - 0.799
SUVA	3.49	2.47	5	1.70 - 7.59	1.99	0.29	5	1.64 - 2.35	2.25	1.06	5	1.57 - 4.08
Bromide	**13**	**5**	**4**	**10 - 20**	**13**	**5**	**4**	**10 - 20**				
TOX	**113**	**142**	**5**	**13 - 356**	**27**	**20**	**5**	**13 - 57**				
CHCl3	238.0	392.6	5	48.0 - 940.0	42.9	7.9	5	34.0 - 51.0				
BDCM	16.8	4.7	5	11.0 - 24.0	11.0	1.4	5	10.0 - 13.0				
DBCM	2.6	1.8	5	0.0 - 5.0	2.4	1.1	5	1.0 - 4.0				
CHBr3	0.2	0.4	5	0.0 - 1.0	0.0	0.0	5	0.0 - 0.0				
THM4	**257.6**	**395.1**	**5**	**70.0 - 964.0**	**56.3**	**7.9**	**5**	**48.0 - 66.5**				
MCAA	15.7	26.5	5	3.0 - 63.0	4.2	1.1	5	3.0 - 6.0				
DCAA	27.9	16.3	5	0.0 - 40.0	21.2	12.7	5	0.0 - 31.0				
TCAA	149.9	256.8	5	26.0 - 609.0	23.9	6.5	5	16.0 - 30.0				
MBAA	203.0	451.7	5	0.0 - 1011.0	5.6	11.4	5	0.0 - 26.0				
DBAA	2.0	3.5	5	0.0 - 8.0	1.0	1.7	5	0.0 - 4.0				
BCAA	6.3	4.4	5	0.0 - 12.0	5.8	2.8	5	2.0 - 9.0				
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	**398.5**	**722.6**	**5**	**60.5 - 1691.0**	**55.9**	**10.8**	**5**	**43.5 - 65.0**				
HAA6	**404.8**	**719.1**	**5**	**69.0 - 1691.0**	**61.7**	**9.1**	**5**	**50.5 - 72.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	5	-6	9
TDS	4	-31	49
TotHard	5	-15	33
CaHard	5	-24	36
Turb	0	n/a	n/a
Amm	0	n/a	n/a
TOC	5	-31	21
UV254	5	-162	280
TDSt	39	-4	25

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	1.55	0.60	10	1.00 - 2.50
Temp (^oC)	22.0	0.0	10	22.0 - 22.0
pH (unit)	7.6	0.0	10	7.6 - 7.6
Time (hr)	48.0	0.0	10	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
Memcor Direct Microfiltration	Microfiltration	pilot scale
Hypersperse AF 200	Antiscalent	pilot scale
Cartridge Filtration	5 mm exclusion 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	-14.7%	7.5%
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	48.3%	7.6%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	4.0%	7.5%

Stage Summary

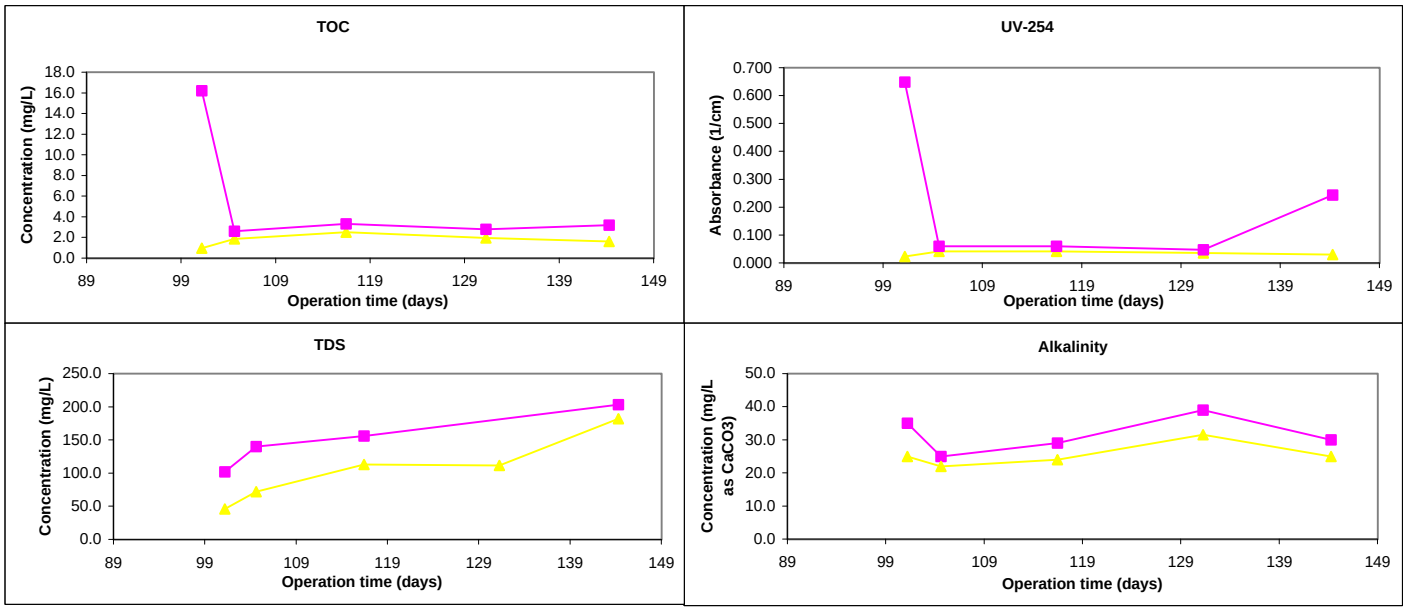
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.33**	**0.10**	**5**	**0.20 - 0.44**					
pH	6.5	6.6	6.5	0.3	5	6.3 - 6.9	6.4	6.4	0.2	5	6.2 - 6.7
Temp	17.2	22.8	22.8	1.9	5	20.0 - 25.0	20.4	20.4	4.9	5	12.2 - 25.0
Alk	32	35	33	6	5	25 - 41	26	27	5	5	22 - 34
TDS	**150**	**182**	153	**48**	**4**	**109 - 221**	**105**	**89**	**36**	**4**	**65 - 142**
TotHard	90	107	98	27	5	58 - 128	62	65	19	5	44 - 86
CaHard	81	94	85	26	5	48 - 116	51	56	19	5	37 - 79
Turb	0.16	NA	0.19	0	5	0.11 - 0.28	0.08	0.09	0.02	5	0 - 0
TOC	**5.6**	**6.4**	5.7	**6.4**	**5**	**2.4 - 17.1**	**1.8**	**2.0**	**0.3**	**5**	**1.8 - 2.5**
UV254	0.212	**0.203**	**0.181**	0.294	5	0.045 - 0.708	0.034	0.043	0.006	5	0.036 - 0.052
SUVA	3.49	**2.25**	**2.22**	1.10	5	1.54 - 4.14	1.99	2.19	0.40	5	1.76 - 2.76

	Stage 2 Influent						Stage 2 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.23**	**0.10**	**5**	**0.14 - 0.39**					
pH	6.5	6.6	6.6	0.2	5	6.4 - 6.9	6.4	6.4	0.1	5	6.2 - 6.5
Temp	17.2	22.8	22.8	1.9	5	20.0 - 25.0	20.4	22.8	1.9	5	20.0 - 25.0
Alk	32	35	34	7	5	25 - 43	26	22	6	5	13 - 31
TDS	**150**	**182**	151	**48**	**4**	**106 - 219**	**105**	**103**	**55**	**4**	**56 - 180**
TotHard	90	107	100	31	5	54 - 134	62	57	21	5	28 - 79
CaHard	81	94	90	30	5	48 - 125	51	46	23	5	13 - 71
Turb	0.16	NA	0.23	0	5	0.15 - 0.34	0.08	0.08	0.02	5	0 - 0
TOC	**5.6**	**6.4**	6.3	**6.7**	**5**	**3.2 - 18.2**	**1.8**	**1.3**	**0.7**	**5**	**0.3 - 2.0**
UV254	0.212	**0.203**	**0.188**	0.301	5	0.048 - 0.727	0.034	0.025	0.012	5	0.005 - 0.033
SUVA	3.49	**2.25**	**2.09**	1.07	5.00	1.45 - 4.00	1.99	1.85	0.15	5.00	1.65 - 2.01

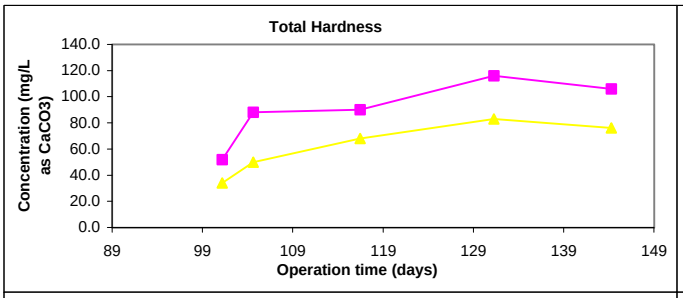
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

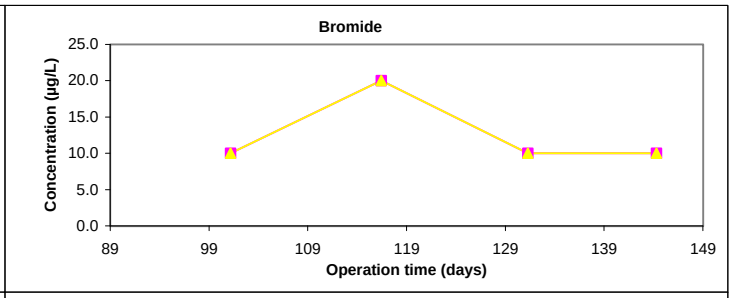
Chart Legend:
- Feed (System)
- Permeate (System)

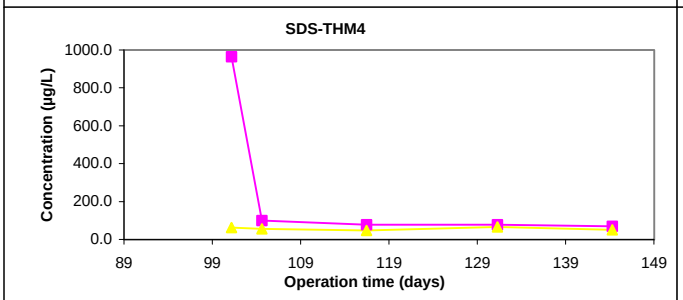
Water Quality Parameter Graphs

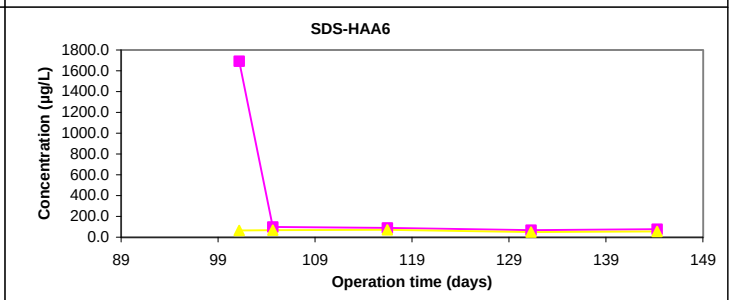


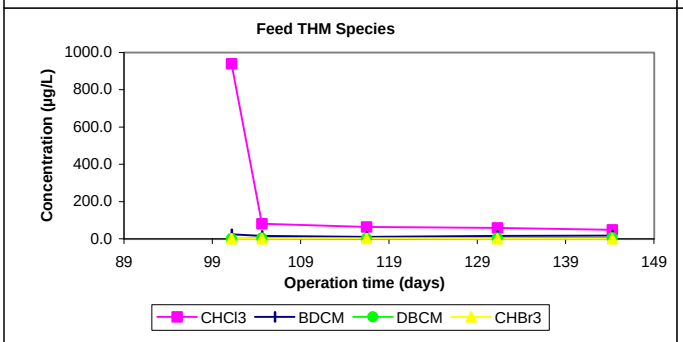
Water Quality Graphs (Continued)

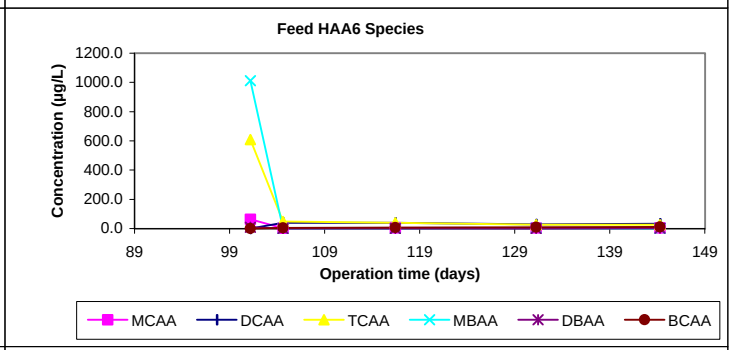


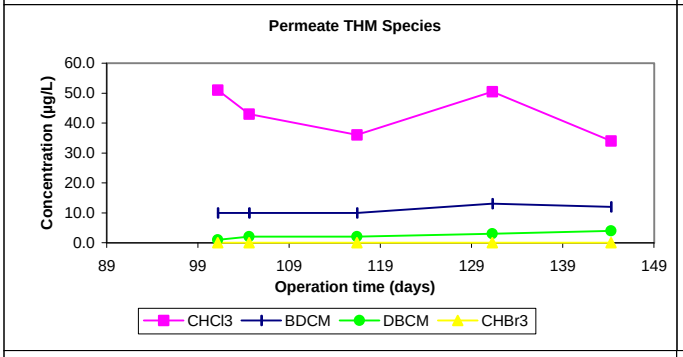


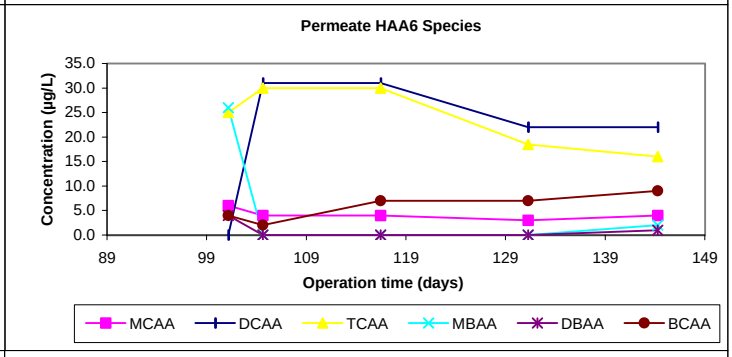


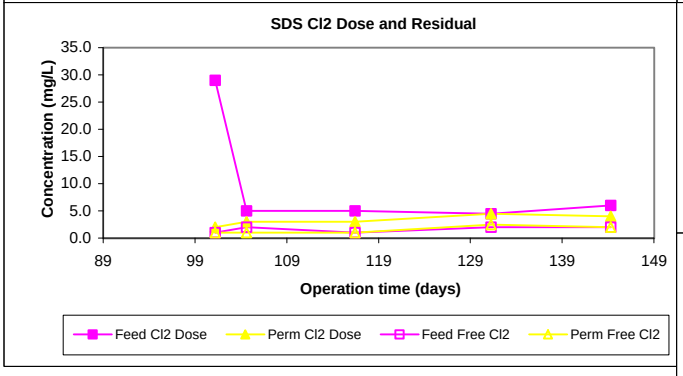


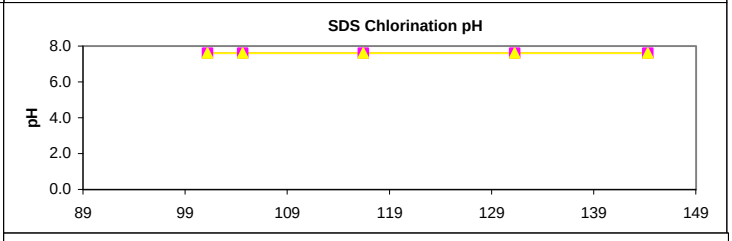


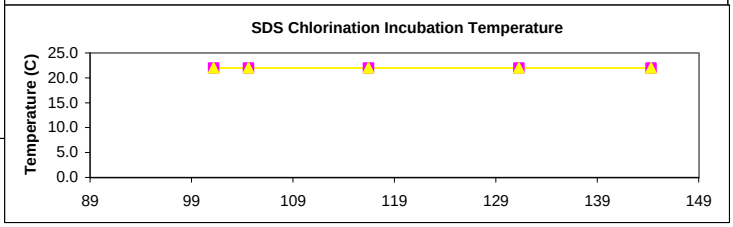




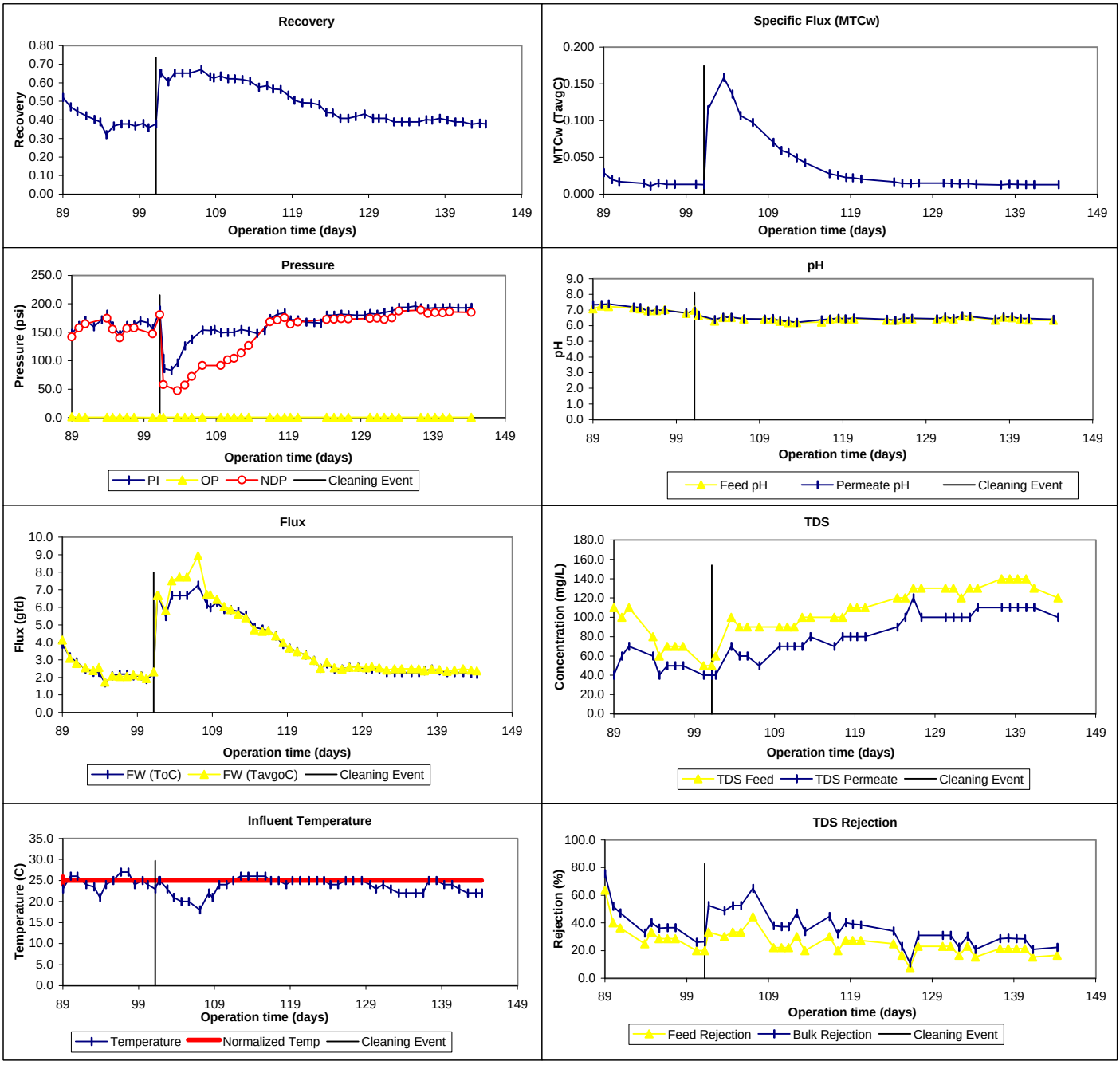








Productivity Graphs



TAMPA WATER DEPARTMENT | **Pilot-Scale Membrane Treatment Study Summary** | **Session:** 4

ICR Information

ID / ICR#:	FL 6290327 / 311
ICR Contact:	MIKE BENNETT
Phone No.:	(813) 231-5254
Period:	2/10/98 - 4/27/98 (76 days)

Membrane Information

Manufacturer:	Hydranautics
Trade Name:	LFC
Membrane Model:	4040-UHA-LFC1
MWCO:	200-300 Daltons
Element Size:	4' x 40"
Element Area:	85.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	135.0 psi
Mfr. $MTC_{W:}$	0.150 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	4.0 gpm
Total Width :	15.0 ft
Feed Spacer Thickness:	0.0022 ft
840 Element Area	400.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.150 TavgC
Design Recovery:	0.85
Avg Sys Flux F_W:	14.0 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:	14.0 gfd
Recycle Ratio:	0.27
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.7	0.8	4	5.9 - 7.5	5.6	0.2	4	5.4 - 5.9	7.0	0.7	4	6.4 - 7.9
Temp	20.3	1.3	4	19.0 - 22.0	24.8	2.1	4	22.0 - 27.0	24.8	2.1	4	22.0 - 27.0
Alk	48	38	4	14 - 94	2	1	4	1 - 3	214	234	4	53 - 555
TDS	**136**	**34**	**4**	**85 - 160**	**5**	**8**	**4**	**0 - 17**	**603**	**331**	**4**	**304 - 1058**
TotHard	82	30	4	48 - 118	1	2	4	0 - 4	337	241	4	168 - 694
CaHard	59	30	4	23 - 93	0	0	4	0 - 0	260	171	4	133 - 512
Turb	0.14	0.0	4	0.11 - 0.16	0.09	0.0	4	0.08 - 0.10	NA	NA	0	0.00 - 0.00
Amm	0.25	0.50	4	0.00 - 1.00	0.00	0.00	4	0.00 - 0.00	0.00	0.00	4	0.0 - 0.0
TOC	**15.9**	**1.2**	**4**	**14.3 - 17.1**	**0.3**	**0.0**	**4**	**0.3 - 0.3**	**63.2**	**24.8**	**4**	**38.1 - 93.3**
UV254	0.741	0.1	4	0.598 - 0.801	0.005	0.0	4	0.005 - 0.005	3.076	1.1	4	2.136 - 4.308
SUVA	4.63	0.31	4	4.18 - 4.87	1.80	0.00	4	1.80 - 1.80	4.94	0.56	4	4.40 - 5.66
Bromide	**38**	**36**	**4**	**10 - 84**	**10**	**0**	**4**	**10 - 10**				
TOX	**990**	**271**	**4**	**598 - 1218**	**13**	**0**	**4**	**13 - 13**				
CHCl3	1253.8	444.6	4	940.0 - 1913.0	3.3	2.3	3	2.0 - 6.0				
BDCM	29.9	10.2	4	20.0 - 42.0	0.7	0.6	3	0.0 - 1.0				
DBCM	2.3	3.2	4	0.0 - 7.0	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	**1391.2**	**483.1**	**3**	**1091.0 - 1948.5**	**4.0**	**1.7**	**3**	**3.0 - 6.0**				
MCAA	67.6	25.0	4	53.0 - 105.0	0.0	0.0	3	0.0 - 0.0				
DCAA	660.8	175.9	4	527.0 - 918.0	10.7	8.0	3	3.0 - 19.0				
TCAA	1396.0	430.4	4	974.0 - 1985.0	15.7	13.5	3	2.0 - 29.0				
MBAA	2.3	2.6	4	0.0 - 6.0	0.0	0.0	3	0.0 - 0.0				
DBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0				
BCAA	11.1	1.0	4	10.0 - 12.5	0.3	0.6	3	0.0 - 1.0				
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	**2126.6**	**586.3**	**4**	**1608.0 - 2957.0**	**26.3**	**21.5**	**3**	**5.0 - 48.0**				
HAA6	**2137.8**	**585.6**	**4**	**1619.0 - 2967.0**	**26.7**	**21.5**	**3**	**5.0 - 48.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	4	-7	9
TDS	2	-1	4
TotHard	1	-17	n/a
CaHard	0	n/a	n/a
Turb	0	n/a	n/a
Amm	0	n/a	n/a
TOC	0	n/a	n/a
UV254	3	-12	10
TDSt	14	16	10

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (1)	1.88	0.99	8	0.00 - 3.00
Temp (^oC)	22.0	0.0	8	22.0 - 22.0
pH (unit)	7.6	0.0	8	7.6 - 7.6
Time (hr)	48.0	0.0	8	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
Memcor Direct Microfiltration	Microfiltration	pilot scale
Hypersperse AF 200	Antiscalent	pilot scale
Cartridge Filtration	5 mm exclusion size	Pilot-scale
NaOCL + NH4CL	Chloramine addition	Pilot scale
Hydrochloric Acid Addition	pH Adjustment	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	#DIV/0!	#DIV/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	0.0%	0.0%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	2.1%	4.6%

Stage Summary

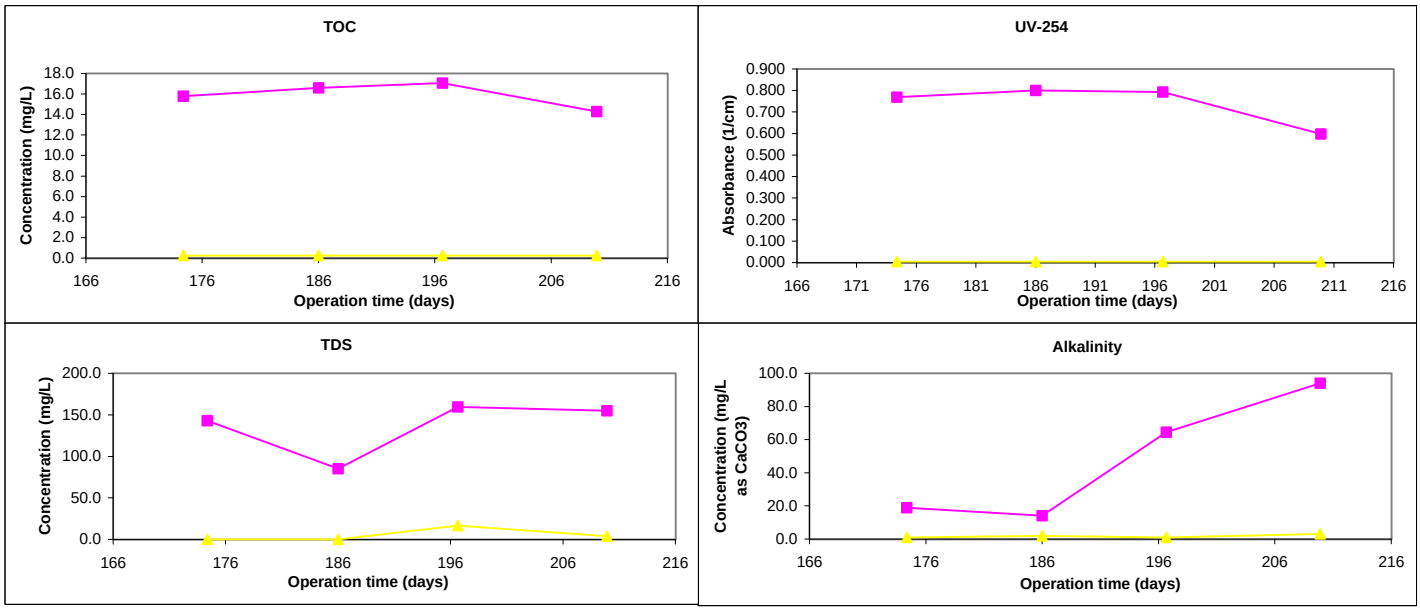
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.50**	**0.08**	**4**	**0.43 - 0.57**					
pH	6.7	7.0	6.9	0.8	4	6.3 - 7.8	5.6	5.7	0.2	4	5.5 - 6.0
Temp	20.3	24.8	24.8	2.1	4	22.0 - 27.0	24.8	24.8	2.1	4	22.0 - 27.0
Alk	48	214	122	138	4	30 - 325	2	3	2	4	1 - 4
TDS	**136**	**603**	338	**177**	**4**	**193 - 585**	**5**	**31**	**46**	**4**	**0 - 98**
TotHard	82	337	193	144	4	86 - 404	1	2	3	4	0 - 6
CaHard	59	260	157	112	4	73 - 322	0	0	0	4	0 - 0
Turb	0.14	NA	0.22	0	4	0.15 - 0.30	0.09	0.09	0.01	4	0 - 0
TOC	**15.9**	**63.2**	36.9	**14.9**	**4**	**20.2 - 49.5**	**0.3**	**0.3**	**0.0**	**4**	**0.3 - 0.3**
UV254	0.741	**3.076**	1.669	0.555	4	1.147 - 2.152	0.005	0.005	0.000	4	0.005 - 0.005
SUVA	4.63	**4.94**	4.71	0.93	4	4.05 - 6.09	1.80	1.80	0.00	4	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**	**0.16**	**4**	**0.37 - 0.66**					
pH	6.7	7.0	7.0	0.7	4	6.4 - 7.8	5.6	5.6	0.2	4	5.5 - 5.9
Temp	20.3	24.8	24.8	2.1	4	22.0 - 27.0	24.8	24.8	2.1	4	22.0 - 27.0
Alk	48	214	172	191	4	43 - 450	2	2	1	4	**1 - 4**
TDS	**136**	**603**	498	**280**	**4**	**278 - 891**	**5**	**2**	**3**	**4**	**0 - 6**
TotHard	82	337	264	193	4	128 - 550	1	1	2	4	0 - 4
CaHard	59	260	212	149	4	103 - 433	0	0	0	4	0 - 0
Turb	0.14	NA	0.24	0	4	0.21 - 0.30	0.09	0.10	0.02	4	0 - 0
TOC	**15.9**	**63.2**	50.8	**22.6**	**4**	**27.9 - 79.6**	**0.3**	**0.3**	**0.0**	**4**	**0.3 - 0.3**
UV254	0.741	**3.076**	2.473	0.927	4	1.696 - 3.572	0.005	0.005	0.000	4	0.005 - 0.005
SUVA	4.63	**4.94**	**5.02**	0.77	4.00	4.41 - 6.08	1.80	1.80	0.00	4.00	1.80 - 1.80

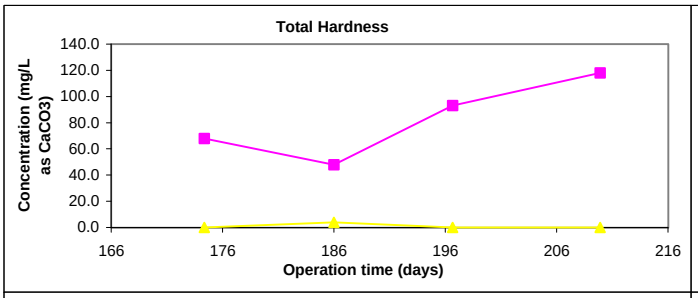
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

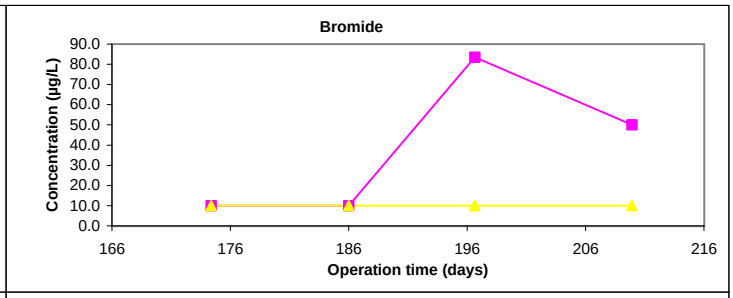
Chart Legend:
Feed (System)
Permeate (System)

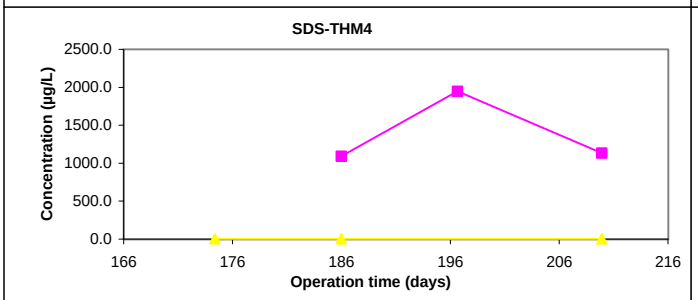
Water Quality Parameter Graphs

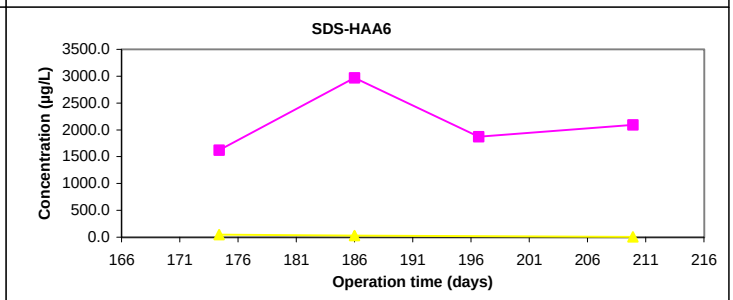


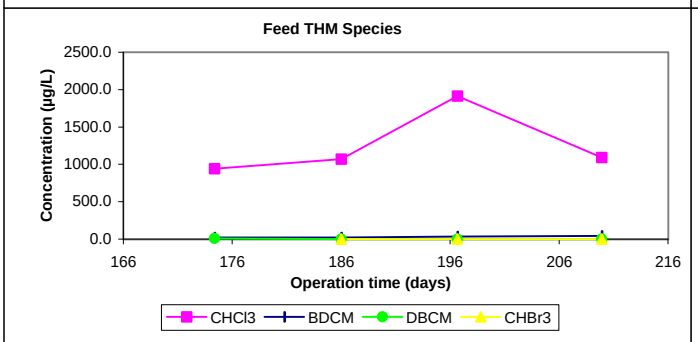
Water Quality Graphs (Continued)

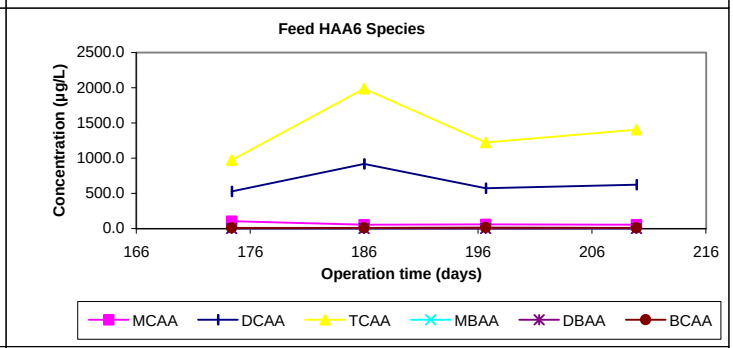


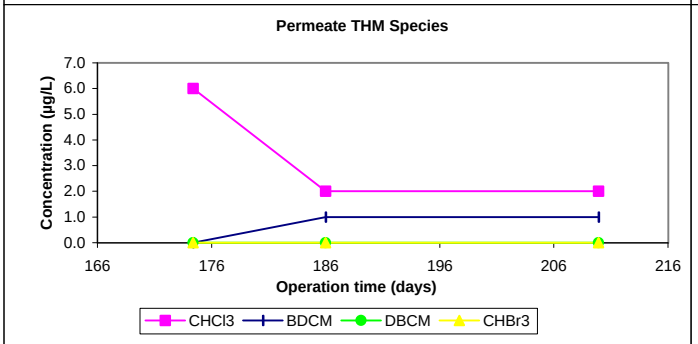


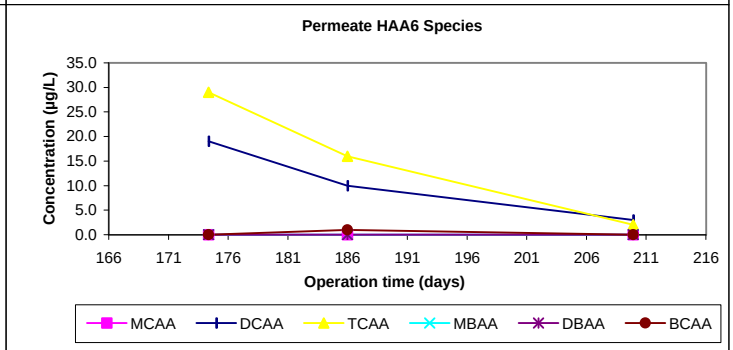


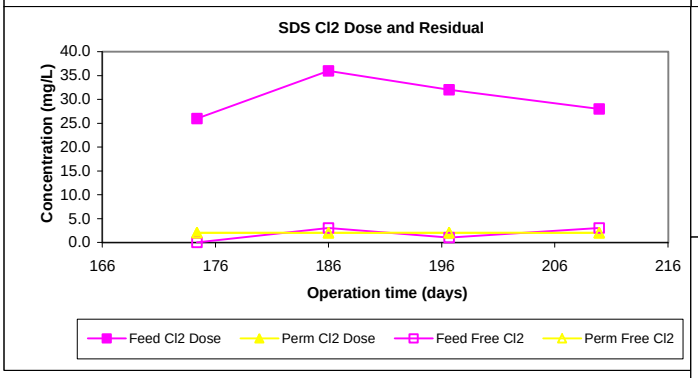


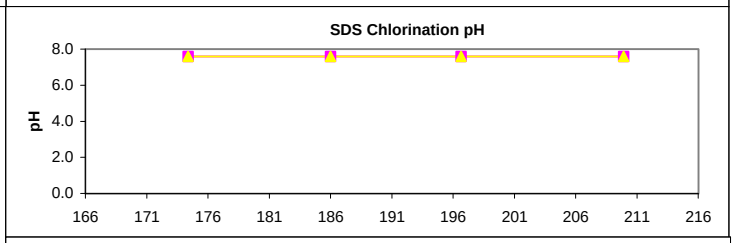


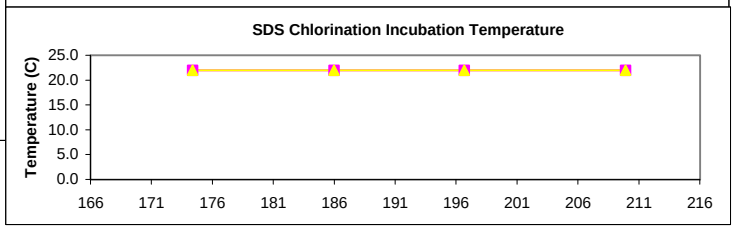




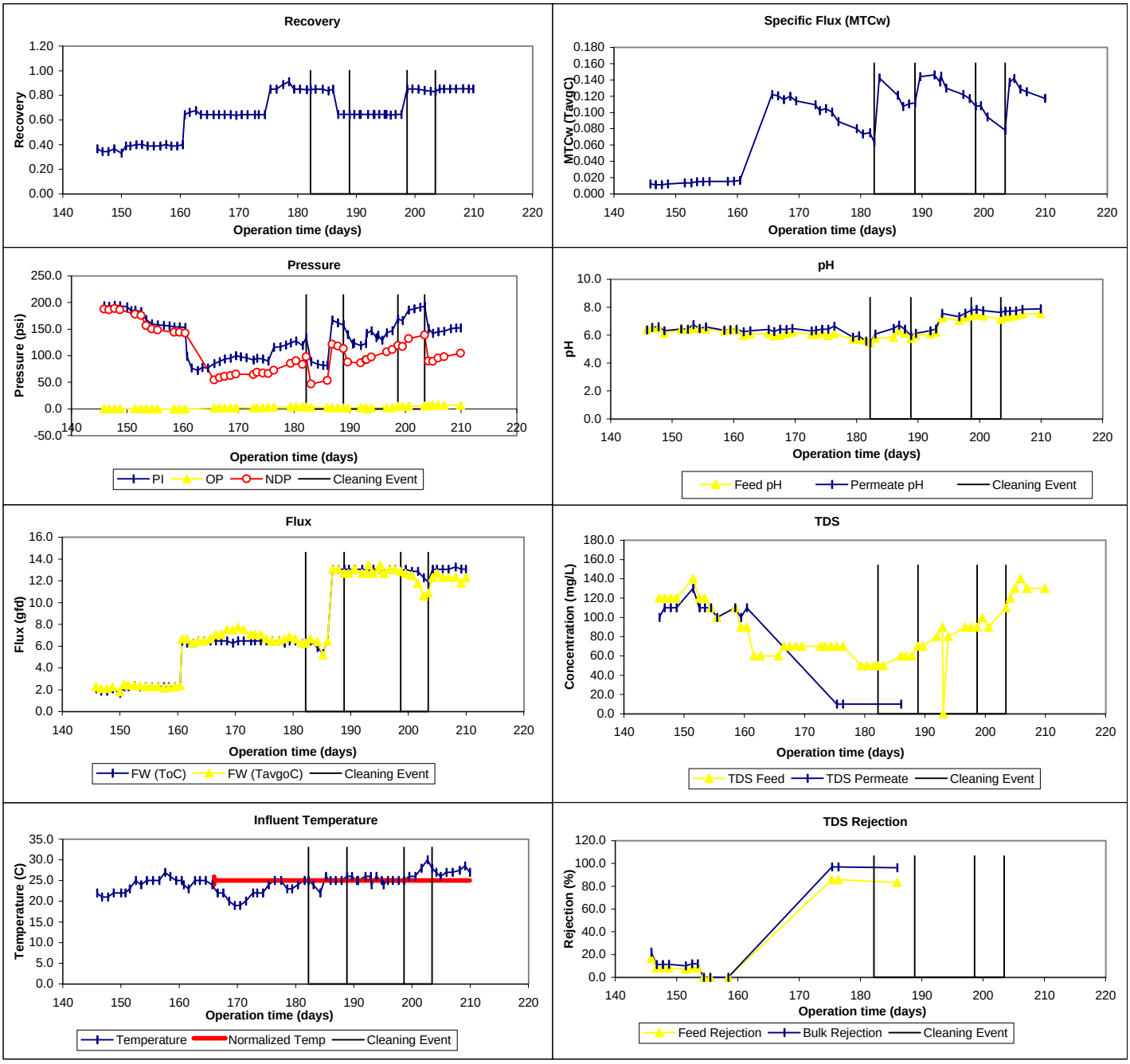








Productivity Graphs



TAMPA WATER DEPARTMENT **Pilot-Scale Membrane Treatment Study Summary** **Session:** 5

ICR Information

ID / ICR#: FL 6290327 / 311
ICR Contact: MIKE BENNETT
Phone No.: (813) 231-5254
Period: 4/28/98 - 7/20/98 (83 days)

Membrane Information

Manufacturer:	Hydranautics
Trade Name:	LFC
Membrane Model:	4040-UHA-LFC1
MWCO:	200-300 Daltons
Element Size:	4' x 40"
Element Area:	85.0 ft^2
Design Flux:	20.0 gfd
Mfr. NDP:	135.0 psi
Mfr. MTC_w:	0.150 (gfd/psi)
Mfr. Temp:	25.0 ^oC
Maximum Flow:	16.0 gpm
Minimum Flow:	4.0 gpm
Total Width :	15.0 ft
Feed Spacer Thickness:	0.0022 ft
840 Element Area	400.0 ft^2
840 Purchase Price:	NA

Design Parameters

Norm Temp:	25.0 ^oC
Temp Norm MTC-w:	0.150 TavgC
Design Recovery:	0.85
Avg Sys Flux F_w:	14.0 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:	14.0 gfd
Recycle Ratio:	0.27
Osmotic P Stage 1:	3.5 psi
Osmotic P Stage 2:	4.5 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	6.9	1.5	5	4.6 - 8.1	6.3	0.8	5	5.4 - 7.2	7.1	1.3	5	5.2 - 8.2
Temp	27.0	1.4	5	25.0 - 29.0	34.0	2.2	5	31.0 - 37.0	34.0	2.2	5	31.0 - 37.0
Alk	82	56	5	12 - 134	10	3	5	7 - 15	297	258	5	7 - 655
TDS	**316**	**104**	**5**	**234 - 436**	**38**	**8**	**5**	**27 - 48**	**1256**	**735**	**5**	**565 - 2496**
TotHard	169	28	5	136 - 210	12	10	5	0 - 25	560	387	5	50 - 1096
CaHard	139	14	5	118 - 155	3	3	5	0 - 7	597	208	5	355 - 845
Turb	0.16	0.0	5	0.12 - 0.24	0.09	0.0	5	0.07 - 0.12	NA	NA	0	0.00 - 0.00
Amm	0.40	0.55	5	0.00 - 1.00	0.80	0.84	5	0.00 - 2.00	1.80	2.05	5	0.0 - 4.0
TOC	**5.1**	**3.2**	**5**	**1.7 - 9.9**	**0.3**	**0.0**	**5**	**0.3 - 0.3**	**17.6**	**10.1**	**5**	**4.1 - 30.2**
UV254	0.185	0.1	5	0.026 - 0.393	0.006	0.0	5	0.005 - 0.011	0.772	0.5	5	0.061 - 1.241
SUVA	3.28	1.02	5	1.50 - 3.97	2.34	1.21	5	1.80 - 4.50	3.96	1.47	5	1.48 - 5.13
Bromide	**10**	**0**	**5**	**10 - 10**	**38**	**63**	**5**	**10 - 150**				
TOX	**311**	**212**	**5**	**102 - 572**	**13**	**0**	**5**	**13 - 13**				
CHCl3	359.5	321.6	5	30.8 - 871.0	7.0	6.5	5	3.0 - 18.5				
BDCM	45.0	14.2	5	19.9 - 53.0	3.5	4.1	5	1.0 - 10.4				
DBCM	4.5	2.6	5	2.0 - 8.8	1.1	1.2	5	0.0 - 2.6				
CHBr3	0.2	0.5	5	0.0 - 1.0	0.0	0.0	5	0.0 - 0.0				
THM4	**409.1**	**328.3**	**5**	**60.5 - 926.0**	**11.6**	**11.6**	**5**	**4.0 - 31.5**				
MCAA	12.0	9.8	5	0.0 - 23.0	0.0	0.0	5	0.0 - 0.0				
DCAA	181.4	136.9	5	9.0 - 379.0	3.4	1.2	5	2.0 - 5.0				
TCAA	196.9	197.7	5	4.8 - 524.0	1.2	1.8	5	0.0 - 4.0				
MBAA	1.4	0.9	5	0.0 - 2.0	0.0	0.0	5	0.0 - 0.0				
DBAA	0.3	0.7	5	0.0 - 1.6	0.0	0.0	5	0.0 - 0.0				
BCAA	10.9	3.2	5	5.6 - 14.0	2.2	1.5	5	0.0 - 4.0				
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	**392.0**	**338.7**	**5**	**15.4 - 926.0**	**4.6**	**2.7**	**5**	**2.0 - 9.0**				
HAA6	**402.9**	**340.6**	**5**	**21.0 - 938.0**	**6.7**	**2.9**	**5**	**4.0 - 11.0**				
HAA9	**NA**	**NA**	**0**	**NA**	**NA**	**NA**	**0**	**NA**				

Mass Balance Closure Errors (%)

WQP	Count	Avg	SD/RD
Alk	5	-38	49
TDS	5	-5	7
TotHard	4	-264	496
CaHard	3	-9	14
Turb	0	n/a	n/a
Amm	2	113	38
TOC	0	n/a	n/a
UV254	5	-4	14
TDSt	38	-26	10

Comments:

SDS Conditions

WQP	**Avg**	**SD**	**Count**	**Min - Max**
Res (0)	2.30	0.82	10	1.00 - 4.00
Temp (^oC)	22.0	0.0	10	22.0 - 22.0
pH (unit)	7.6	0.0	10	7.6 - 7.6
Time (hr)	48.0	0.0	10	48.0 - 48.0

Pretreatment Information

Process	**Description**	**Scale**
Zenon Microfiltration	Microfiltration	pilot scale
Hypersperse AF 200	Antiscalent	pilot scale
Cartridge Filtration	5 mm exclusion size	Pilot-scale
NaOCL + NH4CL	Chloramine addition	Pilot scale
Hydrochloric Acid Addition	pH Adjustment	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	-50.8%	41.3%
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	0.0%	0.0%	Sys Perm - Sum Stg Pe	0.0%	0.0%	Sys Perm - Avg Stg Perm	-13.0%	15.3%

Stage Summary

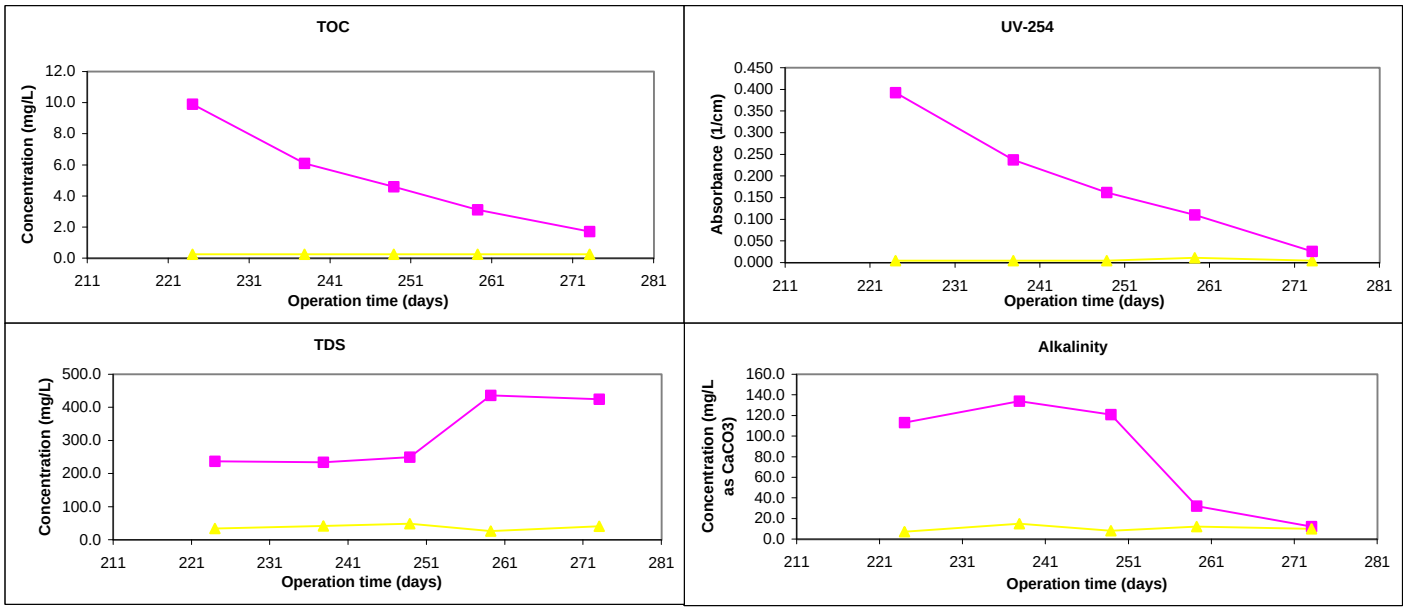
	Stage 1 Influent						Stage 1 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery			**0.50**	**0.07**	**5**	**0.43 - 0.57**					
pH	6.9	7.1	7.1	1.3	5	5.2 - 8.2	6.3	6.3	0.9	5	5.4 - 7.4
Temp	27.0	34.0	33.6	2.6	5	31.0 - 37.0	34.0	33.6	2.6	5	31.0 - 37.0
Alk	82	297	184	151	5	9 - 395	10	10	2	5	8 - 13
TDS	**316**	**1256**	721	**436**	**5**	**332 - 1457**	**38**	**36**	**23**	**5**	**10 - 73**
TotHard	169	560	396	168	5	204 - 602	12	10	10	5	0 - 26
CaHard	139	597	332	146	5	180 - 540	3	4	4	5	0 - 9
Turb	0.16	NA	**0.16**	0	5	0.14 - 0.17	0.09	0.09	0.01	5	0 - 0
TOC	**5.1**	**17.6**	12.8	**7.1**	**5**	**2.3 - 21.3**	**0.3**	**0.3**	**0.0**	**5**	**0.3 - 0.3**
UV254	0.185	**0.772**	0.438	0.274	5	0.037 - 0.776	0.006	0.006	0.004	5	0.005 - 0.013
SUVA	3.28	**3.96**	**3.12**	0.97	5	1.62 - 3.99	2.34	2.51	1.59	5	1.80 - 5.36

	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**	**0.14**	**5**	**0.37 - 0.67**					
pH	6.9	7.1	7.1	1.3	5	5.2 - 8.2	6.3	6.3	0.8	5	5.4 - 7.2
Temp	27.0	34.0	33.6	2.6	5	31.0 - 37.0	34.0	33.6	2.6	5	31.0 - 37.0
Alk	82	297	255	220	5	7 - 574	10	10	3	5	**7 - 14**
TDS	**316**	**1256**	1000	**574**	**5**	**444 - 1964**	**38**	**40**	**19**	**5**	**23 - 72**
TotHard	169	560	537	240	5	268 - 864	12	11	8	5	0 - 20
CaHard	139	597	485	191	4	245 - 673	3	4	4	5	0 - 9
Turb	0.16	NA	0.20	0	5	0.15 - 0.26	0.09	0.10	0.02	5	0 - 0
TOC	**5.1**	**17.6**	15.7	**9.0**	**5**	**3.2 - 28.2**	**0.3**	**0.3**	**0.0**	**5**	**0.3 - 0.3**
UV254	0.185	**0.772**	0.482	0.513	5	0.005 - 1.277	0.006	0.008	0.005	5	0.005 - 0.016
SUVA	3.28	**3.96**	**2.74**	1.87	5.00	0.02 - 4.53	2.34	3.09	1.99	5.00	1.80 - 6.32

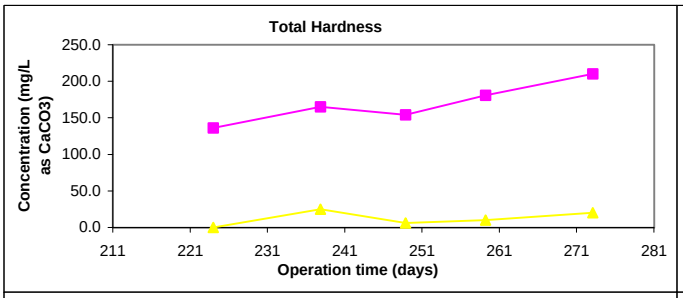
	Stage 3 Influent						Stage 3 Permeate				
WQP	**Sys Feed**	**Sys Conc**	**Mean**	**SD**	**Count**	**Min/Max**	**Sys Perm**	**Mean**	**SD**	**Count**	**Min/Max**
Recovery											
pH											
Temp											
Alk	This	was	**only**	a	two	stage	study.				
TDS											
TotHard											
CaHard			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

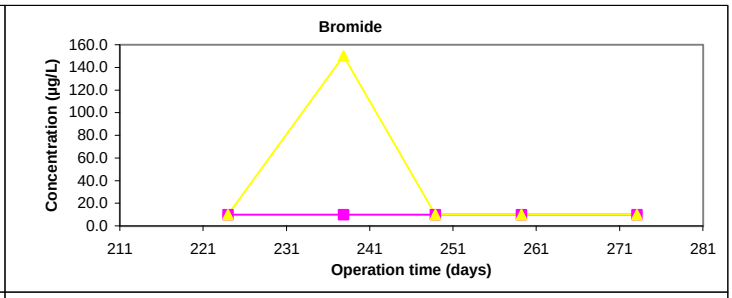
Chart Legend:
- Feed (System)
- Permeate (System)

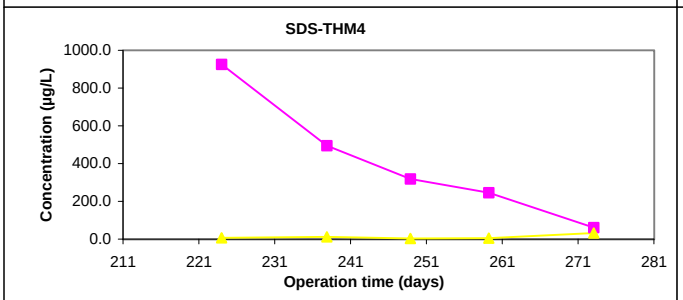
Water Quality Parameter Graphs

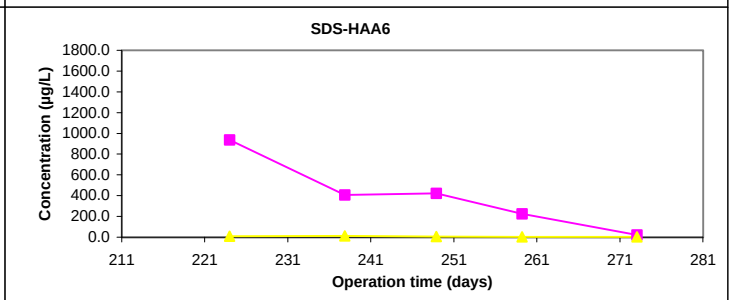


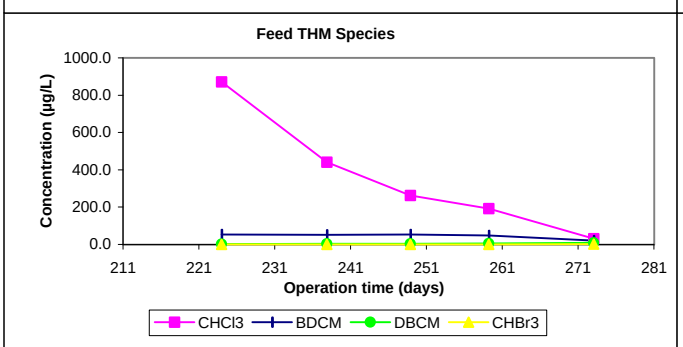
Water Quality Graphs (Continued)

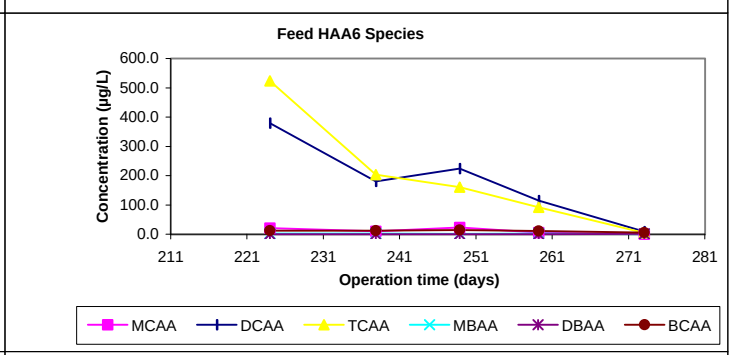


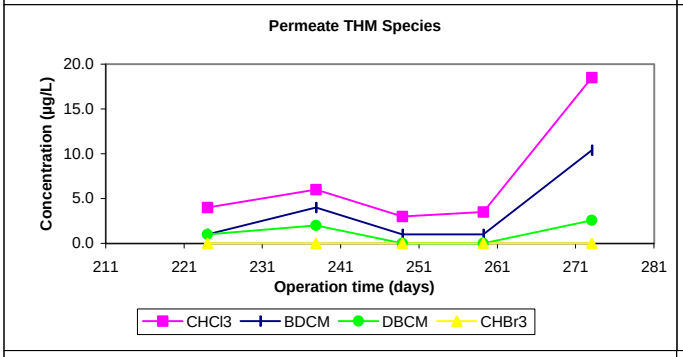


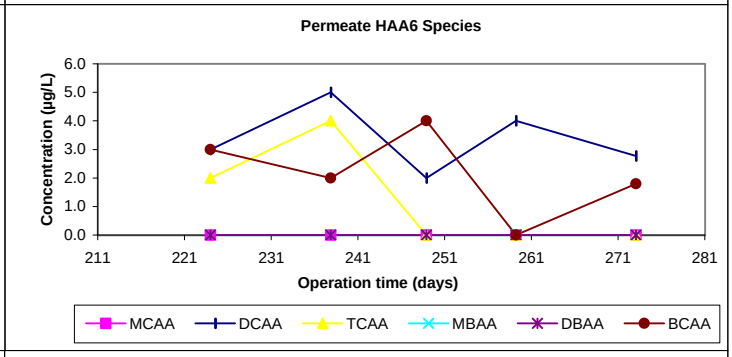


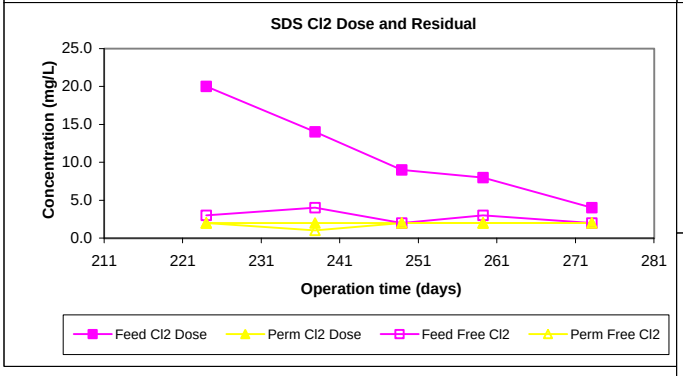


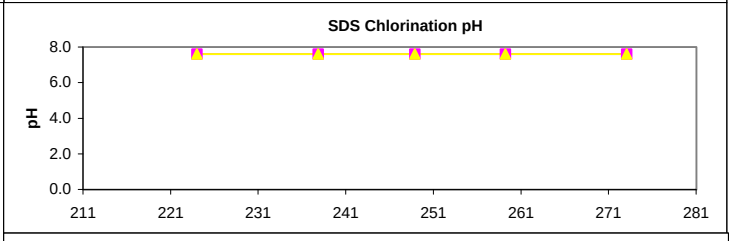


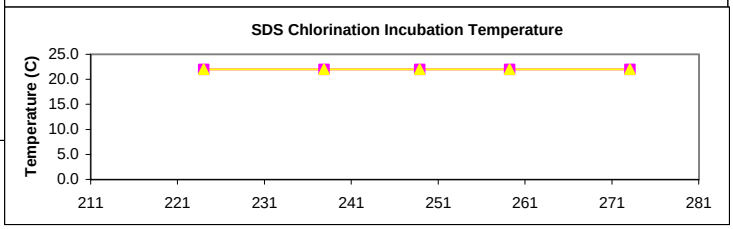












Productivity Graphs