

ICR TREATMENT STUDY ANALYSIS

Base Analysis and Data Review Comments

Treatment Study ID	3004
Study Protocol	Membrane Single-Element Long-Term Pilot Study
Plant ICR Number	677
PWS Name	City of Norfolk
City, State, Zip	Norfolk, VA 23502

General Comments:

1. The City of Norfolk was only required to conduct a bench-scale test under the ICR, but opted to conduct a LTSEBST.
2. During this study the NF-70 (FilmTec) was evaluated for 6100 hours; however, due to excessive membrane fouling, this membrane was replaced with the LFC1 (Hydranautics) membrane for the remainder of the study (2000 hours).
3. The NF-70 membrane system was operated at 90% recovery during the last water quality sampling event during Sessions 2 and 3 in order to evaluate concentrate (and permeate) water quality at higher recoveries for concentrate disposal options. All other water quality sampling was done while system was operating at 70% recovery.
4. The Summary Report presents the results of some toxicity testing performed using the concentrate from the SEBST system.

Water Quality Comments:

1. Fifty-five water quality outliers were identified and removed prior to base analysis.
2. SDS-temperature (in degrees Celsius) decreased during the study, starting in Session 3 from the mid-to-low 20s to the mid-teens in Session 4 (NF-70) and Session 1 (LFC1).
3. There were several instances when the pH of the SDS samples was considerably lower, compared to "normal" conditions, including: week 16 feed sample (pH = 5.6, compared to 6.7 to 7.3 during the other weeks in that session), week 28 permeate sample (pH = 5.6, compared to 7.0 to 7.4 during the other weeks in that session), and week 32 permeate sample (pH = 4.2, compared to 7.0 to 7.1 during the other weeks in that session). The corresponding DBP samples were not used during data analysis.

Productivity Comments:

1. No productivity outliers were identified and removed prior to base analysis.
2. During early operation of the NF-70 membrane, the membrane-specific pretreatment included only antiscalent addition and cartridge filtration. However, due to excessive fouling, several pretreatment modifications were made during this evaluation. These changes are listed in Table 3 and shown on Figure 4 in the Summary Report. Also, a detailed description of NF-70 cleaning events and their impact on membrane performance is given in the final report.
3. Chloramines was fed to the NF-70 membrane system from 1364 through 2812 hours in an attempt to mitigate the excessive membrane fouling; however, this did not result in improved membrane productivity performance. The chloramine feed was shut-off one hour prior to biweekly water quality sampling.
4. During analysis of the productivity data from the NF-70 evaluation, a large range of cleaning intervals were calculated, from 7 to 346 days. The average cleaning interval was calculated to be 62 ± 125 days. This range of cleaning intervals is largely due to severe fouling events, hypothesized to be a result of precipitation of aluminum salts and/or organic matter. When the pretreatment was adequate to prevent inorganic scale formation, the longest cleaning interval of 346 days was observed; however, this high level of productivity ended when the full-scale plant began feeding iron. Although this level of productivity may be achievable (see results for the LFC1 membrane) the analyst felt that it was inappropriate to use only this operational cycle in computing the cleaning interval since most operating cycles exhibited much shorted cleaning intervals.
5. Less fouling was observed during operation with the LFC1, as detailed in the text of the Summary Report, and Figure 5. This membrane was operated for a period with pH depression to control inorganic scale formation; however, after the first and only cleaning event, the system was operated at ambient pH. During operation at this higher pH, the rate of fouling was an order of magnitude higher than during operation at the lower pH. Analysis of the productivity data during operation at the depressed pH yielded a cleaning interval of one year or greater. Both the EPA analysis and the consultant's analysis yielded similar results. The upper bound of 365 days was used for the cleaning interval.

ICR Information

ID / ICR#: VA37010100 / 677
 ICR Contact: Mr. Vernon Land
 Phone No.: 757/ 441-5678
 Period: 5/15/98 - 7/23/98 (69 days)

Membrane Information

Manufacturer: FilmTec	Mfr. MTC _w : 0.315 (gfd/psi)
Trade Name: NF70	Mfr. Temp: 21.5 °C
Membrane Model: NF70-4040	Max Flow: 18.0 gpm
MWCO: 200 Daltons	Min Flow: 4.0 gpm
Element Size: 4" x 40"	Total Width: 12.7 ft
Element Area: 70.0 ft ²	Feed Sp Thickness: 0.0023 ft
Design Flux: 14.4 gfd	840 Element Area: 400.0 ft ²
Mfr. NDP: 45.7 psi	840 Purchase Price: \$700

Design Parameters

Norm Temp: 20.0 °C	Recycle Ratio: 4.28
Temp Norm MTC-w: 0.301 TavGC	Manuf rep Re _{JTDS} : 70%
Design Recovery: 0.75	TDS _F : 70.0 mg/L
Design Flux: 14.4 gfd	

Water Quality Summary

	Mean	SD	Feed Count	Min/Max	Mean	SD	Permeate Count	Min/Max	Mean	SD	Concentrate Count	Min/Max
pH	6.3	0.2	5	6.1 - 6.6	5.8	0.1	5	5.7 - 5.9	6.7	0.3	4	6.4 - 7.0
Temp	24.1	3.7	5	19.8 - 29.4	24.7	3.5	5	21.8 - 30.5	24.8	6.1	3	18.3 - 30.5
Alk	10	2	5	7 - 13	3	1	5	1 - 4	27	10	5	15 - 42
TDS	70	11	5	56 - 82	7	1	5	6 - 8	188	22	5	158 - 212
TotHard	42	8	5	33 - 51	7	3	5	2 - 11	154	33	5	114 - 186
CaHard	27	8	5	19 - 35	0	1	5	0 - 2	115	39	5	70 - 162
Turb	0.17	0.06	5	0.14 - 0.27	0.10	0.02	5	0.08 - 0.13	0.17	0.03	5	0.15 - 0.22
Amm	0.0	0.1	5	0.0 - 0.2	0.0	0.1	5	0.0 - 0.2	0.0	0.1	5	0.0 - 0.1
TOC	2.7	0.1	5	2.6 - 2.8	0.3	0.0	5	0.3 - 0.3	9.9	0.4	5	9.5 - 10.5
UV254	0.049	0.0	5	0.041 - 0.056	0.005	0.0	5	0.005 - 0.009	0.190	0.0	5	0.176 - 0.204
SUVA	1.81	0.19	5	1.60 - 2.07	2.16	0.80	5	1.80 - 3.60	1.91	0.06	5	1.83 - 1.98
Bromide	21	7	5	10 - 27	10	0	5	10 - 10				
TOX	183	54	5	137 - 268	13	0	5	13 - 13				
CHCl3	42.4	13.3	5	32.0 - 62.3	2.1	1.5	5	0.0 - 4.0	Mass Balance Closure Errors (%)			
BDCM	8.1	1.3	5	6.6 - 9.7	0.2	0.5	5	0.0 - 1.1				
DBCM	0.4	0.6	5	0.0 - 1.1	0.0	0.0	5	0.0 - 0.0	WQP	Count	Avg	SD/RD
CHBr3	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Alk	5	-17	26
THM4	50.9	14.8	5	38.6 - 73.0	2.3	1.9	5	0.0 - 5.1	TDS	5	-42	21
MCAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	TotHard	5	-1	28
DCAA	16.7	1.5	5	15.0 - 18.5	0.7	1.5	5	0.0 - 3.3	CaHard	1	0	n/a
TCAA	23.6	5.3	5	18.0 - 30.0	0.2	0.4	5	0.0 - 1.0	Turb	5	-111	88
MBAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Amm	1	-99	n/a
DBAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	TOC	0	n/a	n/a
BCAA	3.3	0.3	5	2.9 - 3.6	0.0	0.0	5	0.0 - 0.0	UV254	1	-4	n/a
TBAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	TDS _t	68	-42	29
CDBAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Comments:			
DCBAA	5.5	1.4	5	3.9 - 6.6	0.0	0.0	5	0.0 - 0.0				
HAA5	40.3	6.8	5	33.0 - 48.5	0.9	1.4	5	0.0 - 3.3				
HAA6	43.6	7.0	5	35.9 - 52.1	0.9	1.4	5	0.0 - 3.3				
HAA9	49.1	9.4	3	39.8 - 58.7	0.3	0.6	3	0.0 - 1.0				

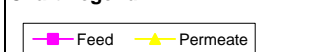
SDS Conditions

WQP	Avg	SD	Count	Min - Max
Res (0)	1.28	1.16	10	0.12 - 4.15
Temp (°C)	22.8	1.5	10	21.0 - 24.7
pH (unit)	7.0	0.2	10	6.5 - 7.2
Time (hr)	24.2	0.4	10	23.9 - 25.1

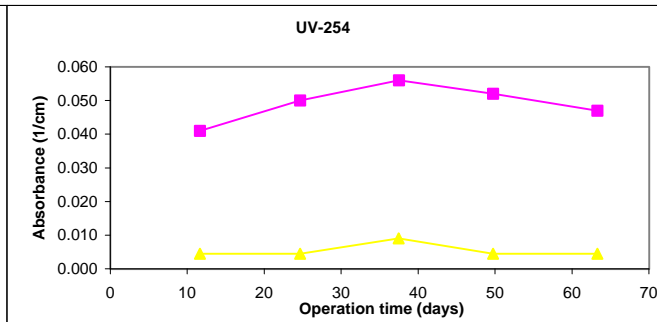
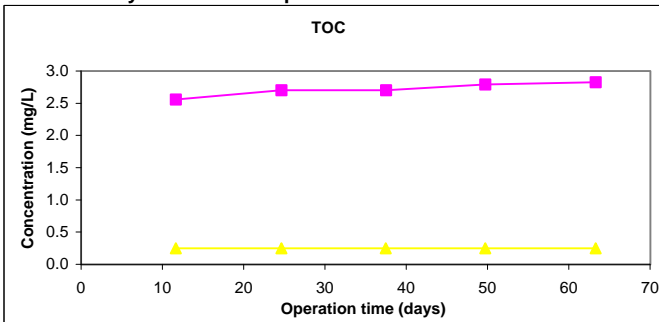
Pretreatment Information

Process	Description	Scale
Rapid Mix	Mechanical	Full-Scale
	Powdered Activated Carbon: Ave. dose 2.36 mg	
	Alum Al ₂ (SO ₄) ₃ *14H ₂ O : Ave. dose 30.1 mg/L	
Flocculation	Mechanical	Full-Scale
Sedimentation	Conventional	Full-Scale
Filtration	Dual Media - Anthracite/sand	Pilot-Scale

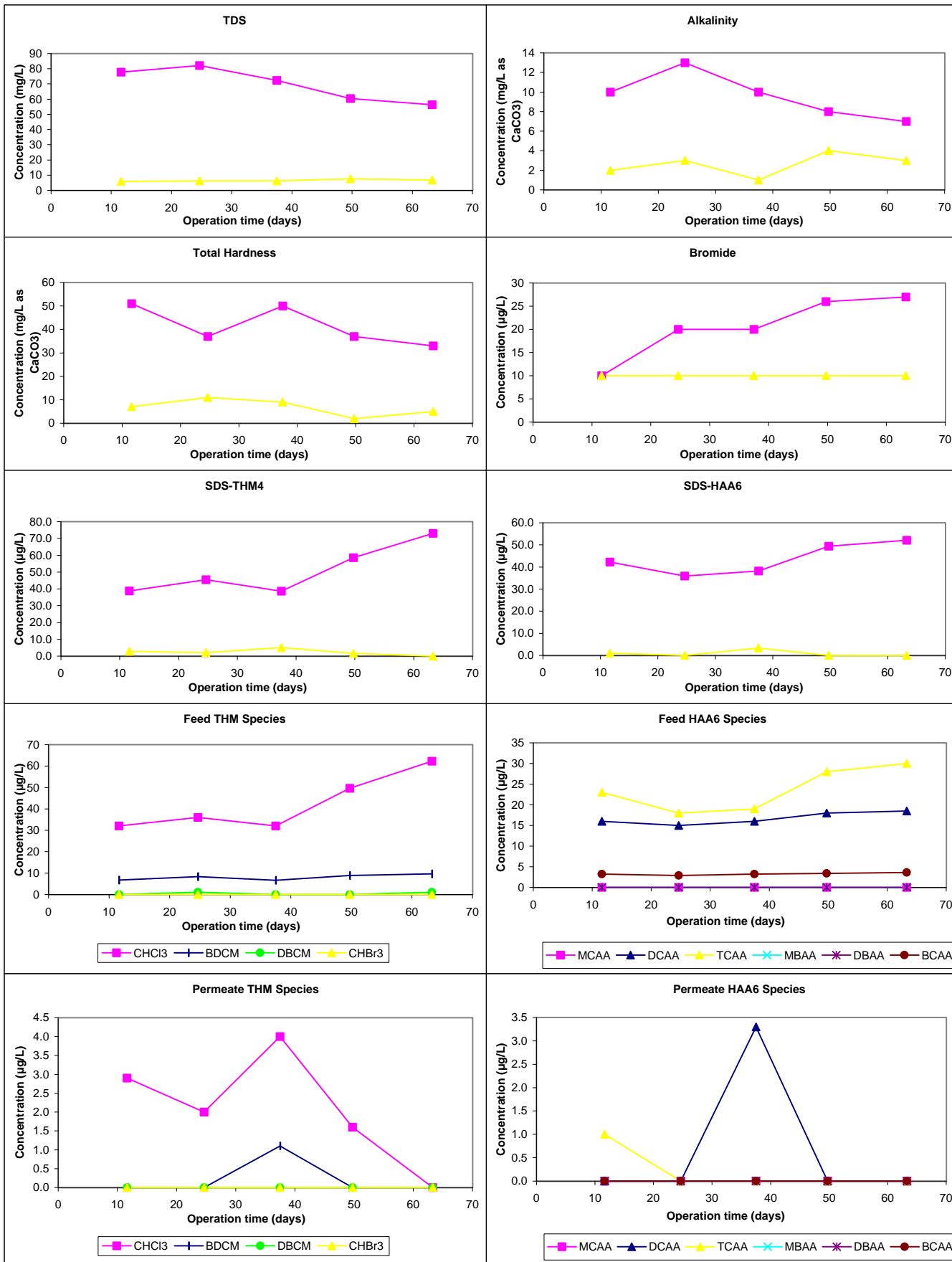
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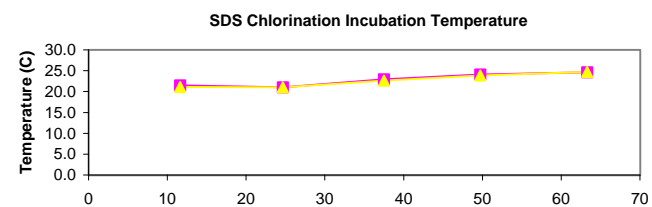
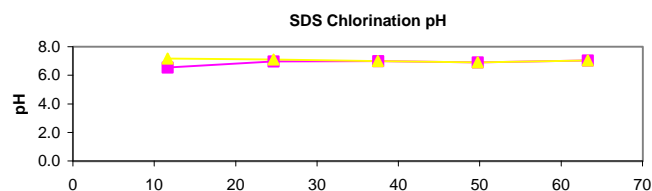
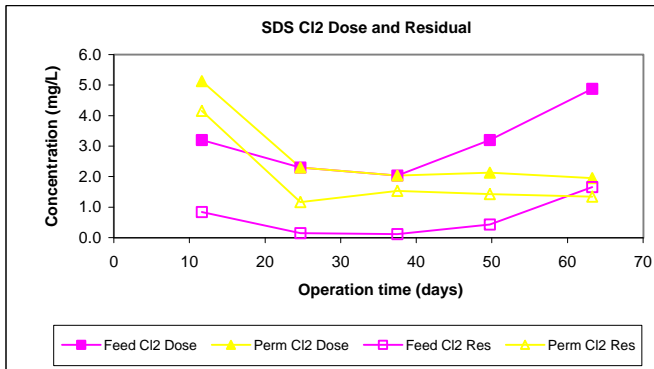
Water Quality Parameter Graphs



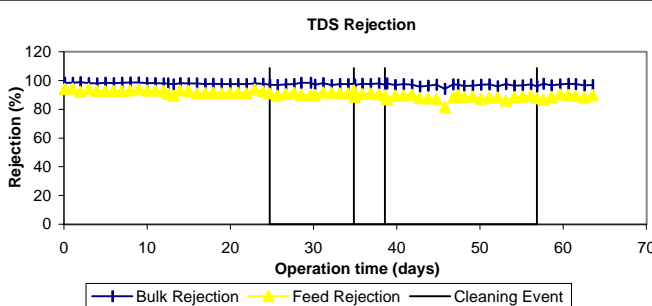
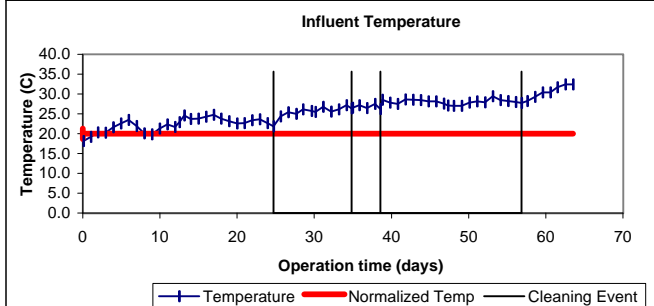
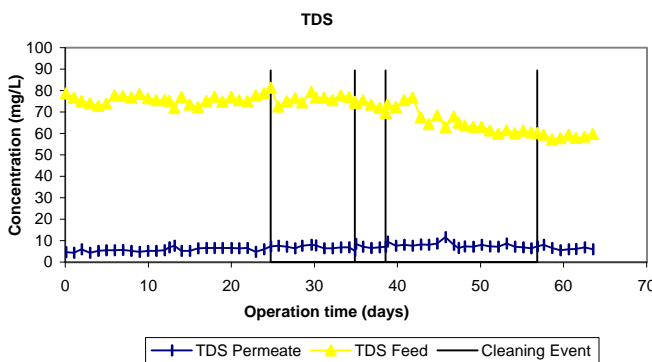
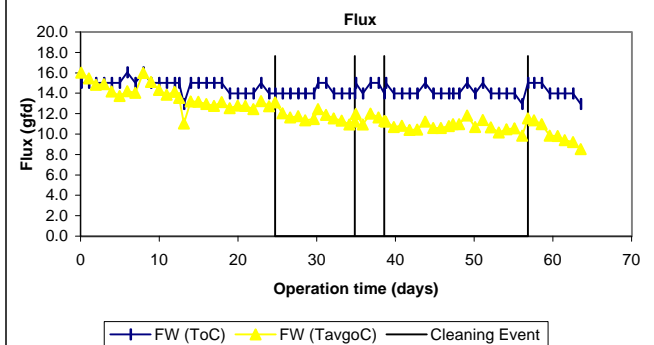
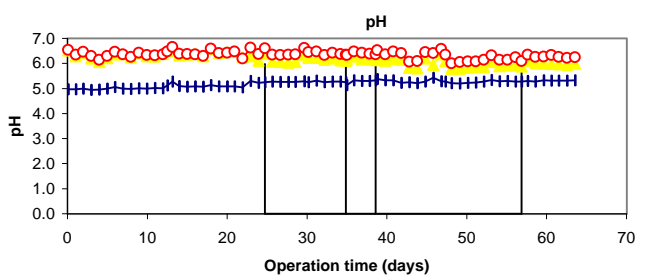
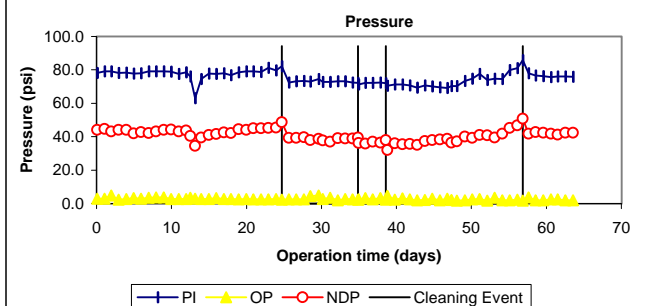
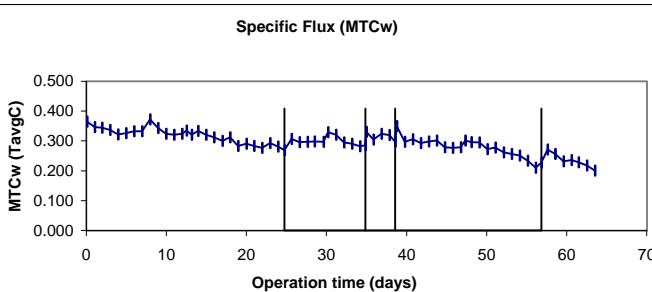
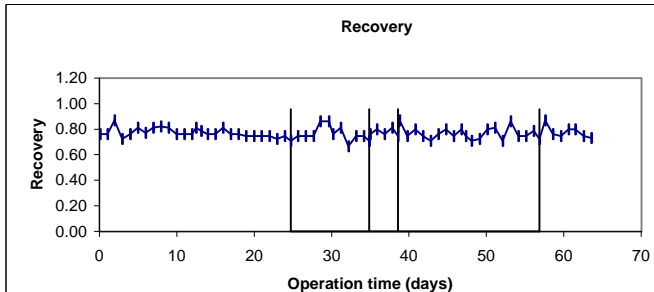
Water Quality Parameter Graphs (Continued)



Water Quality Parameter Graphs (Continued)



Productivity Graphs



ICR Information

ID / ICR#: VA37010100 / 677
 ICR Contact: Mr. Vernon Land
 Phone No.: 757/441-5678
 Period: 7/24/98 - 10/1/98 (69 days)

Membrane Information

Manufacturer: FilmTec	Mfr. MTC _w : 0.315 (gfd/psi)
Trade Name: NF70	Mfr. Temp: 21.5 °C
Membrane Model: NF70-4040	Max Flow: 16.0 gpm
MWCO: 200 Daltons	Min Flow: 4.0 gpm
Element Size: 4" x 40"	Total Width: 12.7 ft
Element Area: 70.0 ft ²	Feed Sp Thickness: 0.0023 ft
Design Flux: 14.4 gfd	840 Element Area: 400.0 ft ²
Mfr. NDP: 45.7 psi	840 Purchase Price: \$700

Design Parameters

Norm Temp: 20.0 °C	Recycle Ratio: 4.28
Temp Norm MTC-w: 0.301 TavGC	Manuf rep Re _{JTDS} : 70%
Design Recovery: 0.75	TDS _F : 70.0 mg/L
Design Flux: 14.4 gfd	

Water Quality Summary

	Mean	SD	Feed Count	Min/Max	Mean	SD	Permeate Count	Min/Max	Mean	SD	Concentrate Count	Min/Max
pH	6.8	0.5	5	6.1 - 7.4	6.6	0.5	5	5.8 - 6.9	7.5	0.8	5	6.5 - 8.4
Temp	27.6	0.7	5	26.4 - 28.3	27.9	0.8	5	26.7 - 28.8	28.2	1.0	5	26.7 - 29.2
Alk	14	5	5	6 - 18	4	1	5	3 - 5	72	39	5	18 - 127
TDS	74	8	5	60 - 81	6	1	5	6 - 7	280	82	5	205 - 418
TotHard	36	5	5	27 - 40	7	4	5	3 - 10	122	36	5	97 - 184
CaHard	17	2	5	15 - 19	0	0	5	0 - 0	76	19	5	59 - 109
Turb	0.19	0.15	5	0.07 - 0.44	0.13	0.08	5	0.06 - 0.25	0.23	0.11	5	0.13 - 0.38
Amm	0.0	0.0	5	0.0 - 0.0	0.1	0.1	5	0.0 - 0.1	0.0	0.1	5	0.0 - 0.2
TOC	2.6	0.2	5	2.3 - 2.9	0.3	0.0	5	0.3 - 0.3	10.8	2.5	5	9.2 - 15.1
UV254	0.043	0.0	4	0.039 - 0.046	0.005	0.0	4	0.005 - 0.005	0.195	0.1	4	0.151 - 0.264
SUVA	NA	NA	4	NA	NA	NA	4	NA	NA	NA	4	NA
Bromide	22	11	5	10 - 32	10	0	5	10 - 10				
TOX	191	42	4	145 - 235	19	14	4	13 - 40				
CHCl3	37.8	9.4	5	24.3 - 47.6	2.0	1.4	5	0.0 - 3.4	Mass Balance Closure Errors (%)			
BDCM	8.9	2.9	5	5.8 - 12.5	0.0	0.0	5	0.0 - 0.0				
DBCM	0.9	0.9	5	0.0 - 2.1	0.0	0.0	5	0.0 - 0.0	WQP Count Avg SD/RD			
CHBr3	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Alk	5	10	23
THM4	47.6	12.7	5	30.5 - 60.3	2.0	1.4	5	0.0 - 3.4	TDS	5	-37	45
MCAA	1.2	1.8	5	0.0 - 4.1	0.0	0.0	5	0.0 - 0.0	TotHard	5	-36	16
DCAA	16.4	4.1	5	13.0 - 23.0	0.6	1.0	5	0.0 - 2.2	CaHard	0	n/a	n/a
TCAA	25.2	4.1	5	20.0 - 31.0	0.0	0.0	5	0.0 - 0.0	Turb	5	-87	203
MBAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Amm	0	n/a	n/a
DBAA	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	TOC	0	n/a	n/a
BCAA	3.5	0.4	5	2.9 - 3.8	0.0	0.0	5	0.0 - 0.0	UV254	0	n/a	n/a
TBAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	TDS _t	68	-12	21
CDBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	Comments:			
DCBAA	6.0	0.6	5	5.2 - 6.8	0.0	0.0	5	0.0 - 0.0				
HAA5	42.8	7.0	5	35.0 - 54.0	0.6	1.0	5	0.0 - 2.2				
HAA6	46.4	7.2	5	38.6 - 57.8	0.6	1.0	5	0.0 - 2.2				
HAA9	54.4	9.9	3	44.8 - 64.6	1.1	1.1	3	0.0 - 2.2				

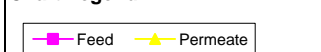
SDS Conditions

WQP	Avg	SD	Count	Min - Max
Res (0)	1.29	0.36	10	0.78 - 2.09
Temp (°C)	24.2	0.6	10	23.1 - 24.9
pH (unit)	7.0	0.5	10	5.6 - 7.3
Time (hr)	23.8	0.7	10	23.0 - 25.0

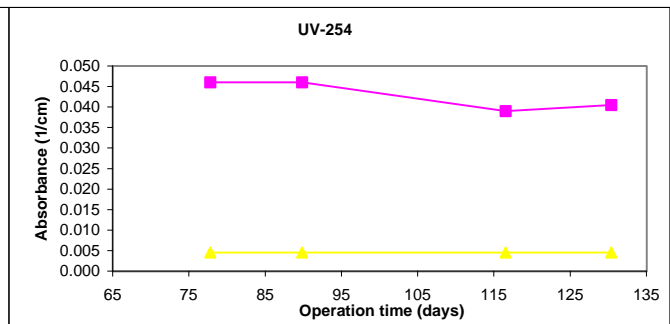
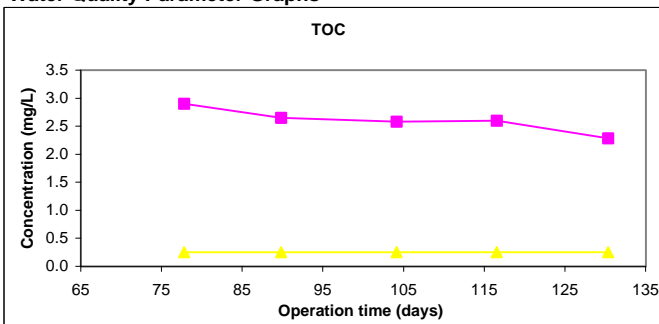
Pretreatment Information

Process	Description	Scale
Rapid Mix	Mechanical	Full-Scale
	Powdered Activated Carbon: Ave. dose 2.36 mg	
	Alum Al ₂ (SO ₄) ₃ *14H ₂ O : Ave. dose 30.1 mg/L	
Flocculation	Mechanical	Full-Scale
Sedimentation	Conventional	Full-Scale
Filtration	Dual Media - Anthracite/sand	Pilot-Scale

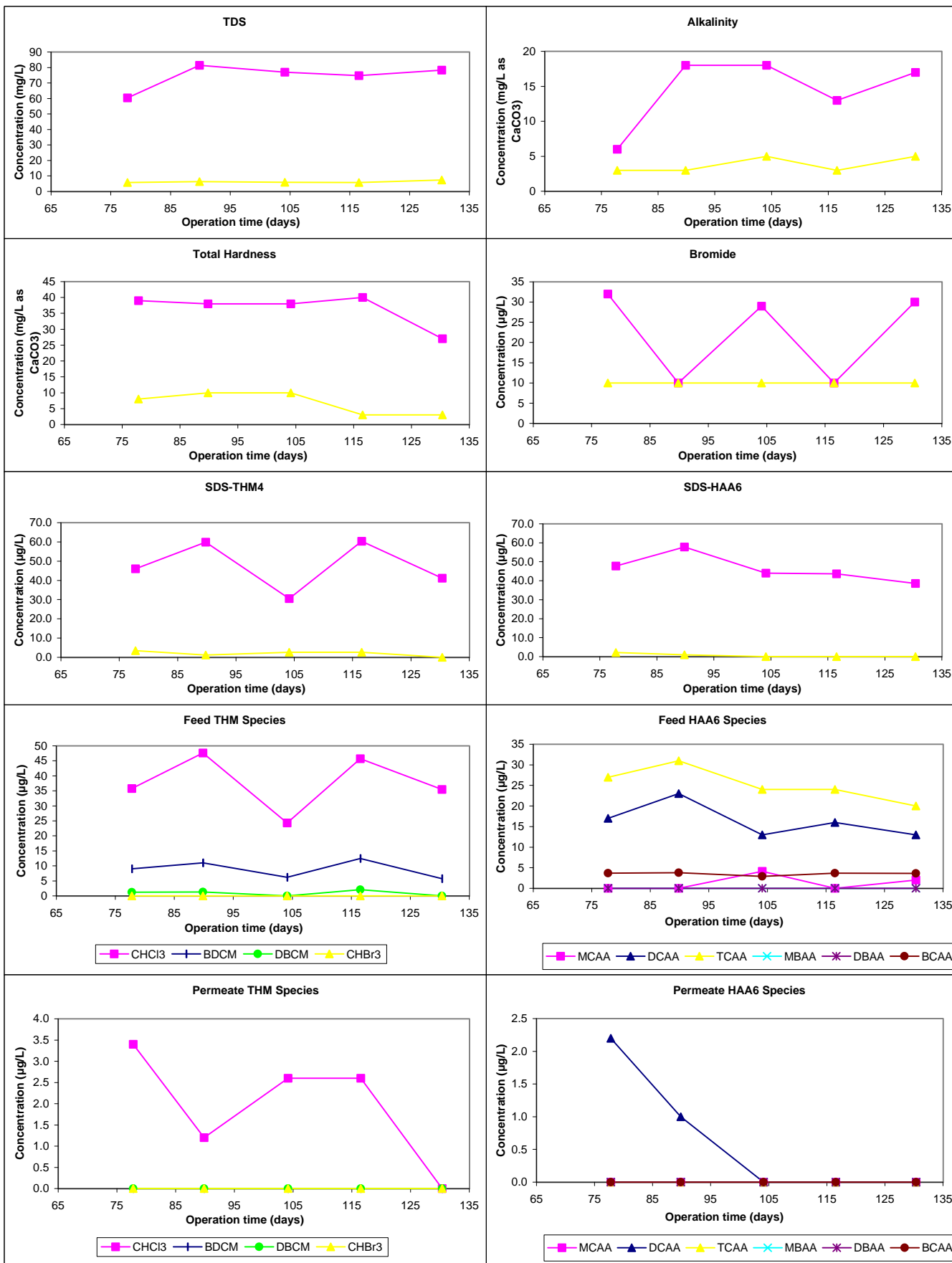
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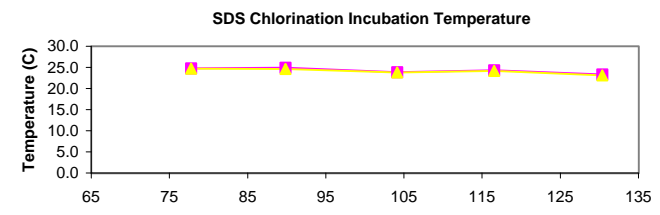
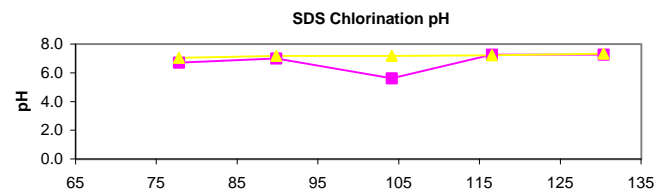
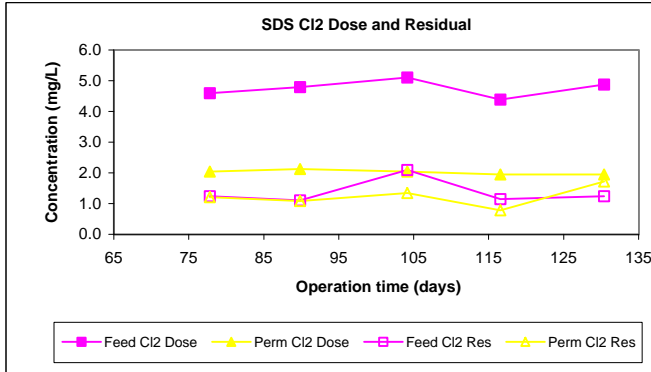
Water Quality Parameter Graphs



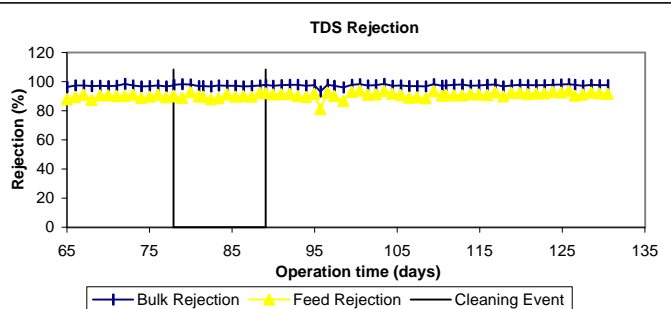
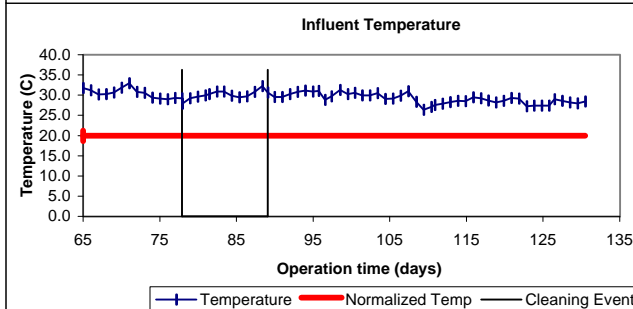
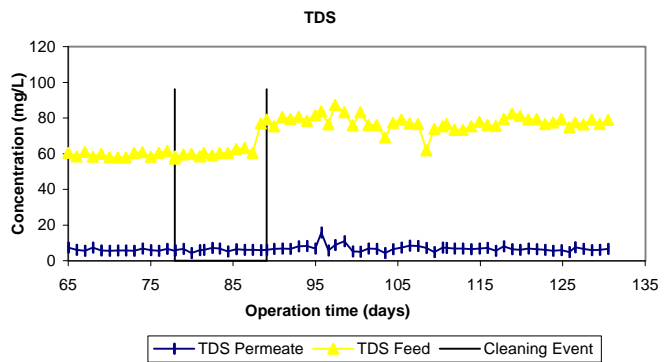
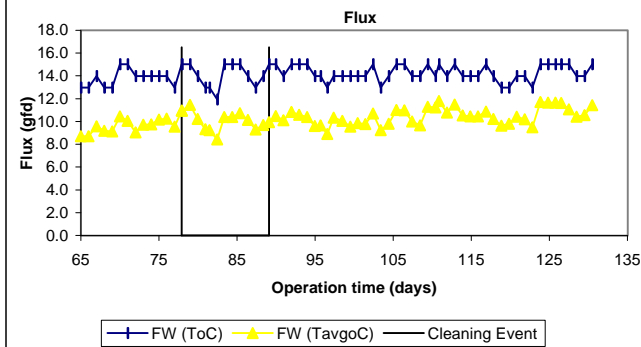
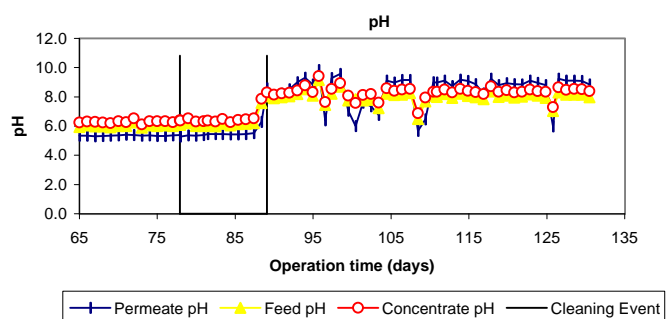
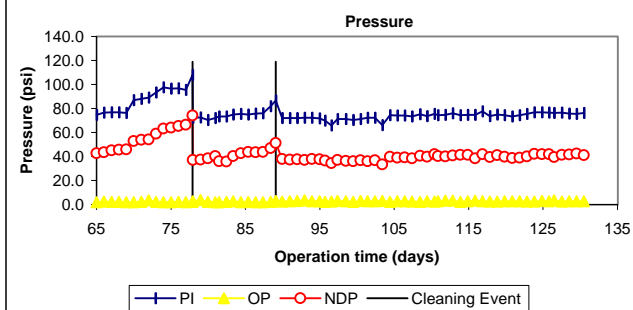
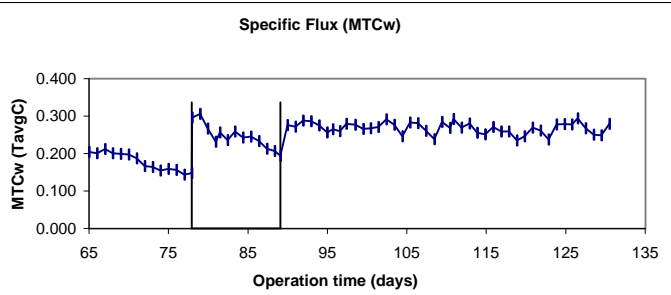
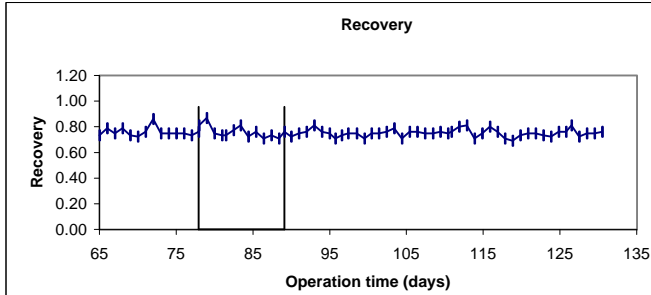
Water Quality Parameter Graphs (Continued)



Water Quality Parameter Graphs (Continued)



Productivity Graphs



ICR Information

ID / ICR#: VA37010100 / 677
 ICR Contact: Mr. Vernon Land
 Phone No.: 757/ 441-5678
 Period: 10/2/98 - 12/10/98 (69 days)

Membrane Information

Manufacturer: FilmTec
 Trade Name: NF70
 Membrane Model: NF70-4040
 MWCO: 200 Daltons
 Element Size: 4" x 40"
 Element Area: 70.0 ft²
 Design Flux: 14.4 gfd
 Mfr. NDP: 45.7 psi

Mfr. MTC_w: 0.315 (gfd/psi)
 Mfr. Temp: 21.5 °C
 Max Flow: 16.0 gpm
 Min Flow: 4.0 gpm
 Total Width : 12.7 ft
 Feed Sp Thickness: 0.0023 ft
 840 Element Area 400.0 ft²
 840 Purchase Price: \$700

Design Parameters

Norm Temp: 20.0 °C
 Temp Norm MTC-w: 0.301 TavGC
 Design Recovery: 0.75
 Design Flux: 14.4 gfd

Recycle Ratio: 4.28
 Manuf rep Re_{JDS}: 70%
 TDS_F: 70.0 mg/L

Water Quality Summary

	Mean	SD	Feed Count	Min/Max	Mean	SD	Permeate Count	Min/Max	Mean	SD	Concentrate Count	Min/Max
pH	7.8	0.9	5	6.9 - 9.2	8.1	1.0	5	6.6 - 9.1	8.3	0.5	5	7.6 - 8.7
Temp	20.0	2.0	5	18.1 - 23.0	21.4	1.2	5	20.3 - 23.3	21.4	0.9	5	20.9 - 22.9
Alk	17	3	5	15 - 21	4	2	5	1 - 7	100	68	5	62 - 221
TDS	67	13	5	57 - 89	12	9	5	2 - 24	372	250	5	230 - 819
TotHard	31	3	5	28 - 35	4	3	5	2 - 8	149	89	5	101 - 308
CaHard	15	1	5	14 - 16	1	3	5	0 - 7	83	56	5	53 - 183
Turb	0.15	0.12	5	0.08 - 0.36	0.13	0.09	5	0.06 - 0.28	0.20	0.13	5	0.10 - 0.42
Amm	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	0.0	0.0	5	0.0 - 0.1
TOC	2.4	0.2	5	2.2 - 2.6	0.3	0.0	5	0.3 - 0.3	12.8	8.4	5	8.5 - 27.8
UV254	0.044	0.0	5	0.041 - 0.049	0.005	0.0	5	0.005 - 0.005	0.232	0.2	5	0.149 - 0.504
SUVA	1.86	0.25	5	1.58 - 2.20	1.80	0.00	5	1.80 - 1.80	1.81	0.11	5	1.73 - 2.00
Bromide	35	4	5	30 - 40	10	0	5	10 - 10				
TOX	170	8	4	162 - 180	26	19	5	13 - 50				
CHCl3	43.9	25.6	4	19.2 - 79.9	0.0	0.0	5	0.0 - 0.0	Mass Balance			
BDCM	7.8	1.4	4	6.5 - 9.0	0.0	0.0	5	0.0 - 0.0	Closure Errors (%)			
DBCM	0.6	0.7	4	0.0 - 1.3	0.0	0.0	5	0.0 - 0.0	WQP	Count	Avg	SD/RD
CHBr3	0.0	0.0	4	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Alk	5	14	26
THM4	52.2	27.0	4	25.7 - 89.9	0.0	0.0	5	0.0 - 0.0	TDS	5	12	10
MCAA	0.9	1.7	4	0.0 - 3.4	0.0	0.0	5	0.0 - 0.0	TotHard	5	-9	26
DCAA	13.9	3.0	4	11.0 - 17.5	0.0	0.0	5	0.0 - 0.0	CaHard	1	28	n/a
TCAA	19.9	2.2	4	18.0 - 23.0	0.0	0.0	5	0.0 - 0.0	Turb	5	-20	89
MBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Amm	0	n/a	n/a
DBAA	0.0	0.0	4	0.0 - 0.0	0.6	1.3	5	0.0 - 3.0	TOC	0	n/a	n/a
BCAA	4.0	0.4	4	3.4 - 4.3	1.5	3.4	5	0.0 - 7.7	UV254	0	n/a	n/a
TBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	TDS _t	68	0	10
CDBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	5	0.0 - 0.0	Comments:			
DCBAA	5.4	3.7	4	0.0 - 8.0	0.0	0.0	5	0.0 - 0.0				
HAA5	34.6	5.5	4	29.0 - 40.4	0.6	1.3	5	0.0 - 3.0				
HAA6	38.6	5.7	4	32.4 - 44.6	2.1	4.8	5	0.0 - 10.7				
HAA9	44.1	4.6	4	40.0 - 50.7	2.1	4.8	5	0.0 - 10.7				

SDS Conditions

WQP	Avg	SD	Count	Min - Max
Res (0)	1.27	0.87	9	0.35 - 3.10
Temp (°C)	18.8	2.2	9	16.8 - 22.5
pH (unit)	7.0	0.6	9	5.4 - 7.5
Time (hr)	23.8	0.4	9	23.0 - 24.0

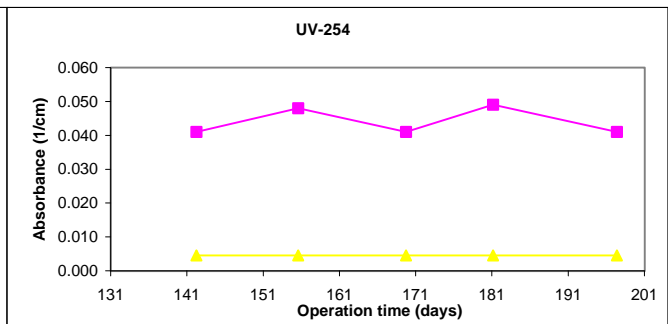
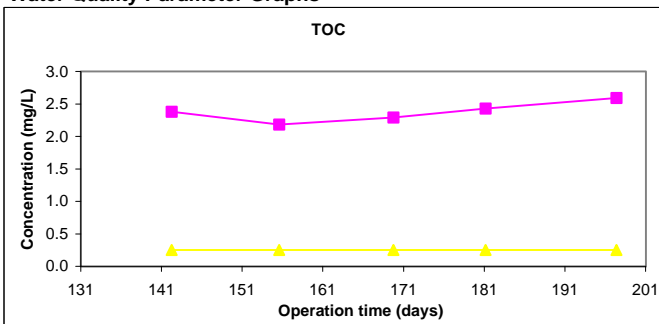
Pretreatment Information

Process	Description	Scale
Rapid Mix	Mechanical	Full-Scale
	Powdered Activated Carbon: Ave. dose 2.36 mg	
	Alum Al ₂ (SO ₄) ₃ *14H ₂ O : Ave. dose 30.1 mg/L	
Flocculation	Mechanical	Full-Scale
Sedimentation	Conventional	Full-Scale
Filtration	Dual Media - Anthracite/sand	Pilot-Scale

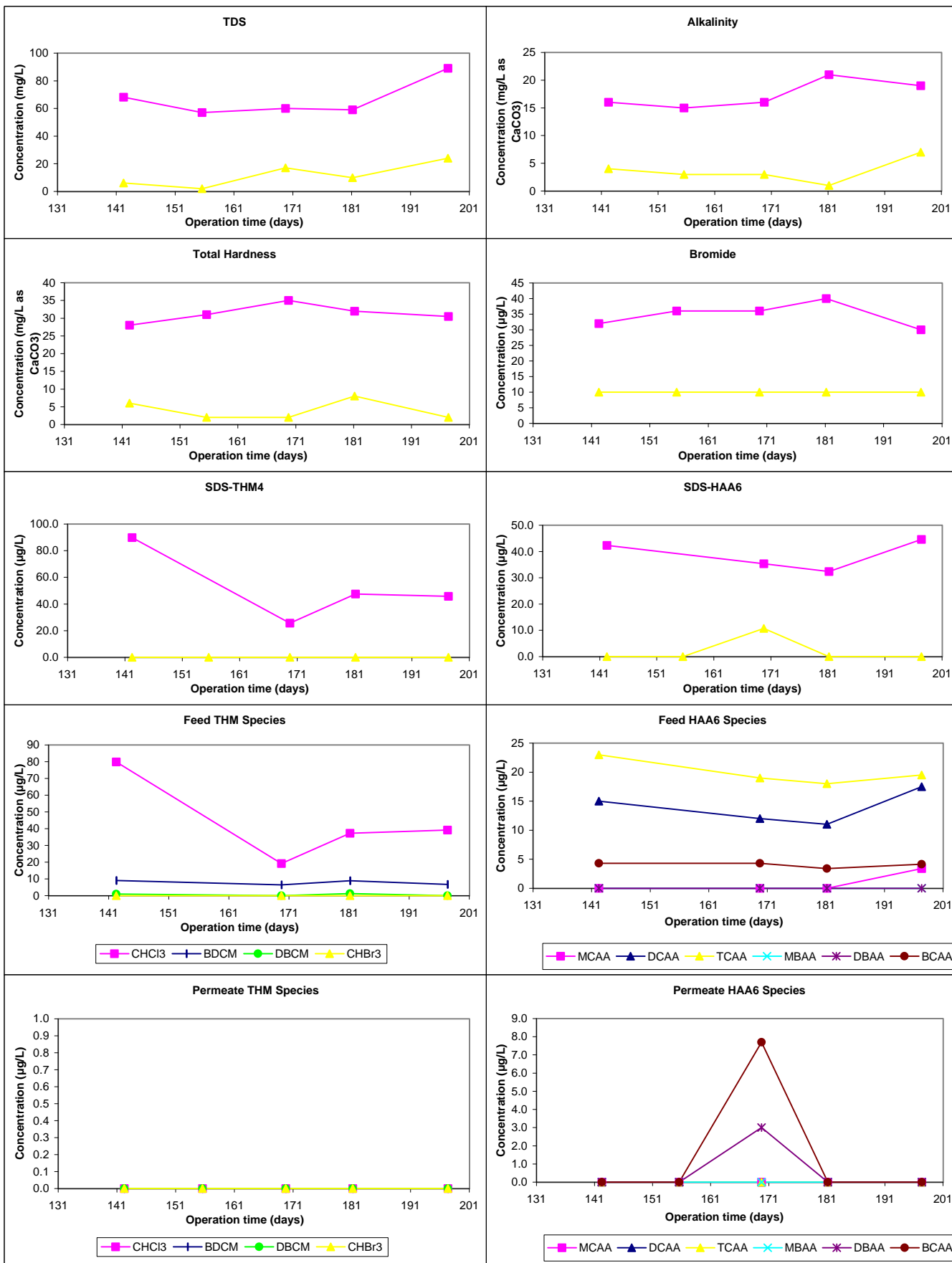
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Feed Permeate

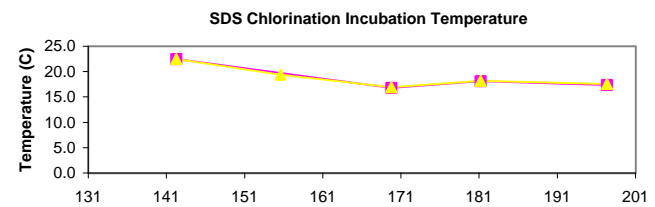
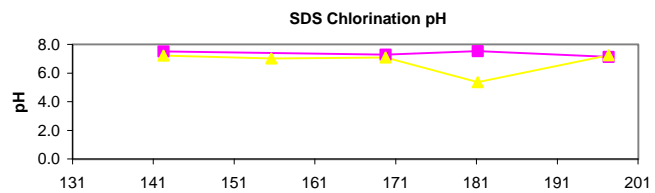
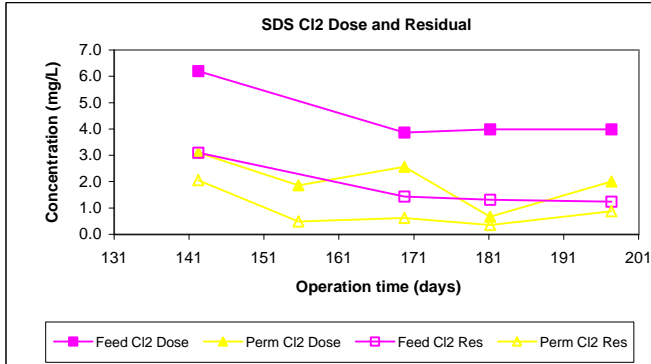
Water Quality Parameter Graphs



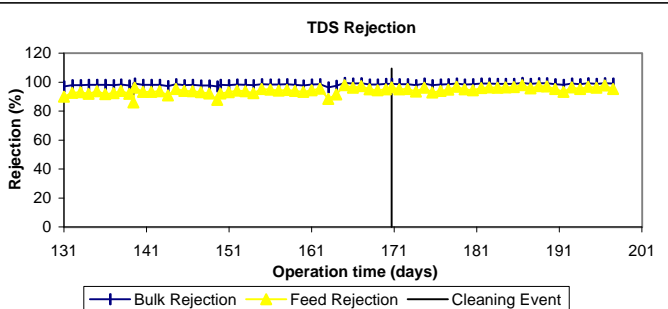
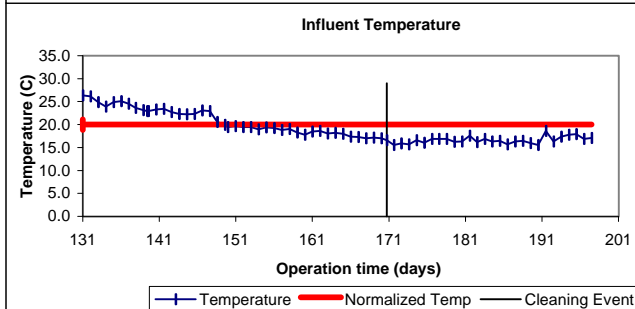
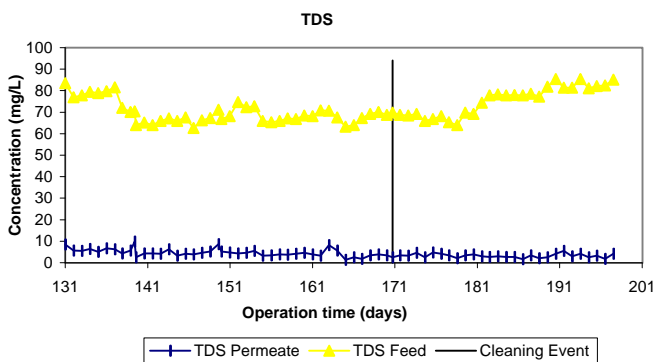
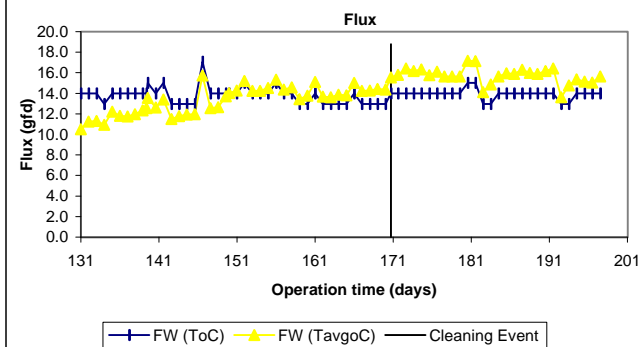
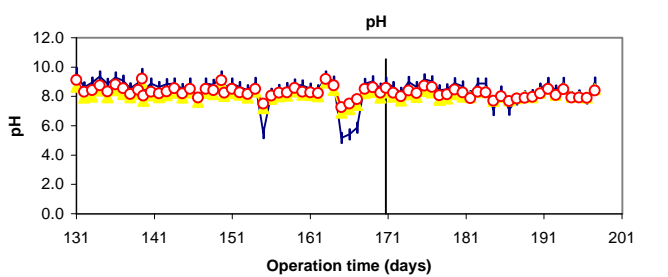
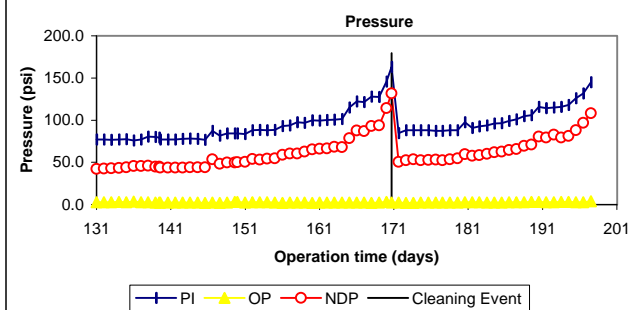
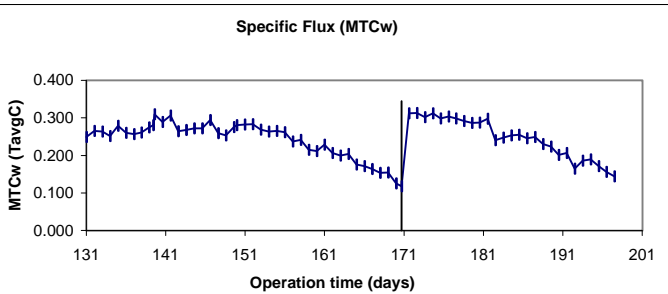
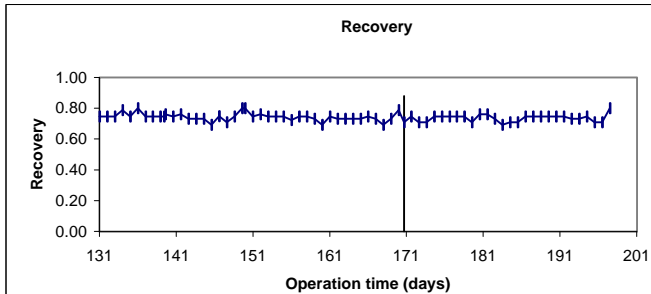
Water Quality Parameter Graphs (Continued)



Water Quality Parameter Graphs (Continued)



Productivity Graphs



ICR Information

ID / ICR#: VA37010100 / 677
 ICR Contact: Mr. Vernon Land
 Phone No.: 757/ 441-5678
 Period: 12/11/98 - 2/9/99 (60 days)

Membrane Information

Manufacturer: FilmTec
 Trade Name: NF70
 Membrane Model: NF70-4040
 MWCO: 200 Daltons
 Element Size: 4" x 40"
 Element Area: 70.0 ft²
 Design Flux: 14.4 gfd
 Mfr. NDP: 45.7 psi

Mfr. MTC_w: 0.315 (gfd/psi)
 Mfr. Temp: 21.5 °C
 Max Flow: 16.0 gpm
 Min Flow: 4.0 gpm
 Total Width: 12.7 ft
 Feed Sp Thickness: 0.0023 ft
 840 Element Area: 400.0 ft²
 840 Purchase Price: \$700

Design Parameters

Norm Temp: 20.0 °C
 Temp Norm MTC-w: 0.301 TavGC
 Design Recovery: 0.75
 Design Flux: 14.4 gfd

Recycle Ratio: 4.28
 Manuf rep Re_{JDS}: 70%
 TDS_F: 70.0 mg/L

Water Quality Summary

	Mean	SD	Feed Count	Min/Max	Mean	SD	Permeate Count	Min/Max	Mean	SD	Concentrate Count	Min/Max
pH	6.5	0.9	4	5.6 - 7.4	6.8	1.6	4	5.5 - 8.9	6.5	2.1	4	4.5 - 8.3
Temp	13.8	2.0	4	11.7 - 15.8	15.2	1.8	4	13.7 - 17.7	15.8	1.8	4	13.8 - 18.1
Alk	10	8	4	2 - 18	2	1	4	1 - 4	37	42	4	0 - 74
TDS	67	16	4	51 - 90	7	6	4	2 - 14	276	34	4	254 - 327
TotHard	30	3	4	27 - 33	2	1	4	1 - 3	105	5	4	98 - 108
CaHard	13	2	4	11 - 15	0	0	4	0 - 0	61	4	4	55 - 64
Turb	0.14	0.05	4	0.09 - 0.20	0.09	0.02	4	0.07 - 0.11	0.15	0.05	4	0.12 - 0.22
Amm	0.0	0.0	4	0.0 - 0.1	0.0	0.1	4	0.0 - 0.1	0.0	0.0	4	0.0 - 0.1
TOC	2.3	0.1	4	2.2 - 2.4	0.3	0.0	4	0.3 - 0.3	9.2	0.7	4	8.7 - 10.1
UV254	0.035	0.0	4	0.031 - 0.040	0.005	0.0	4	0.005 - 0.005	0.153	0.0	4	0.135 - 0.168
SUVA	1.51	0.24	4	1.29 - 1.81	NA	NA	4	NA	1.65	0.09	4	1.55 - 1.77
Bromide	31	2	4	29 - 33	10	0	4	10 - 10				
TOX	144	30	4	127 - 189	13	0	4	13 - 13				
CHCl3	28.9	4.6	4	22.9 - 33.7	1.3	1.6	4	0.0 - 3.3	Mass Balance Closure Errors (%)			
BDCM	6.9	0.8	4	6.0 - 7.9	0.5	1.0	4	0.0 - 2.0				
DBCM	2.3	1.5	4	0.0 - 3.2	0.0	0.0	4	0.0 - 0.0	WQP	Count	Avg	SD/RD
CHBr3	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	Alk	2	-43	30
THM4	38.1	5.2	4	31.8 - 44.6	1.4	2.3	5	0.0 - 5.3	TDS	4	-33	59
MCAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	TotHard	4	-58	54
DCAA	12.7	2.3	3	10.0 - 14.0	1.1	1.8	3	0.0 - 3.2	CaHard	0	n/a	n/a
TCAA	17.0	2.6	3	15.0 - 20.0	0.0	0.0	3	0.0 - 0.0	Turb	4	-106	68
MBAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	Amm	0	n/a	n/a
DBAA	0.4	0.6	3	0.0 - 1.1	0.0	0.0	3	0.0 - 0.0	TOC	0	n/a	n/a
BCAA	3.3	0.4	3	2.9 - 3.6	0.0	0.0	3	0.0 - 0.0	UV254	0	n/a	n/a
TBAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	TDS _t	59	-11	31
CDBAA	0.0	0.0	3	0.0 - 0.0	0.0	0.0	3	0.0 - 0.0	Comments:			
DCBAA	6.1	0.7	3	5.5 - 6.9	1.1	1.8	3	0.0 - 3.2				
HAA5	30.0	4.6	3	25.0 - 34.0	0.8	1.6	4	0.0 - 3.2				
HAA6	33.4	5.0	3	27.9 - 37.6	0.8	1.6	4	0.0 - 3.2				
HAA9	39.5	5.6	3	33.4 - 44.5	1.6	3.2	4	0.0 - 6.4				

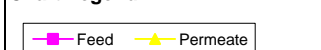
SDS Conditions

WQP	Avg	SD	Count	Min - Max
Res (0)	1.28	0.09	8	1.14 - 1.41
Temp (°C)	15.7	1.3	8	13.7 - 17.3
pH (unit)	6.7	1.0	8	4.2 - 7.2
Time (hr)	24.7	1.2	8	23.9 - 26.8

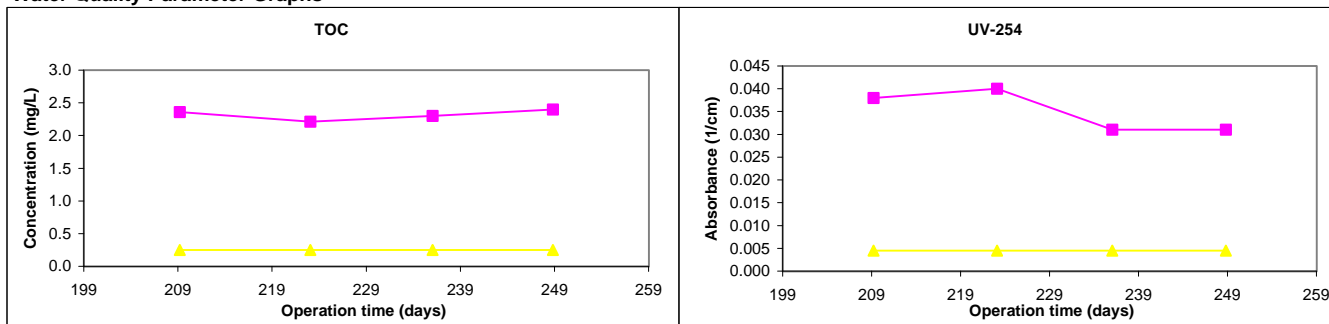
Pretreatment Information

Process	Description	Scale
Rapid Mix	Mechanical	Full-Scale
	Powdered Activated Carbon: Ave. dose 2.36 mg	
	Alum Al ₂ (SO ₄) ₃ *14H ₂ O : Ave. dose 30.1 mg/L	
Flocculation	Mechanical	Full-Scale
Sedimentation	Conventional	Full-Scale
Filtration	Dual Media - Anthracite/sand	Pilot-Scale

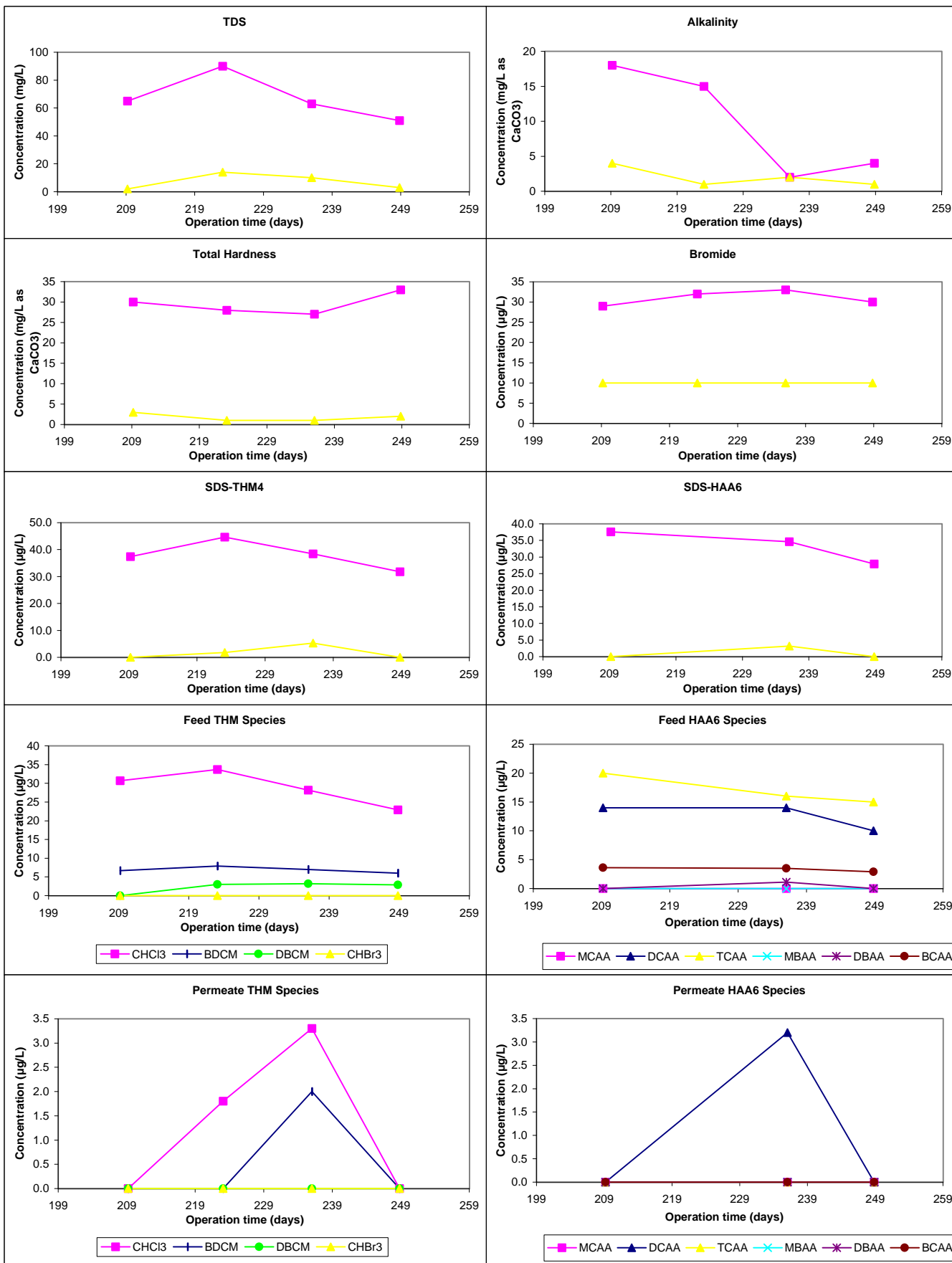
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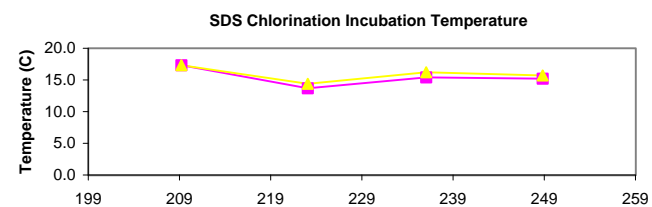
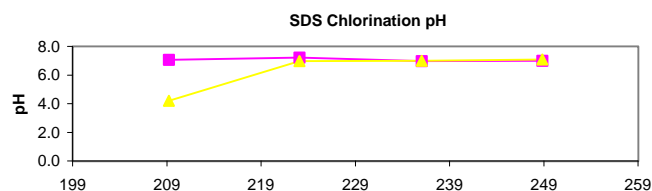
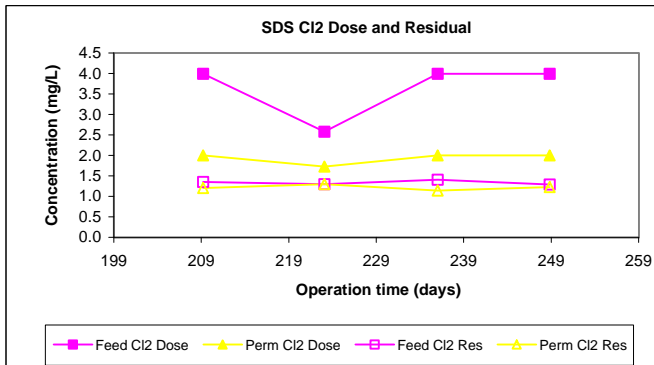
Water Quality Parameter Graphs



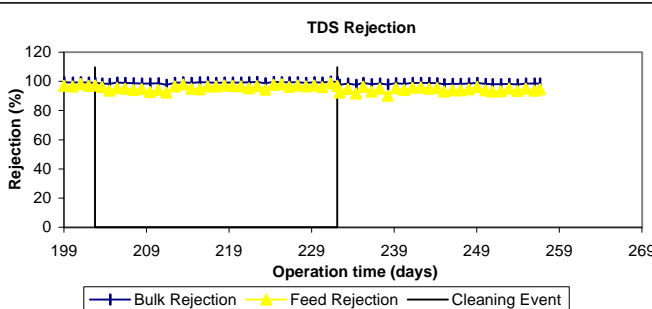
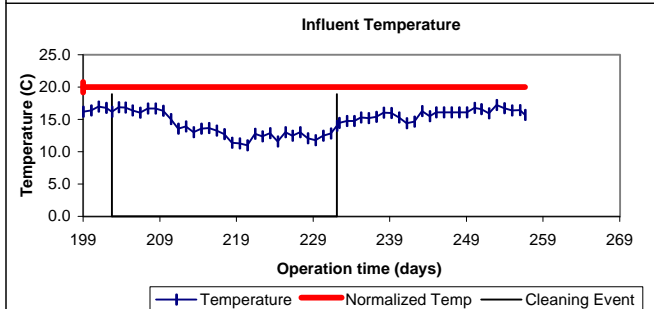
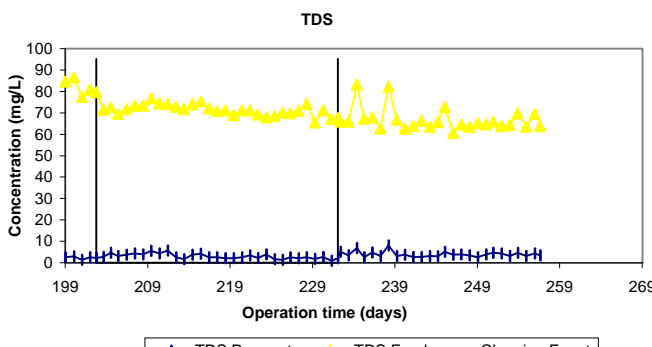
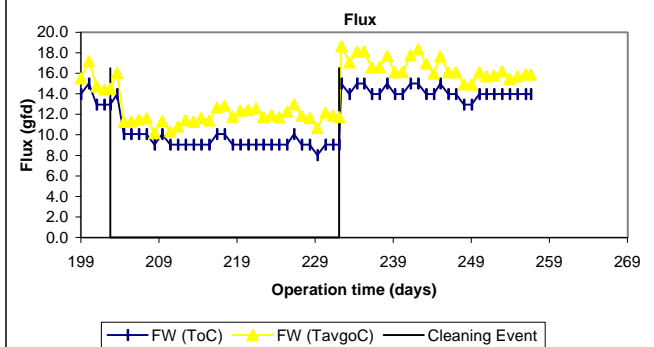
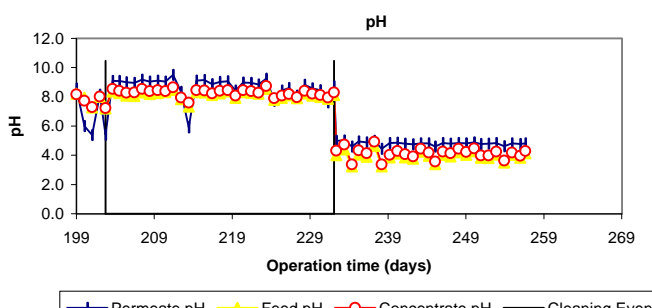
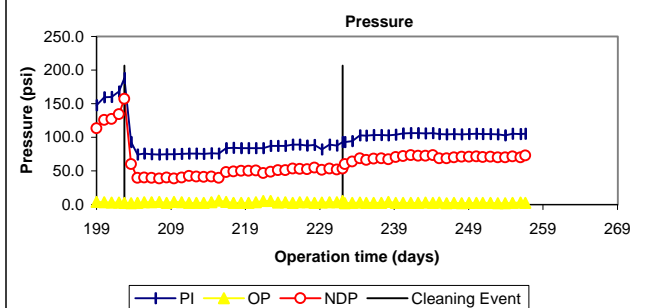
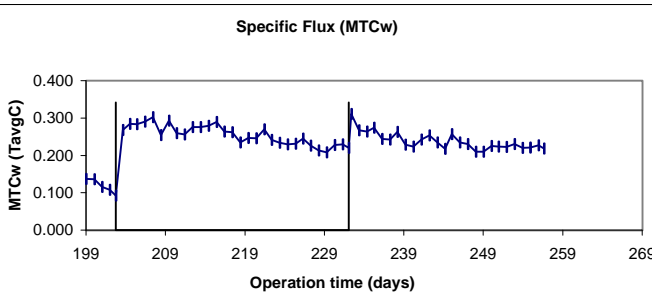
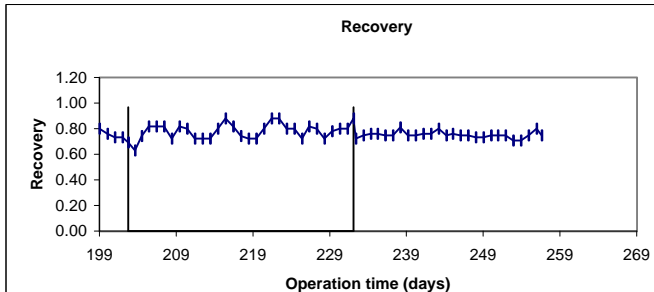
Water Quality Parameter Graphs (Continued)



Water Quality Parameter Graphs (Continued)



Productivity Graphs



ICR Information

ID / ICR#: VA37010100 / 677
 ICR Contact: Mr. Vernon Land
 Phone No.: 757/ 441-5678
 Period: 9/2/99 - 12/4/99 (93 days)

Membrane Information

Manufacturer: Hydranautics Mfr. MTC_w: 0.091 (gfd/psi)
 Trade Name: Low Fouling Composite Mfr. Temp: 17.4 °C
 Membrane Model: LFC1 Max Flow: 20.0 gpm
 MWCO: 200-300 Daltons Min Flow: 12.0 gpm
 Element Size: 4" x 40" Total Width : 12.3 ft
 Element Area: 85.0 ft² Feed Sp Thickness: 0.0023 ft
 Design Flux: 11.9 gfd 840 Element Area 365.0 ft²
 Mfr. NDP: 131.0 psi 840 Purchase Price: \$900

Design Parameters

Norm Temp: 20.0 °C Recycle Ratio: 4.28
 Temp Norm MTC-w: 0.098 TavGC Manuf rep Re_{JTDS}: 70%
 Design Recovery: 0.75 TDS_F: 70.0 mg/L
 Design Flux: 11.9 gfd

Water Quality Summary

	Mean	SD	Feed Count	Min/Max	Mean	SD	Permeate Count	Min/Max	Mean	SD	Concentrate Count	Min/Max
pH	5.5	0.5	4	5.0 - 6.0	5.5	0.1	4	5.3 - 5.6	4.5	0.3	4	4.0 - 4.7
Temp	13.6	1.2	4	12.5 - 15.2	16.1	1.2	4	14.8 - 17.5	16.1	1.0	4	15.1 - 17.5
Alk	2	2	4	1 - 4	2	1	4	1 - 3	0	0	4	0 - 0
TDS	73	7	4	63 - 79	11	7	4	3 - 17	220	45	4	154 - 250
TotHard	28	3	4	26 - 33	1	1	4	1 - 2	99	7	4	91 - 106
CaHard	15	1	4	14 - 15	0	0	4	0 - 0	59	6	4	53 - 67
Turb	0.12	0.02	4	0.10 - 0.13	0.10	0.04	4	0.06 - 0.16	0.22	0.05	4	0.16 - 0.27
Amm	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	0.1	0.1	4	0.0 - 0.2
TOC	2.5	0.1	4	2.4 - 2.7	0.3	0.0	4	0.3 - 0.3	9.0	0.8	4	8.2 - 9.9
UV254	0.036	0.0	4	0.033 - 0.039	0.005	0.0	4	0.005 - 0.005	0.144	0.0	4	0.129 - 0.155
SUVA	1.43	0.12	4	1.28 - 1.58	1.80	0.00	4	1.80 - 1.80	1.59	0.03	4	1.57 - 1.63
Bromide	26	5	4	20 - 30	10	0	4	10 - 10				
TOX	132	16	4	117 - 151	13	0	4	13 - 13				
CHCl3	29.6	5.3	4	26.2 - 37.4	0.5	0.6	4	0.0 - 1.1	Mass Balance Closure Errors (%)			
BDCM	6.8	0.9	4	5.6 - 7.7	1.4	0.9	4	0.0 - 1.9				
DBCM	3.0	0.2	4	2.8 - 3.2	0.0	0.0	4	0.0 - 0.0	WQP	Count	Avg	SD/RD
CHBr3	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	Alk	0	n/a	n/a
THM4	39.4	4.5	4	36.4 - 46.0	1.9	1.4	4	0.0 - 2.9	TDS	4	-27	9
MCAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	TotHard	4	-20	20
DCAA	10.6	1.4	4	9.3 - 12.0	0.0	0.0	4	0.0 - 0.0	CaHard	0	n/a	n/a
TCAA	17.1	1.4	4	16.0 - 19.0	0.0	0.0	4	0.0 - 0.0	Turb	4	32	47
MBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	Amm	0	n/a	n/a
DBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	TOC	0	n/a	n/a
BCAA	3.0	0.2	4	2.6 - 3.2	0.0	0.0	4	0.0 - 0.0	UV254	0	n/a	n/a
TBAA	0.0	0.0	4	0.0 - 0.0	0.0	0.0	4	0.0 - 0.0	TDS _t	83	-1	10
CDBAA	0.5	1.1	4	0.0 - 2.1	0.0	0.0	4	0.0 - 0.0	Comments:			
DCBAA	6.1	0.3	4	5.8 - 6.6	0.0	0.0	4	0.0 - 0.0				
HAA5	27.7	2.8	4	25.3 - 31.0	0.0	0.0	4	0.0 - 0.0				
HAA6	30.6	3.0	4	28.0 - 34.1	0.0	0.0	4	0.0 - 0.0				
HAA9	37.3	4.1	4	33.8 - 42.8	0.0	0.0	4	0.0 - 0.0				

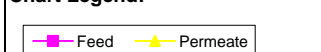
SDS Conditions

WQP	Avg	SD	Count	Min - Max
Res (0)	1.33	0.09	8	1.23 - 1.52
Temp (°C)	15.9	1.2	8	14.7 - 17.8
pH (unit)	7.0	0.1	8	6.9 - 7.1
Time (hr)	23.9	0.3	8	23.4 - 24.3

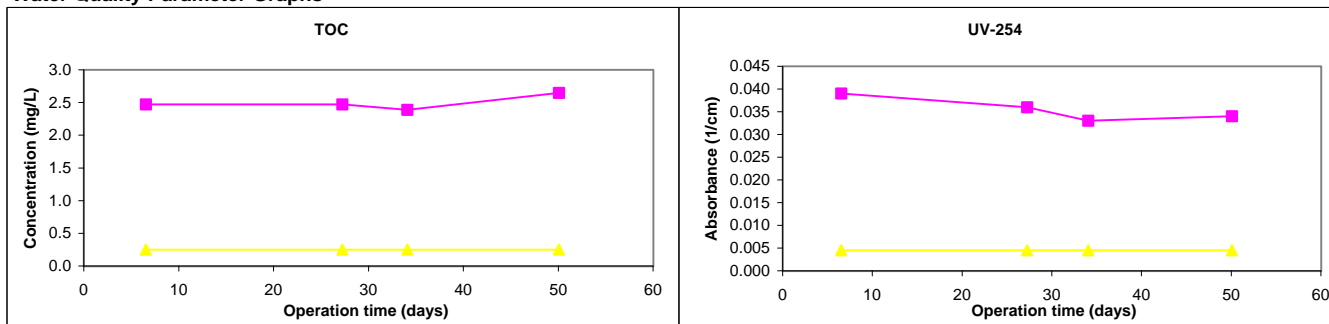
Pretreatment Information

Process	Description	Scale
Rapid Mix	Mechanical	Full-Scale
	Powdered Activated Carbon: Ave. dose 3.2 mg/ Alum Al ₂ (SO ₄) ₃ *14H ₂ O : Ave. dose 25.2 mg/L	
Flocculation	Mechanical	Full-Scale
Sedimentation	Conventional	Full-Scale
Filtration	Dual Media - Anthracite/sand	Pilot-Scale

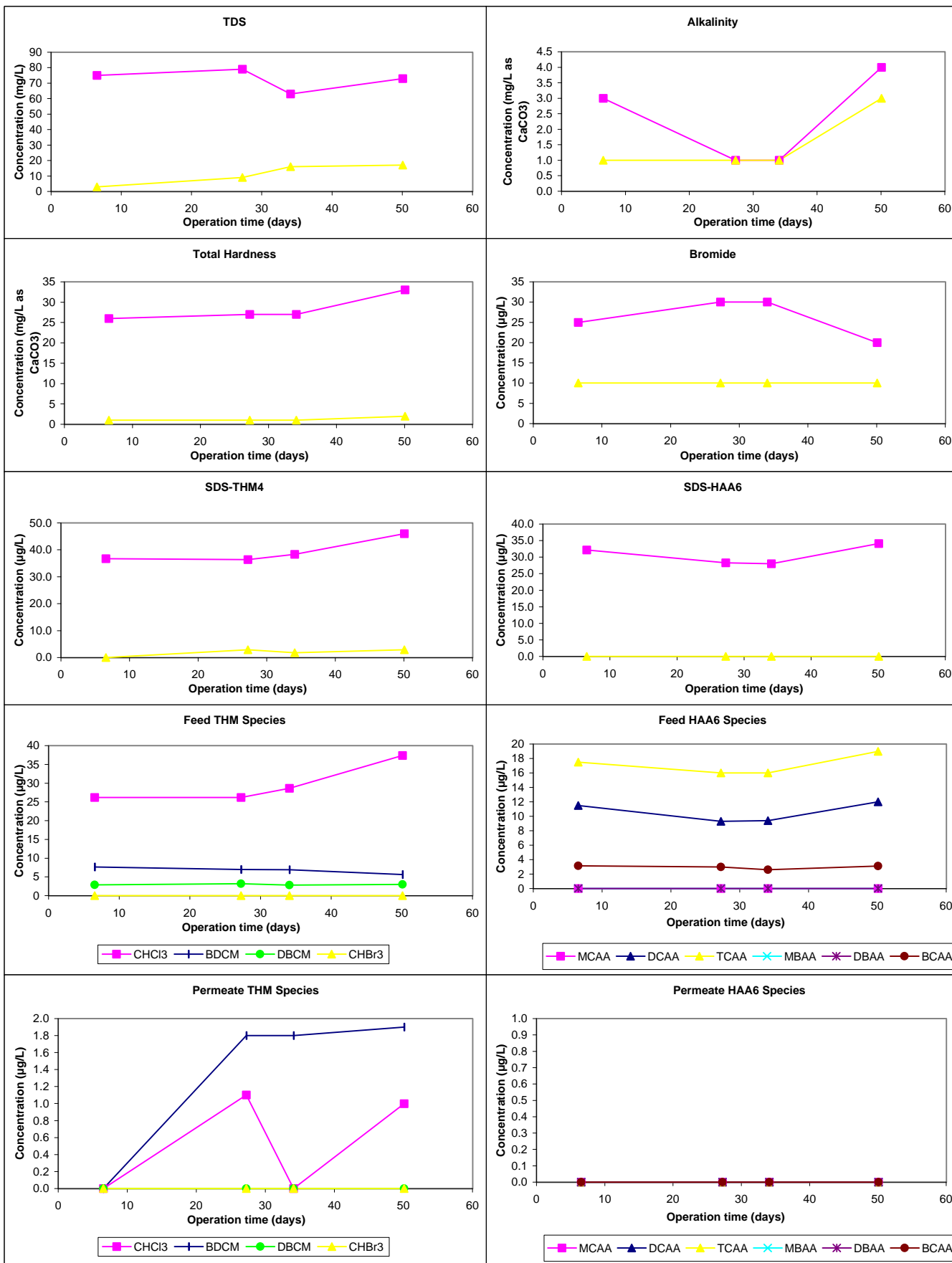
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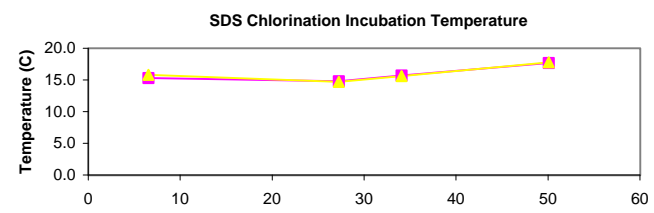
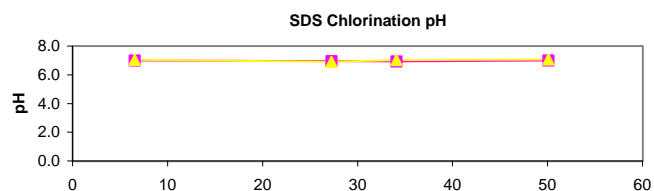
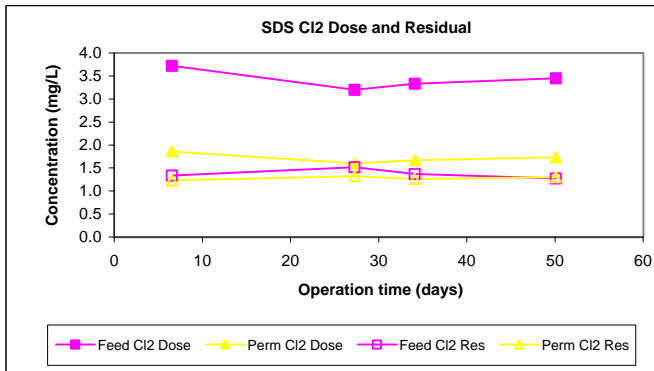
Water Quality Parameter Graphs



Water Quality Parameter Graphs (Continued)



Water Quality Parameter Graphs (Continued)



Productivity Graphs

